LUCAS - Land use and land cover survey

Statistics Explained

No update is planned for this article

The European Union (EU) is composed of a diverse range of landscapes: it is home to a wide variety of flora and fauna and includes some of the most and least densely populated areas of the world. This background article provides information on the Land Use/Cover Area frame Survey (LUCAS) , a survey that provides harmonised and comparable statistics on land use and land cover across the whole of the EU's territory.

The data collected by LUCAS provides harmonised information for studying a range of socioenvironmental challenges, such as land take , soil degradation or biodiversity.

Defining land use, land cover and landscape

Land cover refers to the bio-physical coverage of land (for example, natural areas, forests, buildings and roads or lakes).

Land use refers to the socioeconomic use that is made of land (for example, agriculture, commerce, residential use or recreation); at any one place, there may be multiple and alternative land uses.

Artificial land

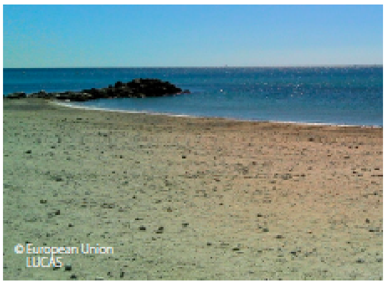
Cropland

Woodland

Shrubland

Grassland

Bare land



Water areas

Wetlands

LUCAS - Land cover

Primary sector:

(for example, agriculture and forestry)

Secondary sector

(industry)

Tertiary sector

(services)

Other uses

(for example, residential use and abandoned areas)

-

LUCAS - Land use

Landscape refers to an area of land whose character and functions are defined by the complex and regionally-specific interaction of natural processes with human activities that are driven by economic, social and environmental forces and values. Landscape can be analysed by taking account of elements such as landscape diversity, the importance of linear features, and the degree of landscape fragmentation.

The LUCAS survey

The Land Use/Cover Area frame Survey (LUCAS) is a harmonised *in situ* land cover and land use data collection exercise that extends over the whole of the EU's territory. An *in situ* survey implies that data are gathered through direct observations made by surveyors on the ground.

LUCAS is based on statistical calculations that interpret observations in the field. It is based on a standardised survey methodology in terms of a sampling plan, classifications, data collection processes and statistical estimators that are used to obtain harmonised and unbiased estimates of land use and land cover.

LUCAS - the historical perspective

LUCAS was initially developed to provide early crop estimates for the European Commission. The survey started as a pilot survey across a limited number of EU Member States; the first survey was held in 2001.

Over time, the survey has become a key tool for policymakers and statisticians alike, with increasing amounts of data on different forms of land use and land cover in the EU. In 2006, the sampling methodology changed and its focus shifted from an agricultural land survey to a broader land cover, land use and landscape survey. In the same year, a three-yearly interval was introduced as the frequency for carrying out the survey.

The 2009 survey saw a marked expansion in terms of the geographical coverage of LUCAS with results made available for 23 of the then EU-27 Member States (Bulgaria, Cyprus, Malta and Romania were not covered).

The classifications used for categorising data on land use and land cover were adapted in order to be more closely aligned with international standards.

The 2012 survey saw a further expansion of the geographical coverage of LUCAS with results made available for all the EU-27 Member States.

The 2015 survey was conducted in and covered all of the EU-28 Member States.

The 2018 survey was conducted in and covered all of the EU-27 Member States (except UK).

The 2022 survey was conducted in with the same coverage as in 2018.

How is LUCAS conducted?

LUCAS is a two phase sample survey. The LUCAS first phase sample is a systematic sample with points spaced 2 km apart in the four cardinal directions covering the whole of the EU's territory; it therefore includes around 1.1 million different points. This first phase sample can also be called the Master or Frame. Each point of the first phase sample is photo-interpreted and assigned a pre-defined land cover class. From the stratified first phase sample, a second phase sample of points, the field sample, is drawn.

Until the 2015 survey, the stratified field sample was independently selected in each NUTS level 2 region, fixing precision targets for the estimates of the main land cover classes. Each of these field samples was classified during the field visit according to the full classification of land use and land cover. For more information on the methodology, follow this link .

A panel approach assures that a certain percentage of the points are surveyed in successive LUCAS campaigns. Until 2015, points above 1500 metres and/or far from the road network were considered inaccessible and excluded from the sample of points to be visited in order to limit the cost of the data collection exercise. A complementary sample to be photo-interpreted in the office, according to the LUCAS instructions, compensated for the bias of the exclusion of certain areas from the field and was taken into account during the production of the final estimates.

The survey design for 2018 has been fine-tuned in several aspects summarised here below (details at this link):

- the original seven classes assigned to each point of the Master — arable land, permanent crops, grassland, wooded areas and shrubland, bare land, artificial land, and water - were enlarged into 10 more detailed modalities: "wooded areas" and "shrubland" were split, while two new modalities “transitional water” (estuaries, lagoons, etc.) and “impossible to photo-interpret” have been introduced

- the data collection is carried out in two different ways: either directly by surveyors in the field (in situ) or by photo-interpretation (PI) in the office; differently from the previous surveys where the collection modality was assigned dividing the Master into eligible and non-eligible points for field collection. In LUCAS 2018, the choice to allocate the point to either the "in-situ" or "PI" modality is done after the sample selection; photo-interpretation is needed if it is impossible or too costly to reach the point.

- for each point in the Master, the most probable amongst 16 land cover modalities (target variables) was estimated by a linear logistic regression model, on the basis of the actual data from the 2015 LUCAS survey, and considering about 16 covariates.

- the second phase sample design is a stratified one but the stratification is not fixed as in the previous surveys (given by the combinations of NUTS level 2 and the seven land cover classes) but is instead obtained by using an iterative algorithm that optimises the CVs of the target variables at NUTS 2 level and taking into account the related, desired sampling errors, in order to allocate the sample in the final strata

The sample design is taken into account for the computation of the final estimates by calculating appropriate weights for each surveyed point. The final weights are computed using information from the Master sample, taking into account four marginal totals in terms of area given by the Cartesian product of:

1. NUTS level 2 regions and strata,
2. NUTS level 1 regions and 4 elevation classes,
3. NUTS level 0 combined with strata and 6 elevation classes,
4. Country area.

In each of these domains, the estimates sum up to the respective totals in the Master.

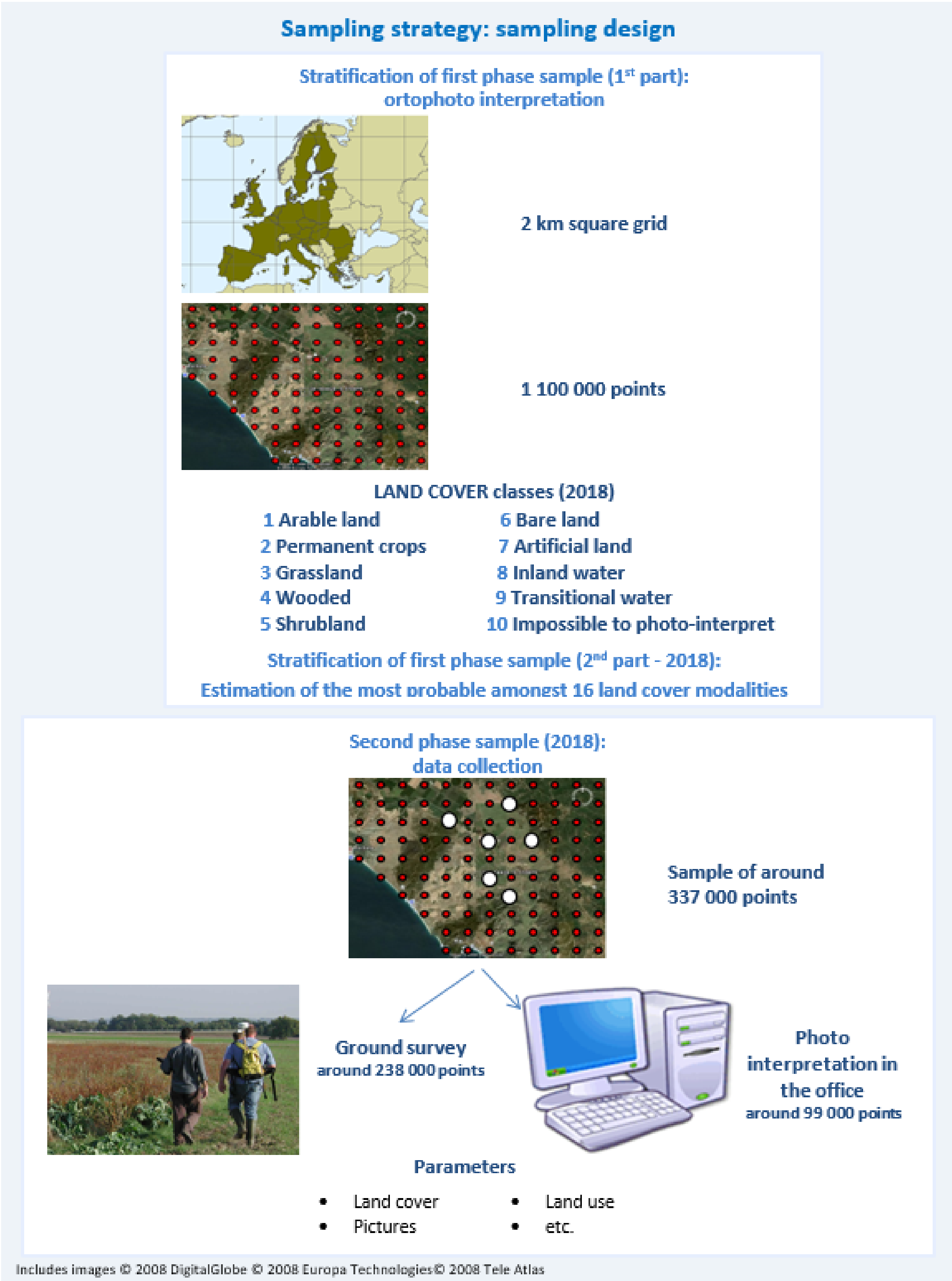
The estimates also take into account both the primary and the secondary land cover and land usage observed.

The 2015 field survey was based on 273 500 points/observations, which were visited by 750 field surveyors (mostly agricultural and forestry engineers); the field survey took place between March and September 2015; the samples from the excluded areas from the 2009-2015 field surveys which were instead photo-interpreted, consisted of around 67 000 points.

The Lucas survey 2018 was based on 337 854 points/observations, of which 238 077 were in-field and 99 777 photo-interpreted.

The Lucas survey 2022 was based on approximately 400 000 points/observations, of which 200 000 were in-field and 200 000 photo-interpreted. The 2022 survey also included the modules of Copernicus in a sample of 150 000 field points, Grassland in a sample of 20 000 field points, Soil in a sample of 41 000 field points and the Landscape features in a sample of 93 000 field points.

The survey design for 2022 has been fine-tuned in several aspects (details at this link):



LUCAS - schema for data collection exercise

The use of an area frame survey reduces the statistical burden on farmers and other land owners as they do not need to respond to questionnaires.

Point next to a field (central photograph) and pictures to the north, south, east and west

LUCAS surveyors go to the points and observe the land cover, land use and environmental parameters they find on the ground. The surveyor documents the land cover and land use according to harmonised classifications. The concept of 'land' is extended to inland water areas (such as lakes, rivers, estuaries or lagoons). The surveyor also collects information relating to the percentage of land cover within a specific window of observation, the area size, the width of any specific features, the height of any trees, as well as information on land and water management (for example, grazing or irrigation). Surveyors receive training before going into the field: they have a set of supporting documents, instructions on how to carry out the survey, and a set of quality control procedures. As such, considerable efforts are made to ensure that each of the surveyors applies the same methods when visiting the assigned geographical point. They fill in a questionnaire with a series of land cover and land use parameters.

Some examples of decisions taken in the field

	Surveyors actions
Example A	the point is located in a common wheat field — the land cover is cropland of common wheat and the land use is agriculture
Example B	the point is located on the lawn of a campsite with trees — the land cover is grassland with sparse trees/shrub cover and the land use is a holiday camp
Example C	the point is located on a road that is wider than three metres — the land cover is a non-built-up linear feature and the land use is road transport
Example D	the point is located in an urban park with mainly broadleaved trees — the land cover is broad-leaved woodland and the land use is leisure; for this particular example the forest species would also be noted by the surveyor (for example, beech)
Example E	the point is located in the parking area of a supermarket — the land cover is a non-built-up area feature and the land use is commerce, financial, professional and information services

Surveyors actions

LUCAS surveyors are sometimes confronted with unusual, even perilous situations, as some points may prove extremely difficult to reach, for example when trying to access flooded areas, encountering rock faces or disturbing (wild) animals. The safety of surveyors is clearly paramount and in some cases the specified point cannot be surveyed.

What sort of information is compiled?

The classifications used within LUCAS are comparable with other statistical standards, for example, standards used in the EU's farm structure survey (FSS) , those used by the United Nations' Food and Agriculture Organisation (FAO) , or the European Nature Information System (EUNIS) for classifying forestry types and areas.

Land cover is classified according to the following classification
(only the first two levels of the hierarchy are shown — there are a total of 8 categories, 29 classes and 76 subclasses):

Land cover			
A00	ARTIFICIAL LAND	**A10**	Roofed built-up areas
		A20	Artificial non-built up areas
		A30	Other artificial areas
B00	CROPLAND	**B10**	Cereals
		B20	Root crops
		B30	Non-permanent industrial crops
		B40	Dry pulses, vegetables and flowers
		B50	Fodder crops
		B70	Permanent crops: fruit trees
		B80	Other permanent crops
C00	WOODLAND	**C10**	Broadleaved woodland
		C20	Coniferous woodland
		C30	Mixed woodland
D00	SHRUBLAND	**D10**	Shrubland with sparse tree cover
		D20	Shrubland without tree cover
E00	GRASSLAND	**E10**	Grassland with sparse tree/shrub cover
		E20	Grassland without tree/shrub cover
		E30	Spontaneously re-vegetated surfaces
F00	BARE LAND AND LICHENS/MOSS	**F10**	Rocks and stones
		F20	Sand
		F30	Lichens and moss
		F40	Other bare soil
G00	WATER AREAS	**G10**	Inland water bodies
		G20	Inland running water
		G30	Transitional water bodies
		G40	Sea and ocean
		G50	Glaciers, permanent snow
H00	WETLANDS	**H10**	Inland wetlands
		H20	Coastal wetlands

LUCAS - classification of land cover

Land use is classified according to the following classification (there are 4 main categories, 16 classes and 31 subclasses)

Land use			
U100	PRIMARY SECTOR	U110	Agriculture
		U120	Forestry
		U130	Aquaculture and fishing
		U140	Mining and quarrying
		U150	Other primary production
U 200	SECONDARY SECTOR	U210	Energy production
		U220	Industry and manufacturing
U300	TERTIARY SECTOR, TRANSPORT, UTILITIES & RESIDENTIAL	U310	Transport, communication networks, storage, protection works
		U320	Water and waste treatment
		U330	Construction
		U340	Commerce, financial, professional and information services
		U350	Community services
		U360	Recreation, leisure, sport
		U361	Residential
U400	UNUSED AND ABANDONED AREAS	U410	Abandoned areas
		U420	Semi-natural and natural areas not in use

LUCAS - classification of land use

How is quality assured?

The results collected by the surveyors are subject to a detailed, quality check. An automated, quality check, verifying completeness and consistency, is carried out either during the compilation phase or when the data collected in the field is uploaded to a central data repository. A second level of quality controls is carried out at the regional or central offices, where all of the surveyed points are checked visually. A further quality control is then done by an independent quality controller and includes:

- interactive control of accuracy and compliance to the quality requirements as defined in the LUCAS framework for 36 % of the points;
- the first 20 % of points assigned to a surveyor are controlled in their entirety to detect early on any systematic errors being made.

All information available is used to carry out the controls, including:

- the ground documents that the surveyors receive to locate the point;
- the current photos as well as any historic photos and data available should the point have been previously surveyed;
- the GPS tracking that shows the complete path that was followed by the surveyor;
- any comments made by surveyors and local controllers, which are transmitted along with the data.

Those data points requiring correction or additional clarification (around 7 % of the total number of points) are rejected and sent back to the field contractors for correction.

What results are made available?

There are two main types of information presented to users: aggregated statistical tables and elementary data (linked to individual points).

The aggregated results for the EU and national totals show the land cover and land use for each of the main categories and their subclasses, as well as woodland areas by size and by canopy cover . The statistics can also be analysed at a more detailed level according to the NUTS classification — the EU's classification of regions — providing data for the almost 300 NUTS level 2 regions within the EU.

The elementary data in its most disaggregated form (in situ microdata) can be accessed for individual points. The data are presented in a tabular format in country-specific files, available here .

Since the 2006 reference period, Eurostat has also made a photo archive from LUCAS available. Photos can be requested by using the online form, available here .

Furthermore, there is a LUCAS online viewer for the 2009, 2012, 2015 and 2018 data collections, available here .

LUCAS soil data is available here .

How can LUCAS data be used?

Data on land cover and land use can be used for a variety of environmental and socioeconomic projects linked to a range of policy areas:

- the European Commission's Directorate-General for Agriculture and Rural Development , for evaluating the impact of agriculture on the environment through agri-environmental indicators (AEI), including for organic soil matter and soil erosion as well as indicators on the degree of artificiality and the physical structure of landscapes within the framework of the integration of environmental concerns into the Common Agricultural Policy (CAP) post-2013 ;
- the European Commission's Directorate-General for Environment , for resource efficiency indicators that form part of the Europe 2020 strategy to and for soil protection ;
- the European Commission's Directorate-General for Climate Action for analysing climate change as part of the European climate change programme;
- the European Commission's Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs , where in situ data from LUCAS contribute to the production, verification and validation processes relating to pan-European datasets describing the main land cover types, which are derived from satellite images, as conducted by Copernicus observation programme ;
- the European Environment Agency , for their core set of indicators (CSI), climate change indicators (CLIM) and streamlining European biodiversity indicators (SEBI);
- the European Commission's Directorate-General for Climate Action , for land use, land use change and forestry (LULUCF) statistics in relation to the reduction of greenhouse gas emissions.

Specific examples on how the data is used within the European Commission can be found here .

LUCAS data also provides a rich source of information for the research community.

A case study for the usage of LUCAS — monitoring soil across the EU

The remainder of this article provides some background information in relation to the possible uses that can be made of the LUCAS dataset; it concentrates on one particular area, soil.

The formation of soil is an extremely slow process and, in the context of human lifetimes, soil is therefore considered to be a non-renewable resource. Demand for data and information that may be used to assess the state of European soils has been covered, among others, by the 6th Environment Action Programme , which outlined the EU's Soil Thematic Strategy (see box), the sustainable use of soil to preserve its functions, and plans to restore degraded or polluted soils. These principles were confirmed in the 7th Environment Action Programme which restates the EU's commitment to: reduce soil erosion; increase organic matter in soil; limit the effects of man-made pressures on soil; manage land in a sustainable fashion; and remedy sites with contaminated soils.

The EU's Soil Thematic Strategy

In 2006, the European Commission's communication titled ' Thematic strategy for soil protection ' (COM(2006) 231) laid out plans to ensure that the EU is committed to a high level of soil protection, with the objective of protecting soil functions and preventing further soil degradation. Within this framework, the EU Member States decide how best to protect the sustainable development of their own soils, while the European Commission provided an impact assessment of the economic, social and environmental impacts of different policy measures.

In February 2012, the European Commission published a policy report on the implementation of the strategy (COM(2012) 46). This provided an overview of the actions undertaken within the EU's soil thematic strategy, namely in relation to raising awareness, research, integration and legislation. It showed that the strategy has helped raise the profile of soil issues, for instance by integrating them into other policies. It also presented soil degradation trends both in Europe and globally, as well as future challenges to ensure soil protection. For more information: Joint Research Centre, The state of soil in Europe

Soil degradation in Europe

Soil degradation is a change in soil condition, resulting in a diminished capacity of the ecosystem to provide goods and services for its beneficiaries. Soil degradation processes may be exacerbated by human activity, such as agricultural and forestry practices, industrial emissions, tourism, urban and infrastructure sprawl or construction works. As a result, soil degradation may impact directly upon water and air quality, biodiversity and climate change, and is therefore of interest to a range of policymakers.

Some of the main factors that cause soil degradation in the EU include erosion (by water or by wind), and a decline of organic matter content and biodiversity within soils. According to the latest soil erosion assessment for the European Union[1], the mean soil erosion rate is about 2.46 tonnes per hectare per year. The largest and most intensively eroded region is Mediterranean Europe. Erosion is strongly affected by the land use, being higher in agricultural lands than in forests and other forms of semi-natural vegetation. Within the agricultural domain, land management practices such as organic and integrated farming can reduce erosion by maintaining and enhancing organic matter content, protecting soil biodiversity and preserving soil structure. Currently, almost half of the soil in the EU is considered to have low organic matter levels; this is particularly evident in the southern Member States. The role of organic matter and soil organisms on the control of soil erosion is mainly linked to the formation of soil structure. Besides erosion control, soil organic matter and soil organisms are important for the provision of several ecosystem services: from nutrient cycling to climate regulation.

Other forms of soil degradation include salinisation (the accumulation of soluble salts in soils), compaction, flooding and landslides, and soil contamination from industrial activities (the use and presence of dangerous substances in production processes). Salinisation can limit the agroecological potential of soil. Compaction seriously affects the physical and hydraulic properties of soil, which can lead to increased flood risks. Contamination can affect to the ability of soil to provide key ecosystem services such as provision of food and water purification. Flooding and landslides can cause severe environmental damage and land-use restrictions by removing topsoil from the land surface or by introducing contaminants. All these soil degradation processes have important economic and social consequences.

Another form of soil degradation is soil sealing. This occurs when soil is replaced by an impermeable material, for example, due to the construction of housing, infrastructure, retail, industrial or other building work. A roadmap to a resource-efficient Europe COM(2011) 571 — one of the flagship initiatives of the Europe 2020 strategy — has called for EU policies, by 2020, to 'take into account their direct and indirect impact on land use in the EU and globally', such that the rate of land take (land taken for urban and other artificial land development) is maintained on a path which aims to achieve no nett land take by 2050.

LUCAS soil database

In 2009, the European Commission extended the LUCAS exercise to include an additional module in relation to soil. The LUCAS soil module is coordinated by the European Commission's Joint Research Centre (JRC). This survey represents the first attempt to construct a pan-European topsoil database, which can serve as a baseline for EU-wide soil monitoring.

A total of nearly 20 000 topsoil samples (0−20 cm depth) were collected from approximately 10 % of the LUCAS 2009 data points in 23 EU Member States; Bulgaria, Croatia, Cyprus, Malta and Romania were initially excluded. Subsequently, Cyprus and Malta provided topsoil samples even though LUCAS was not carried out on their

[1] https://www.sciencedirect.com/science/article/pii/S1462901115300654 The new assessment of soil loss by water erosion in Europe

territories in 2009. Around 2 000 topsoil samples were collected in Bulgaria and Romania as part of the LUCAS 2012 Survey and analysed following the same standard procedures as for 2009.

A LUCAS topsoil sample is equivalent to around 0.5 kg. All samples were registered and visually checked; mineral soils were air-dried and repacked, before being sent to a central laboratory for physical and chemical analyses to measure, among others: particle size (clay, silt and sand content), pH (acidity and alkalinity), organic carbon content, carbonate content, phosphorus content, total nitrogen content and extractable potassium content.

The LUCAS Topsoil Survey was repeated in 2015. About 23 500 LUCAS data points were sampled in the EU-28 Member States, and for the first time in Albania, Bosnia-Herzegovina, Macedonia, Montenegro, Serbia and Switzerland. Nearly 75 % of the topsoil samples were collected in the same LUCAS data points as in the surveys of 2009 and 2012. The aim was to compare the topsoil data between surveys and to detect possible changes on physical and chemical parameters of topsoil at the EU territory over time. All topsoil samples were collected following the LUCAS standard sampling procedure and were analysed for the same physical and chemical properties as in the LUCAS 2009 and 2012 Topsoil Surveys. Additionally, electrical conductivity, which assesses soil salinity, was also analysed in the LUCAS 2015 Survey.

In 2018, the LUCAS Topsoil Survey was carried out again with the same set of points in the EU Member States surveyed in the previous topsoil surveys (2009, 2012 and 2015). The novelty of the LUCAS 2018 Topsoil Survey[2]is the inclusion of new parameters, namely bulk density and soil biodiversity. These analyses require specific methods of soil sampling, thus the LUCAS standard sampling methodology has been adapted to include them[3]. Data on bulk density will provide an overview of the soil compaction situation and will allow the estimation of organic carbon stocks in the soils of the EU territory. DNA fingerprinting will be applied to analyse soil biodiversity. In particular, bacteria, archaea, fungi, and microbial eukaryotes will be targeted to explore their distribution in different climatic regions and evaluate the impact of land cover / uses on their diversity across the EU territory.

In 2022, the LUCAS Topsoil Survey was carried out again in the EU Member States on a sample of 41 000 LUCAS data points, out of which 14 000 points were the same as in 2018 survey. Data will provide an overview of the soil compaction situation and will allow the estimation of organic carbon stocks in the soils of the EU territory. Furthermore, bulk density and soil biodiversity will be analysed for a selected sample of points.

LUCAS data — its application to monitor the Soil Thematic Strategy

LUCAS is based on a uniform methodology and has flexibility in its design, which allows the European Commission services to specify particular survey modules (such as the topsoil survey), and can provide soil monitoring data every three years.

LUCAS data have been used to make an initial analysis of land take, soil sealing, and more generally land cover and land use, while specific information from the topsoil module have been used to monitor the chemical and physical properties of topsoil across the EU. The latter has allowed a wide range of policy assessments to be made, such as a detailed evaluation of carbon content in European soils, considered important within the context of climate change policy and for food production.

While the Soil Thematic Strategy (COM(2006) 231) has helped raise the profile of these issues, there is still no systematic monitoring and protection of soil quality across Europe. In its progress report on the implementation of the strategy (COM(2012) 46) — published in 2012 — the European Commission noted that results from LUCAS could be a starting point for a harmonised system of monitoring. The LUCAS Topsoil Surveys of 2015 and 2018 are a consequence of the need of a systematic soil monitoring in Europe.

LUCAS data — its application to monitor agro-environmental indicators

The EU's agricultural policy post-2013 contains commitments to incorporate a range of environmental concerns, for example, in a Communication entitled ' Development of agri-environmental indicators for monitoring the integration of environmental concerns into the common agricultural policy ' (COM(2006) 508), the European Commission

[2] `http://onlinelibrary.wiley.com/doi/10.1111/ejss.12499/full` LUCAS Soil, the largest expandable soil dataset for Europe: a review

[3] `https://ec.europa.eu/jrc/en/publication/lucas-2018-soil-component-sampling-instructions-surveyors` LUCAS 2018 - soil component: Sampling Instructions for Surveyors

proposed a set of 28 agri-environmental indicators, including indicators for soil quality and soil erosion.

Soil quality

The LUCAS Topsoil Survey includes the evaluation of the organic carbon content of soil (as derived from residual plant and animal material decomposed under the influence of temperature, moisture and ambient soil conditions); this indicator is named “the organic carbon concentration of soil”. A high level of organic carbon content may be linked with good soil conditions from an agro-environmental point of view and it is likely to promote limited soil erosion, a high water filtration capacity, a habitat potentially rich in soil organisms, and provides a sink for atmospheric carbon dioxide. The annual loss of organic carbon can vary greatly in soils, depending on natural factors (e.g., climate, soil material, drainage status, land cover and topography), and human-induced factors (e.g., type of plant / crop cover, land use, land management practices).

Soil erosion

Soil’s vulnerability to erosion depends on a range of environmental conditions and human activities. By removing the most fertile topsoil, erosion reduces soil productivity and, where soils are shallow, may lead to an irreversible loss of farmland. Severe erosion is commonly associated with the development of temporary or permanently eroded channels or gullies that can fragment farmland.

Soil erosion is defined as the area exposed to the risk of erosion (in hectares and as a percentage of the total area). The LUCAS data has been used in a modelling exercise (RUSLE) conducted by the European Commission’s Joint Research Centre (JRC) which evaluated soil erosion rates. The work carried out by the JRC suggests that the following data are needed to produce updated indicators for soil erosion:

- soil data — texture, organic carbon content, structure, permeability;
- climate data — high temporal precipitation records;
- land cover and vegetation density;
- topography;
- management — human and agricultural practices.

Landscape diversity – results from LUCAS 2012 exercise

Landscape refers to an area of land whose character and functions are defined by the complex and regionally-specific interaction of natural processes (relief, soil type, water availability, climate, biological diversity) and cultural features (human intervention through agriculture, forestry, rural policies, construction and economic pressures).

While some countries have large continuous areas of the same land cover, others have a mosaic of small areas of different land covers. The presence of grass verges, hedges, dry stone walls, ditches and other semi-natural linear elements is considered to be of fundamental importance to help promote biodiversity, providing ecosystem services such as pollination or pest control. On the other hand, the gradual moulding of landscapes by human activity has modified landscapes, for example, through urbanisation, changes in agricultural practices, or the increased use of transport. The density of man-made linear elements, which have a dissecting nature (such as roads, railways and aerial cables) is closely linked to population and infrastructure developments, and these elements may impede biodiversity — for example, a motorway that cuts through a natural area may restrict the free movement of wild animals.

Eurostat produces a range of indicators that may be used to evaluate the links between landscape patterns and biodiversity. Landscapes can be evaluated as LUCAS surveyors walk along a 250m transect recording land cover transitions and the presence of linear features. The structure of EU landscapes is analysed by taking into account the following elements: richness (the number of different types of land cover), diversity (the relative abundance of land cover types — in other words, whether they recur within the transect) and fragmentation (the presence of structural and dissection elements), to provide information on the spatial organisation, presence and arrangement of landscape features.

In the 2009, 2012 and 2015 LUCAS campaigns, the surveyors also recorded the land cover transitions along a so-called transect: a 250 m walk from each field sample towards East. In the 2018 survey, the transect had not taken place and in the 2022 survey it has been replaced by the landscape features module. Landscape

Features(LF) are small non-productive elements within agricultural landscapes, providing support for biodiversity and the supply of ecosystem services. This definition includes several non-productive elements of European agricultural landscapes, such as hedges, ponds, ditches, trees in line or in-group or isolated, field margins, terraces, dry-stone or earth walls, springs or historic canal networks. Traditionally, such elements were important elements of agricultural landscapes, closely linked to agricultural management practices that have modified existing features or actively created them.

From the transect data collected, the Shannon evenness index, which provides one measure of landscape diversity, can be calculated. This exercise was carried out using 2012 data and, for the EU-27 as a whole, this index was 0.70. The majority of the EU Member States recorded Shannon evenness indices that were distributed around the EU-27 average, within the interval of 0.65–0.75.

Shannon evenness index When the LUCAS surveyors walk a 250m transect, they are requested to register all the land cover changes they observe. The degree of homogeneity or heterogeneity of land cover can be analysed by measuring the number of different land cover types in each transect and their relative abundance (in other words, whether the same type of land cover reoccurs in the transect).

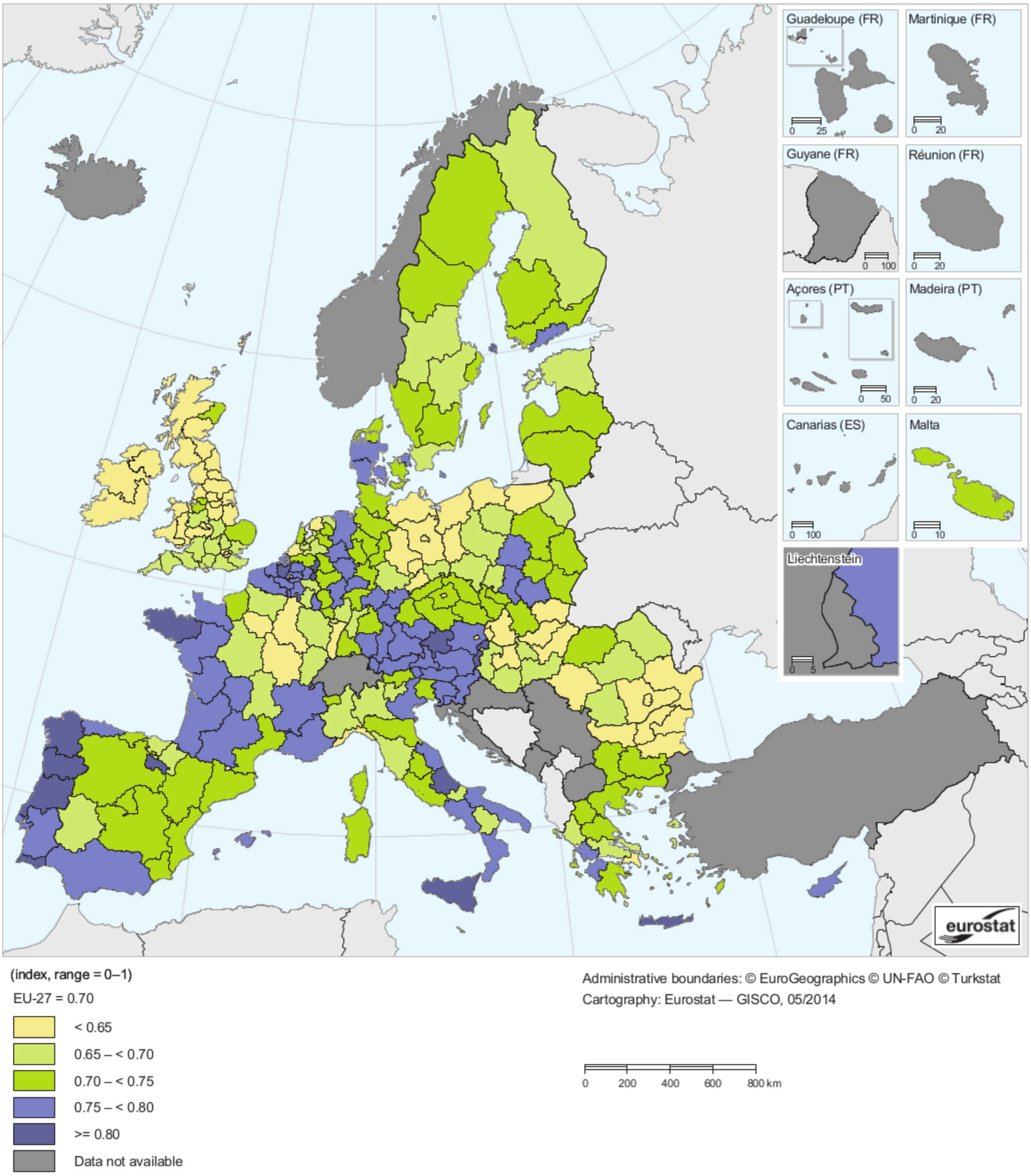
The Shannon evenness index (SEI) can be used to evaluate landscape diversity and takes into consideration both the number of different land cover types observed and their relative abundance; the index is based on values within the range of 0–1, with zero representing a landscape with no diversity (only one land cover type) and a value of one representing the maximum diversity (in other words, featuring all types of land cover in equal amounts). If a landscape is characterised by all different types of land cover being found in equal abundance then the Shannon evenness index will tend towards the value of one; conversely, if there is only one dominant type of land cover then the index will tend towards zero.

Shannon evenness index =

$$-\sum_i^m (Pi * \ln(Pi)) / \ln(m)$$

where the relative abundance of land cover types is denoted by *Pi* and the different types of land cover are denoted by *m* .

Landscape diversity expressed by the Shannon evenness index, by NUTS 2 regions, 2012
(index, range = 0–1)



Source: Eurostat, LUCAS 2012

Landscape diversity expressed by the Shannon evenness index, by NUTS 2 regions, 2012 (index, range = 0–1); with a value of zero representing a landscape with no diversity (only one land cover type) and a value of one representing the maximum diversity (in other words, all types of land cover in equal amounts)) - Source: Eurostat, LUCAS 2012

The highest landscape diversity was recorded in those EU Member States which featured mountainous or hilly areas: for example, Portugal, Slovenia, Austria and Luxembourg; each of these had a relatively high degree of variation in their land cover, with a Shannon evenness index of more than 0.75 in 2012. There then followed a group of Member States whose landscape diversity was close to the EU-27 average (for example, Germany, France or Poland). Another group of countries were rich in forests: these had relatively homogeneous landscapes and lower degrees of diversity (for example, Estonia or Finland). The final group of countries also recorded low levels of landscape diversity, their landscape was homogeneous (indices of less than 0.65) and one land cover type tended to predominate; often this was grassland, cropland or abandoned farmland (for example, Ireland, Hungary, Romania or the United Kingdom).

The Shannon evenness indices for NUTS 2 regions, as opposed to national averages, are shown in Map 1 covering 261 different regions across the EU-27 Member States. There were 12 regions where the Shannon evenness index was at least 0.80 in 2012 (as shown by the darkest shade shown in the map). They were spread across eight different EU Member States: the following section focuses on two of these — Portugal and Austria — providing an indication of the changing landscapes that may be encountered within particular regions.

The most diverse landscapes were in the Norte and Algarve regions of Portugal

The highest landscape diversity was recorded in the Norte region of Portugal. The inland areas of this region moving towards the Spanish border are characterised as relatively mountainous (for example, the Parque Nacional Peneda-Gerês and the Parque Natural do Douro) and are relatively dry, even arid in the summer months. These areas are often characterised as being scrubland or forested areas, and when used for agricultural purposes they tend to have permanent crops (such as vineyards). This northerly region of Portugal also has a lengthy Atlantic coastline where population density and economic activity tends to be much more concentrated; this area also has higher levels of rainfall and is characterised by a wider variety of farming practices.

The second highest Shannon evenness index was recorded for a region at the other end of mainland Portugal, namely, the Algarve. Some of the characteristics of this region were similar to those of the Norte, insofar as the Algarve is characterised by built-up (tourist) developments along its southern coast, where there are also some areas of agricultural activity benefitting from the sheltered climatic conditions, before the landscape transforms quite rapidly into a rural, sparsely populated and relatively hilly inland area (for example, the Serra do Caldeirão).

The Austrian regions of Burgenland and Oberösterreich also had diverse landscapes . . .

The next highest region in terms of landscape diversity was Burgenland, which is the easternmost and least populous region of Austria. It is a largely lowland region which in the north features plains that run towards Vienna and the Neusiedler See (Austria's largest lake), while the south of the region has more hills, a relatively high proportion of forested areas, and a lower level of population density. Agriculture — including permanent crops (vineyards and orchards), fruit and sunflowers — and tourism are important in Burgenland.

There was another region from Austria that featured among those regions with the highest diversity, namely, Oberösterreich (6th place in the ranking). It is located in northern Austria and borders onto Germany and the Czech Republic. This region is also characterised by a varied number of different landscapes: stretching from the Bohemian forest down to relatively flat meadowland and areas of intensive agriculture that are located around Linz — Austria's third largest city and an industrial centre — before climbing through forested foothills to the higher elevations of the Alps.

. . . as did eight other regions — these were located in southern Italy, northern Spain, France, Belgium, the Netherlands and Finland

The remaining eight regions where the Shannon evenness index was at least 0.80 included two regions from southern Italy (the island of Sicilia and the region of Abruzzo which is split between mountainous terrain and lowland coastal regions on the Adriatic Sea); two regions with varied landscapes in northern Spain (Galicia and La Rioja); as well as the largely lowland areas of Bretagne (France), the Prov. Oost-Vlaanderen (Belgium), Limburg (the Netherlands) and the island of Åland (Finland). These final four regions are not characterised by major changes in landscape, instead they have relatively monotonous stretches of flat land. Their high Shannon evenness indices may be attributed, at least in part, to more diverse land use, for example, relatively small patches of land which result in the land cover being fragmented or alternated.

Low levels of landscape diversity across many regions of the United Kingdom

At the other end of the range, there were 64 NUTS 2 regions where the Shannon evenness index was lower than 0.65 in 2012 (as shown by the lightest shade in Map 1). More than one third of these were in the United Kingdom (which may in part be explained by the relatively small size of some NUTS 2 regions in this Member State), while there were seven regions from Germany, five each from France and Hungary, and four each from Bulgaria, Poland and Romania; the remaining regions were divided between Slovakia (three regions), Ireland and the Netherlands (two regions each), Belgium, the Czech Republic, Italy and Austria (a single region each).

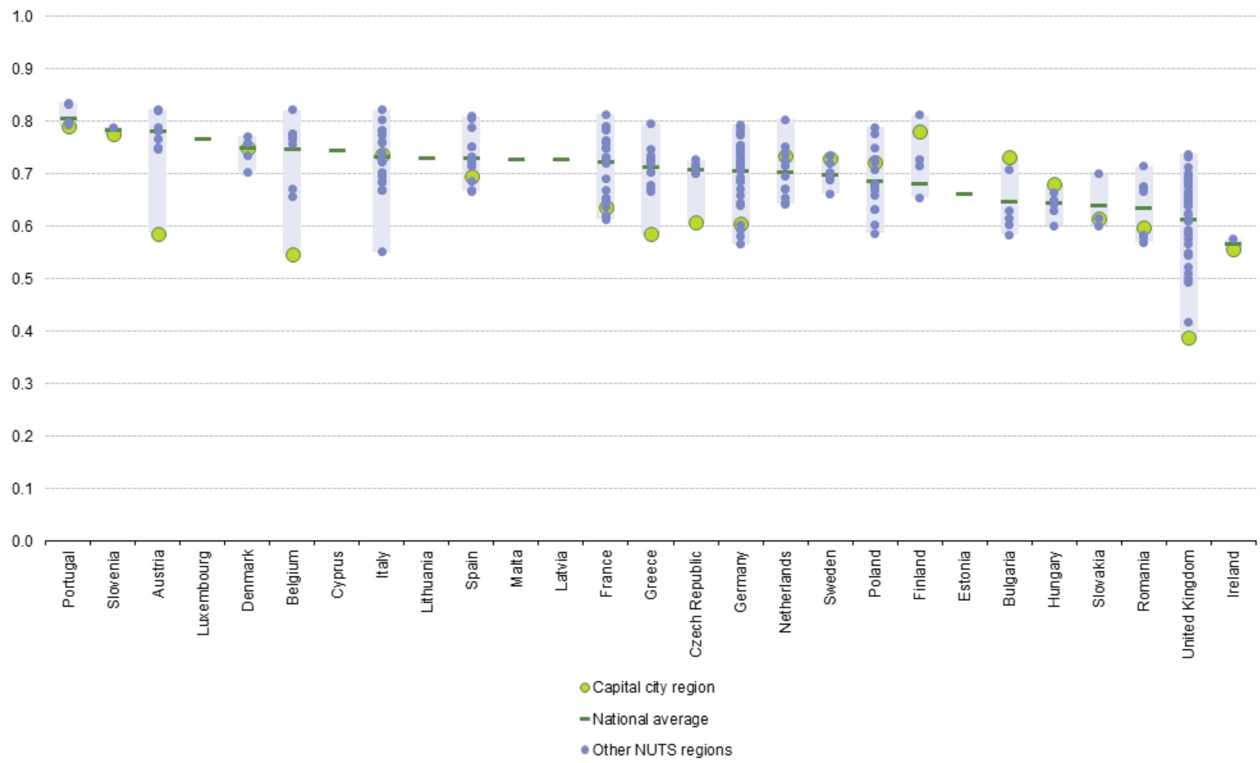
The relatively low level of landscape diversity across many regions of the United Kingdom may, at least in part, be linked to densely populated urbanised areas and a tendency to find large swathes of cropland (in the east) or grassland/scrubland areas (in the west and the north). A total of 23 out of the 37 regions in the United Kingdom recorded a Shannon evenness index that was below 0.65.

A high proportion of the Irish countryside is also composed of grassland and this may explain why both NUTS 2 regions in Ireland also registered indices that were below 0.65. Indeed, grassland accounted for 67.1 % of the total area of Ireland in 2012 and for 40.1 % of the total in the United Kingdom; these were the two highest shares across all of the EU Member States and considerably higher than the EU-27 average of 19.5 %.

Some regions in eastern Europe also recorded relatively uniform landscapes . . .

Five out of the seven Hungarian regions reported a Shannon evenness index of less than 0.65. These regions were often characterised by their relatively high proportion of cropland (for example, across the Great plain), as land used for crops accounted for 46.9 % of the total area of Hungary in 2012, almost twice as high as the EU-27 average of 24.7 %. In Bulgaria, four out of the six NUTS 2 regions recorded indices that were below 0.65: these regions could also be characterised as lowland plains and could be contrasted with the results for the south-western regions of Yugozapaden and Yuzhen tsentralen, where landscape diversity was above the EU-27 average and where the topography was much more varied.

. . . as did many capital regions and densely populated urban regions



(1) The light purple shaded bar shows the range of the highest to lowest region for each country. The dark green bar shows the national average. The green circle shows the capital city region. The dark purple circles show the other regions. Spanish autonomous cities, Canarias, French overseas departments, Croatia and the Portuguese autonomous islands: not available.
Source: Eurostat, LUCAS 2012

Landscape diversity expressed by the Shannon evenness index, by NUTS 2 regions, 2012 (1) (index, range = 0–1)

Figure 1: Landscape diversity expressed by the Shannon evenness index, by NUTS 2 regions, 2012 (1) (index, range = 0–1; with a value of zero representing a landscape with no diversity (only one land cover type) and a value of one representing the maximum diversity (in other words, all types of land cover in equal amounts)) - Source: Eurostat, LUCAS 2012

Perhaps unsurprisingly, there was a relatively low level of landscape diversity for many of the capital regions. This was most noticeable for Inner London, which recorded the lowest Shannon evenness index (0.39 in 2012) among any of the NUTS 2 regions for which data are available. The next lowest index was for the neighbouring region of Outer London, while six more regions from the United Kingdom — North Yorkshire, Northern Ireland, East Wales, West Midlands, East Yorkshire and Northern Lincolnshire, and Lancashire — recorded indices that were lower than for any other region in the EU-27.

Aside from London, the other capital regions which recorded landscape diversity of less than 0.65 included the Belgian capital region of Bruxelles-Capitale / Brussels Hoofdstedelijk Gewest (0.55), the Irish capital region of Southern and Eastern (0.57), Attiki in Greece (0.58), Wien in Austria (0.59), Bucureşti - Ilfov in Romania (0.60), Berlin in Germany (0.60), Praha in the Czech Republic (0.61), Bratislavský kraj in Slovakia (0.61) and the French capital region of Île de France (0.64).

Figure 1 provides an alternative analysis of these landscape diversity results by NUTS 2 region; it shows the variation between regions within the same EU Member State. The general pattern of relatively low levels of landscape diversity for capital regions is evident, although there were some contradictions to this rule. For example, the capital regions of Bulgaria, Hungary and Finland each recorded landscape diversity ratios that were higher than their respective national averages; indeed, the Shannon evenness indices for Yugozapaden and Közép-Magyarország were the highest recorded among any of the NUTS 2 regions in Bulgaria and Hungary.

There was a relatively large variation in landscape diversity between the different regions of Belgium, Germany, Greece, France, Italy, Austria, Poland and the United Kingdom. In the case of Belgium, Greece, Austria and the United Kingdom, this range was amplified due to the low level of landscape diversity recorded for the capital region.

The considerable differences in landscape diversity across Italian regions was, at least in part, due to a low level of diversity in Liguria — a densely populated, mountainous region in the north-west of the country that runs along the Mediterranean coastline from the French border to Tuscany and includes the city of Genova.

Source data for tables and graphs

- Land cover and land use, landscape (LUCAS)

Context

Most changes to landscapes are not visible on a day-to-day basis and the natural features that form landscapes (for example, valleys, plateaus and plains) are, by and large, the result of geographical processes that have taken place over a very long period of time. Alongside these natural processes, human intervention has increasingly left an imprint on environments where people live and work. Indeed, land has become a natural and economic resource that is used for multiple purposes: agriculture and forestry; mining, manufacturing and construction; distributive trades, transport and other services, as well as for residential and leisure use.

The onset of the industrial revolution led to a lengthy period during which forested areas across Europe were cleared (deforestation). Nevertheless, this pattern has been reversed during the last couple of decades, in part as a result of international climate change commitments made by the EU and its Member States — and as a result the EU is currently one of only a few regions in the world where forest cover is currently on the increase.

Historically, there has been a range of different developments that have impacted upon local ecosystems and biodiversity in the EU, including: a decline in agriculture's share of land use; an increase in soil erosion and soil degradation; an increase in (sub)urban sprawl arising from demographic and economic growth; and the continued development of infrastructure (such as new roads, railways and other manifestations of economic development). When combined, these developments have often resulted in increasingly fragmented habitats, potentially impacting upon biodiversity.

Statistics from LUCAS can be used to help analyse and contribute to the development of various EU policy areas, for example: to protect soil, as detailed in the soil thematic strategy to integrate environmental concerns into the Common Agricultural Policy (CAP) post-2013* ; to promote biodiversity and conservation, through the EU's biodiversity strategy ; to encourage the efficient use of resources for sustainable growth, as in the resource-efficient Europe initiative ; to tackle climate change, through monitoring conducted by the European Environment Agency , as well as actions under the European climate change programme ; or for land monitoring, spatial planning and resource management, as carried out by the Copernicus earth observation programme .

Notes

Explore further

Other articles

- Land cover statistics
- Land use statistics

Database

- Land cover and land use, landscape (LUCAS) , see:

Land cover overview by NUTS 2 regions (lan_lcv_ovw)

Land covered by artificial surfaces by NUTS 2 regions (lan_lcv_art)

Land covered by artificial surfaces - index (lan_lcv_arti)

Land use overview by NUTS 2 regions (lan_use_ovw)

Land cover for FAO Forest categories by NUTS 2 regions (lan_lcv_fao)

Thematic section

- Land cover/use statistics (LUCAS)

Publications

- New LUCAS 2022 sample and subsamples design — Criticalities and solutions — 2022 edition
- Redesign sample for Land Use/Cover Area frame Survey (LUCAS) 2018
- Diversified landscape structure in the EU Member States
- New insight into land cover and land use in Europe

Methodology

- Land cover and land use, landscape (LUCAS) (ESMS metadata file — lan_esms)

External links

- Directorate-General for Agriculture and Rural Development
- Directorate-General for Climate Action
- Directorate-General for the Environment
- European Environment Agency
- Joint Research Centre

Visualisation

- Visualisations/Statistics illustrated