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Authors: Alessandra PALMIERI, Paolo DOMINICI,
Marjo KASANKO, Laura MARTINO

Diversified landscape structure in the EU Member States

Landscape indicators from the LUCAS[1] 2009 survey

The heterogeneity of land cover and the presence of linear features such as walls, hedges, roads, railways or irrigation channels are two key elements characterising landscape structures.

Figures from selected landscape diversity indicators derived from the transect which is a 250 m straight line eastward in the LUCAS survey 2009, show clear distinctions among the various EU countries and how varied the European territory is in many respects.

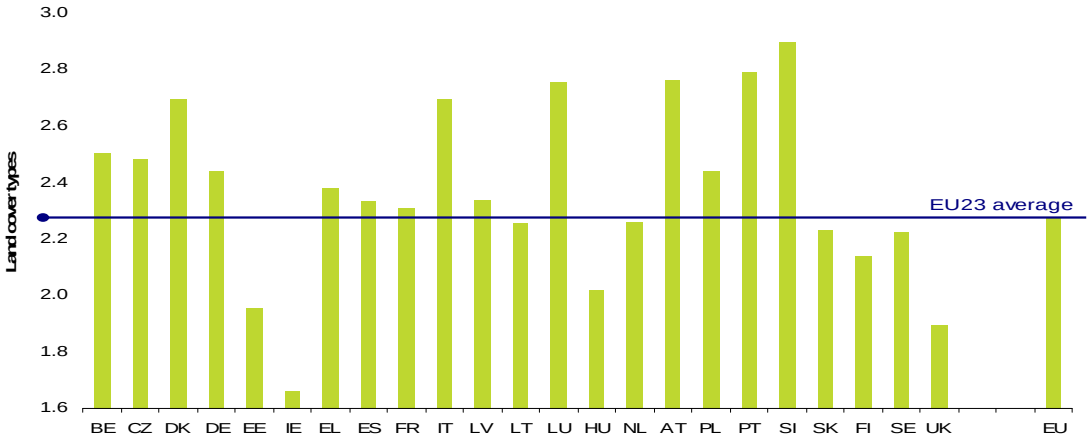
Four main typologies of countries with a different degree of land cover diversity and landscape patterns (combination of natural and human features) can be identified:

- **Countries with a high diversity generally characterized by the significant presence of mountainous or hilly areas (Slovenia, Portugal, Austria, Italy, Luxembourg);**
- **Largely homogeneous countries with a strong predominance of grassland (United Kingdom, Ireland);**
- **Some Baltic and northern countries (Finland and Estonia) rich in forests, quite homogeneous with a diversity score below the EU average;**
- **Countries with a diversity score within a range of 5 % from the EU average; among them Germany, Spain, France and Poland share the same kind of land cover composition[2].**

The presence of linear elements impacts the landscape in different ways according to the nature of the elements.

Results from a measure of correlation between the large presence of linear elements of dissection and structure and the presence of a large land cover diversity show that while "green" linear elements seem to be integrated in the land cover, dissection elements cause a fragmentation of the landscape.

Figure 1: Land cover richness indicator: average number of different land cover types in a 250 m transect, by country, 2009



Data derived from further analysis and computation of elementary data
EU23 average: BG, RO, CY and MT not included
Source: Eurostat (online data code : lan_lcs_ric)

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1 *LUCAS: Land Use and Cover Area frame Survey*

2 *Around 33 % cropland, 33 % woodland and 25 % grassland and shrubland as taken from Results of EU land cover and use published for the first time - Eurostat news release 145/2010 of 4 October 2010*

This insight into the structure of EU landscape in terms of diversity of types of land cover and presence of linear elements is based on the LUCAS Survey 2009 covering 23 EU Member States[3].

A very detailed set of information on landscape elements, unique in its kind, was collected for each of the 234 000 points observed directly or photo-interpreted in the field along a straight line of 250 metres eastward, called “transect”.

Various diversity indicators, from the simpler "richness diversity indicator" to the more sophisticated "Shannon Diversity and Evenness indexes", and separate analysis of linear elements of the landscape, namely structural and dissection linear features, are computed and shown.

Readers are advised to refer to the glossary and methodological notes at the end of the publication.

[3] *BG and RO were covered by the LUCAS survey in 2008 with different methodology for the transect; CY and MT were excluded formethodological reason*

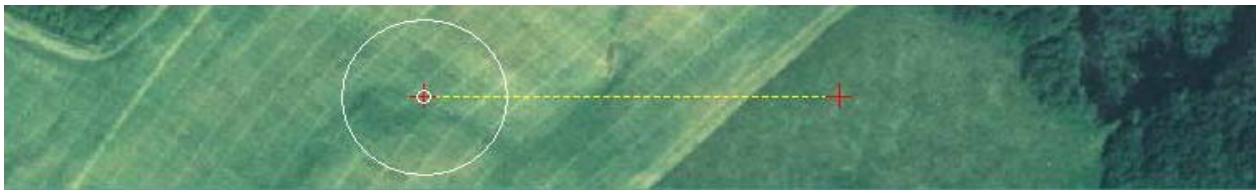
What is landscape and how could landscape structure be measured?

There is no official definition of landscape. Landscape has a transversal nature; it is based on the combination of natural features (relief, soil type, water availability, climate, biological diversity) and cultural features (human intervention through agriculture, forestry, rural policies, construction and economic pressures). Landscape structure refers to the spatial organisation or arrangement of the landscape elements. Composition of land cover and presence of linear features are elements shaping the landscape.

Landscape structure is too complex to be described by a single indicator. It is therefore necessary to interpret various indices jointly within a regional context. The structure of EU landscape is analysed taking into account the following elements: landscape diversity, importance of linear features and landscape degree of fragmentation.

The resulting indicators, i.e. richness (number of different types of land cover), diversity (relative abundance of different land cover types) and fragmentation (presence of structural and dissection elements) are derived by transect information from the 2009 LUCAS campaign. In the transect, land cover transition and the linear features are recorded in the sequence of their appearance. For a given point, a transect may look like the following example:

Figure 2: Example of transect information in LUCAS survey



Land cover features	*Durum wheat*	*Grassland with trees*	*Wood margin*	*Maize*	*Oak tree line*	*Maize*	*Road (>3 m)*	*Ditch*	*Mixed forest*
Codification in field form	*B12*	*E10*	*15*	*B16*	*11*	*B16*	*62*	*31*	*C30*

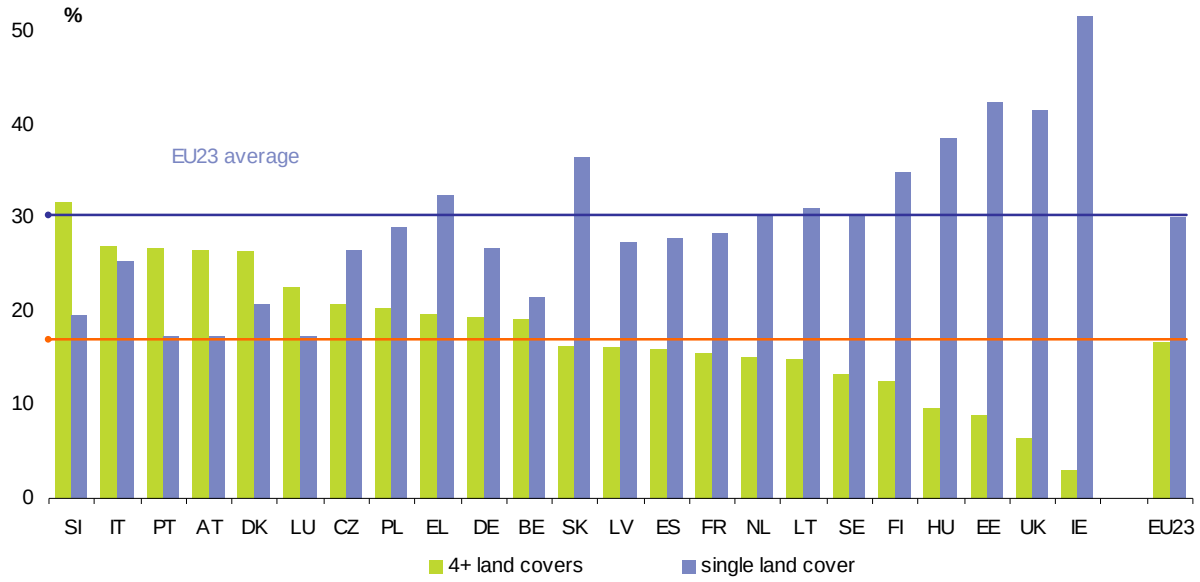
Land cover richness

A direct measure of the degree of homogeneity or heterogeneity in terms of the physical coverage of the land can be drawn by the number of different land cover types observed in each of the transects surveyed. This index of “richness” is portrayed in Figure 1 for the 23 EU countries covered by the LUCAS survey in 2009. A certain degree of complexity in the landscape structure can be observed as, on average, 2.3 different types of land cover are detected along the transect. The range of the average number of different types of land cover spans from more than 2.5 in Slovenia, Portugal, Austria, Luxembourg, Denmark and Italy, to less

than 2.0 in Ireland, the United Kingdom and Estonia.

About 30 % of the surveyed transects in the EU present a single type of land cover, while in 17 % of cases there are 4 or more different types of cover (Figure 3). A more detailed analysis shows that average values can result from quite different combinations of land cover patterns. Countries with high and low average numbers of landscape types are still the same as in Figure 1, but metrics and rankings differ. Shares of single types of land cover vary from less than 20 % to more than 50 %, while the transects with four or more types of land cover occur from 3 % to 31 %. In some countries, such as Greece or Slovakia, a relatively high share of transects with a single land cover type can be observed with a similarly high share of transects with four or more different types of cover. In other cases, such as Belgium, or Luxembourg, relatively low shares of single cover are observed with relatively low shares of highly varied land cover.

Figure 3: Transects with single land cover and with 4 or more land cover types, percentage shares, by country, 2009



Data derived from further analysis and computation of elementary data
EU23 average: BG, RO, CY and MT not included
Source: Eurostat (online data code : lan_lcv_ovw)

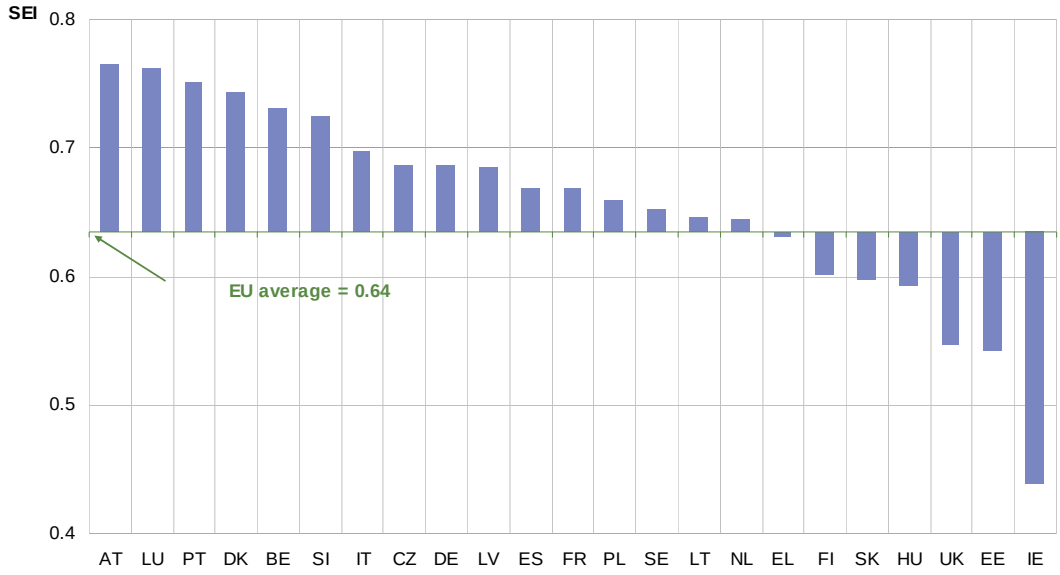
Measuring landscape diversity with the Shannon Index

The information on different types of land cover and their relative abundance (i.e. whether the same type of land cover recurs in a transect) can be summarised by means of two Shannon indices: the Shannon Diversity Index (SDI) and the Shannon Evenness Index (SEI). The latter, obtained by dividing the SDI by its maximum value, is easier to read, as it varies between 0 (no diversity, i.e. a single land cover type) and 1 (maximum observed diversity combined with complete evenness).

Territorial ranking at the country level according to this multi-level indicator confirms the information provided by the average number of different land cover types, although with some differences: for instance, Belgium enters the group of top 5 countries in terms of land cover diversity, while Slovenia falls from first to sixth position (Figure 4)

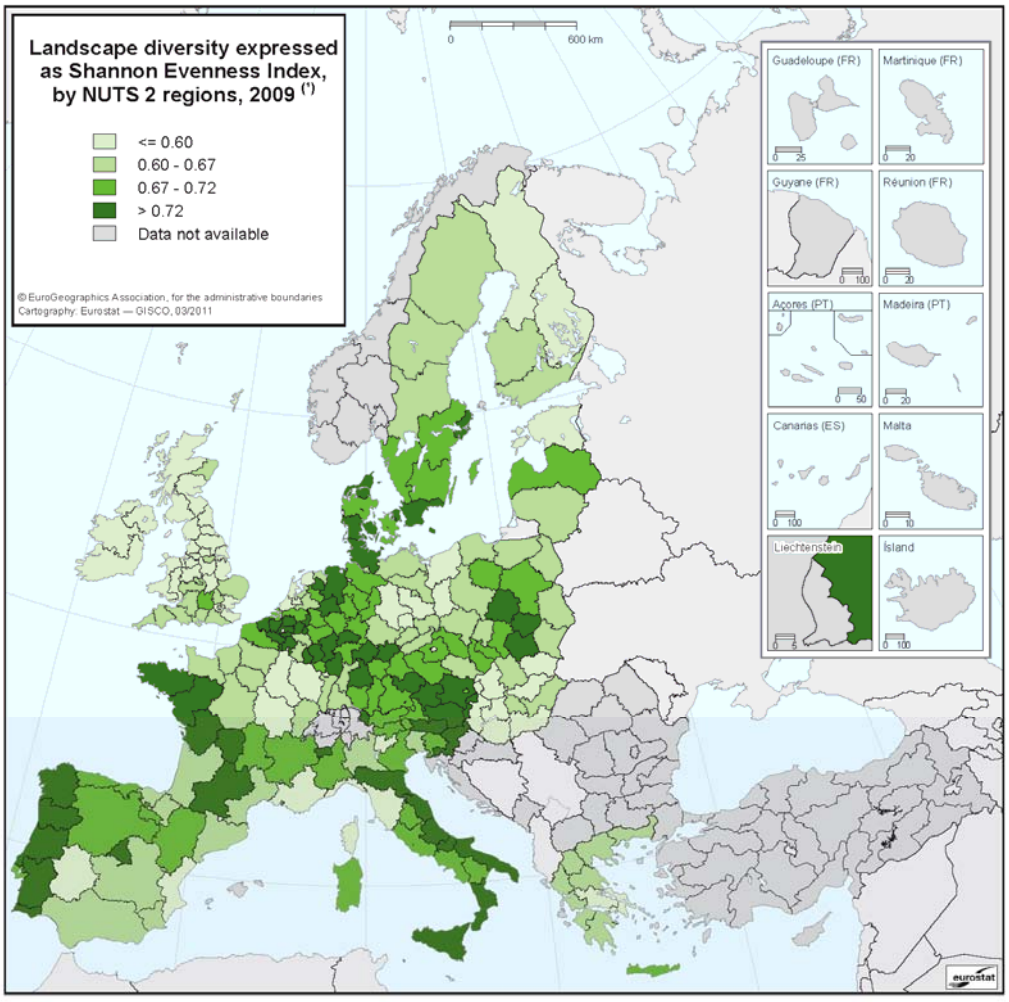
The SEI computed at the NUTS2 level shows that 4 out of 5 regions of Portugal rank amongst the top 25 %; the same occurs for 3 out of 5 Danish regions, 6 out of 9 Austrian regions and for 8 out of the 11 Belgian regions. At the lower (25 %) end of the distribution are both the Irish regions and 24 of the 37 regions of the United Kingdom, 6 of which are amongst the 10 EU regions with the lowest value of the SEI (Map 1).

Figure 4: Shannon Evenness Index, by country, 2009



Data derived from further analysis and computation of elementary data
EU average: BG, RO, CY and MT not included
Source: Eurostat (online data code : lan_lcs_sei)

Map 1: Landscape diversity expressed as Shannon Evenness Index, by NUTS 2 regions, 2009



(*) Bulgaria, Cyprus, Malta and Romania were not included in the LUCAS 2009 survey.
Source: Eurostat (online data code: lan_lcs_sei)

Source: Eurostat (online data code : lan_lcs_sei)

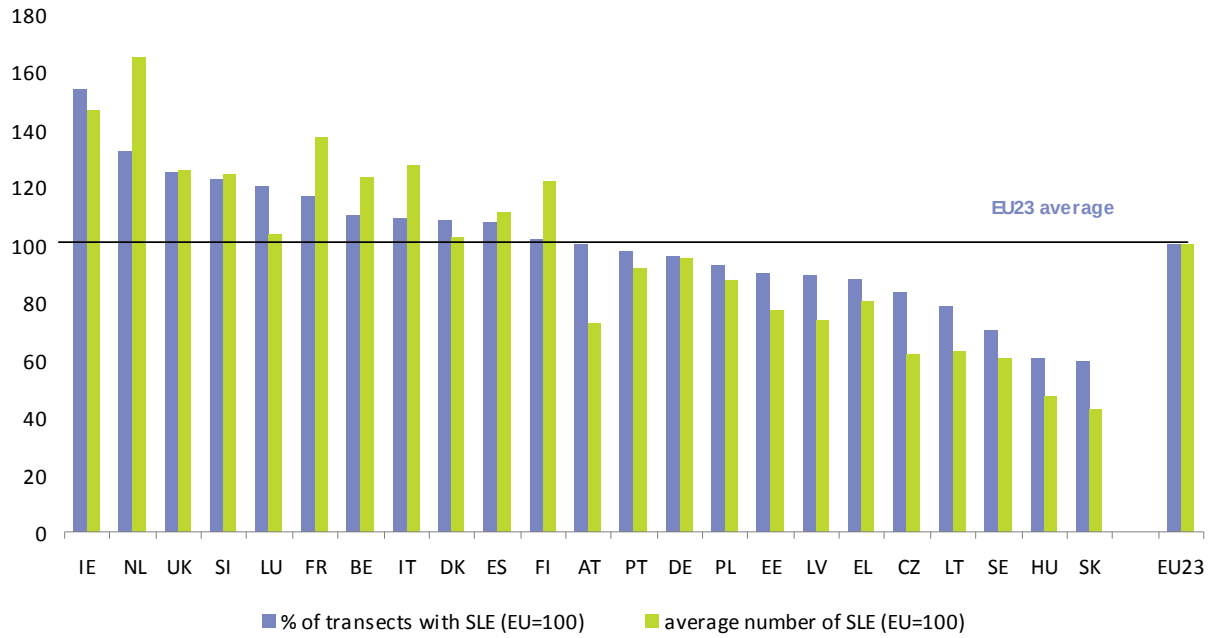
Green linear elements have little impact on landscape disruption

A complementary view on the structure of landscapes can be drawn from the analysis of linear (<3 m wide) elements cutting across the transect line. Amongst them, nature-based features or human artefacts which contribute to the structuring of the countryside – such as grass and tree margins, shrubs, tiny water courses and dry-stone walls – should be distinguished from pure dissection elements, such as fences, electric lines and transport infrastructure. Indeed, elements falling in each of these two categories have a diverse impact on the fragmentation of landscapes which might also affect bio-diversity, although in many cases they might serve the same purpose, or have the same result in terms of land cover (e.g. a dry-stone wall can serve to split land properties with different land cover, and the same could apply to a fence).

About 47 % of all EU (transect based surveyed) landscapes present one or more "structural" linear elements. The presence of these nature-based features across EU landscapes is by far highest in Ireland, where it is recorded in the 73 % of all surveyed transects, and lowest in Slovakia and Hungary (below 30 %). Structural linear elements portray the joint role of nature and mankind in shaping the countryside. Irish landscapes, which rank lowest in terms of all the measures of land cover diversity, rank the highest when it comes to their structuring by linear features, and a similar pattern can be observed to a lesser extent for the United Kingdom. Across the EU, landscapes can be observed which are less structured but have relative homogeneous land cover, such as Hungary, while other are clearly behind with respect to land cover diversity, such as the Czech Republic, Slovakia and Sweden.

The distribution of countries based on the percentage of transects with SLE is presented in Figure 5 (with respect to the EU rate), jointly with the average number of SLE in each transect (with respect to the EU average number). The combination of the two indices provides a measure of intensity of the linear element. In this double ranking (normalised to the EU levels, of 47 % of transects with an SLE, and 1.2 SLE per transect, respectively), high ranking countries with on average 1.5 to 2.0 SLE per transect include those where man-moulded structures of landscapes are well known, such as the Netherlands, France, Italy and Belgium, or have a very diverse set of natural elements, as in Finland, or a mix of the two, such as Ireland, the United Kingdom or Spain; conversely, landscapes in countries such as Austria, the Baltic and most eastern European countries are, on average, relatively less intensely structured.

Figure 5: Structural linear elements (SLE), by country, proportion of transects with at least one SLE and average number of SLE, EU-23 average= 100, 2009



Data derived from further analysis and computation of elementary data
EU23 average: BG, RO, CY and MT not included
Source: Eurostat (online data code : lan_lcs_str)

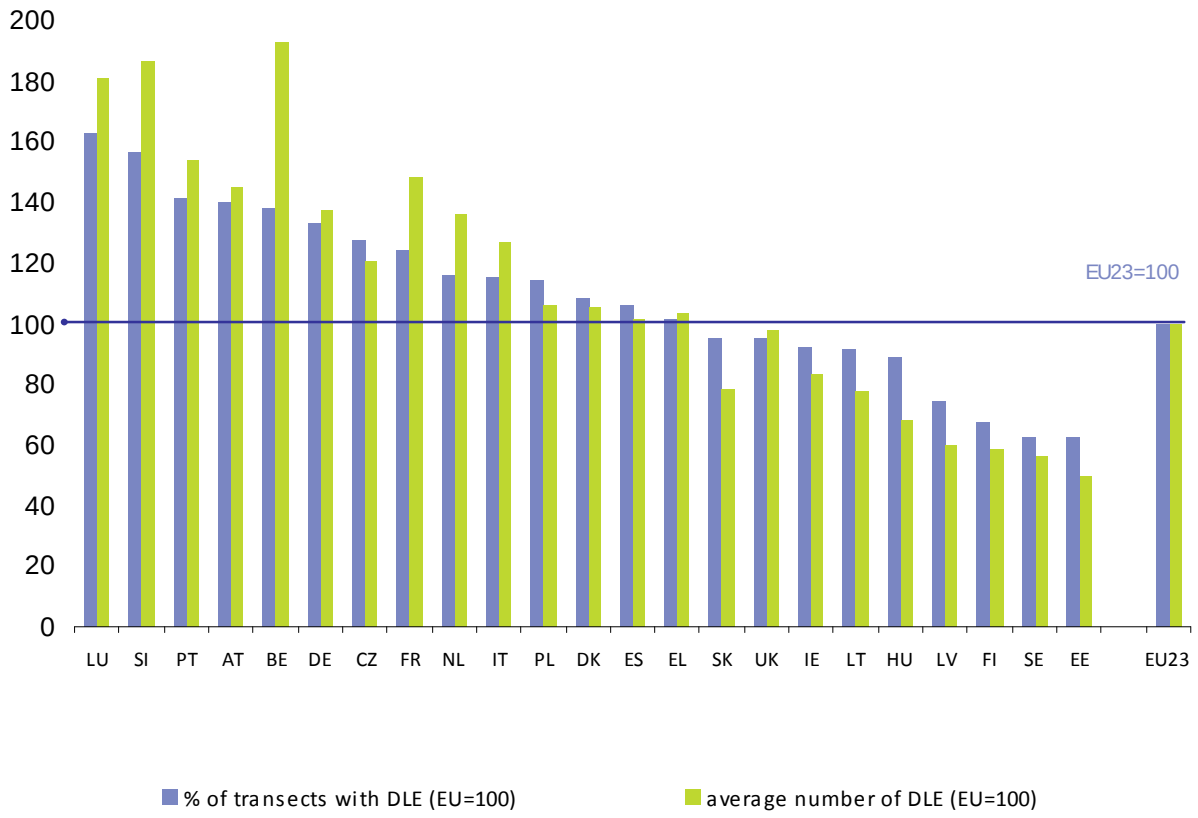
Dissection linear elements (DLE) cause fragmentation of the landscape

Across the EU, the percentage of transects with dissection elements spans from more than 70 % in Luxembourg, Slovenia, Portugal, Austria and Belgium, to less than 33 % in Estonia and Sweden compared to the EU average of around 53 %.

The combined information on presence and intensity of dissection elements is provided in Figure 6.

In this double ranking (normalised to the EU levels, of 53 % of transects with a DLE, and 1.1 DLE per transect, respectively), high ranking countries with on average 1.6 to 2.0 DLE per transect include those relatively high population density countries, such as Belgium, Slovenia, Luxembourg, Portugal and France; at the opposite end of the scale, landscapes with the lowest rates concern countries with low anthropical and infrastructure density in countries such as the Baltic States, Finland, Sweden and most eastern European countries.

Figure 6: Dissection linear elements (DLE), by country, proportion of transects with at least one DLE and average number of DLE, EU-23 average = 100, 2009



Data derived from further analysis and computation of elementary data
EU23: BG, RO, CY and MT not included
Source: Eurostat (online data code : lan_lcs_diss)

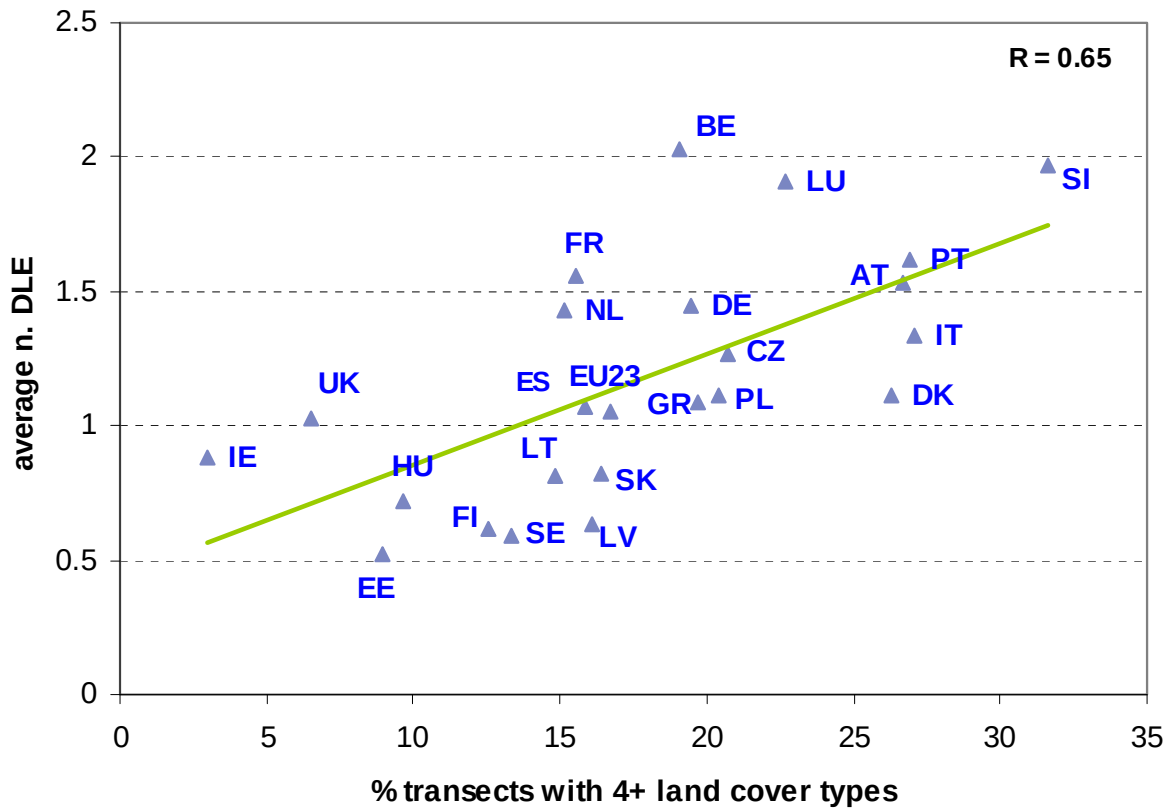
To better understand the different roles that the linear elements can have in the characterisation of the landscape, a measure of correlation has been computed to assess whether the large presence of linear elements of dissection and structure tends to be associated with a large land cover diversity. Figures 7 and 8 show the results of the analysis for the two groups of linear elements.

A positive correlation (R = 0.650288) can be observed between the average number of dissection elements (in the y axes) and the richness of the landscape measured as the number of different types of land cover recorded along a 250m transect (in the x axes).

On the other hand no correlation (R =-0.03488) appears between the average number of structural elements (in the y axes) and richness measured as before (figure 8).

While a high share of transects with at least 4 different types of land cover corresponds to countries with a higher number of dissection elements, the same does not occur with structural elements of the countryside. This result can be interpreted in terms of the different capability of the two classes of linear elements in characterizing the landscape. The "green" linear elements seem to preserve the continuity of the land cover being fully integrated in it (i.e. tree margins usually do not interrupt a natural area covered by grassland). On the other hand, dissection elements cause a fragmentation of the landscape; land cover is likely to change class after a dissection element (i.e. artificial area following a fence).

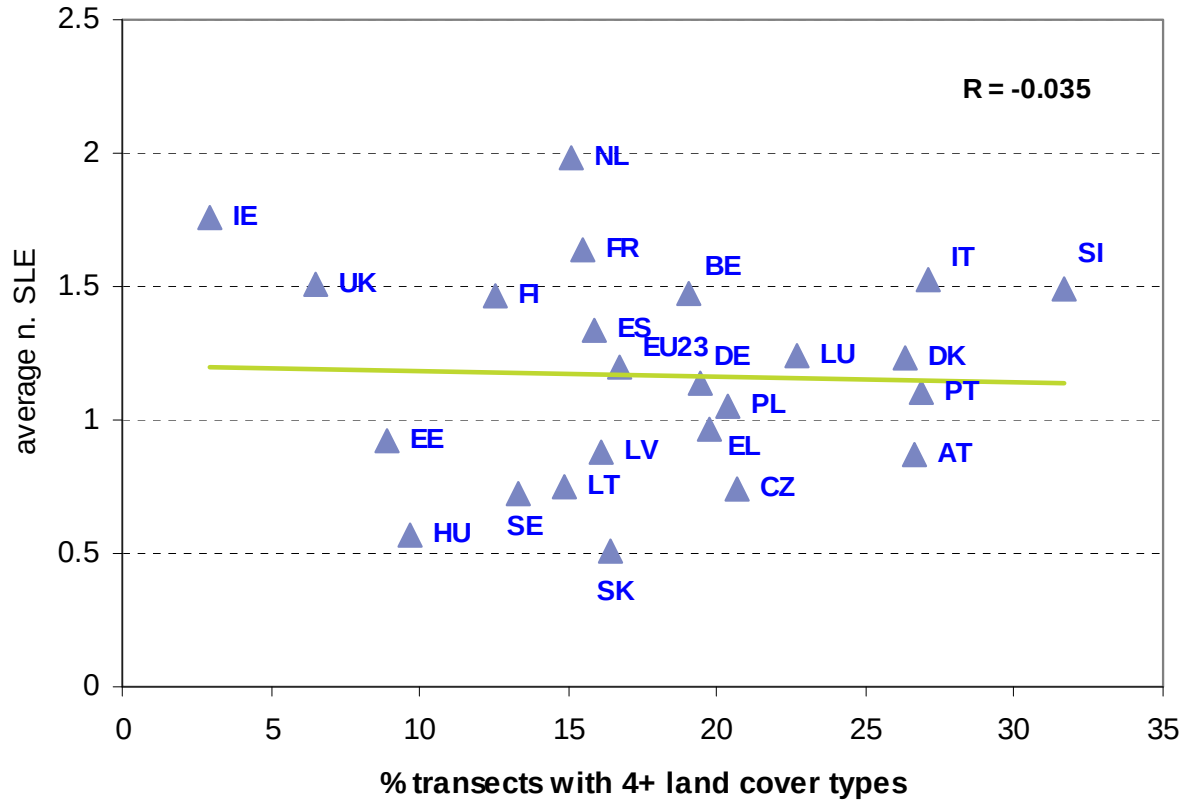
Figure 7: Countries by average number of dissection elements and richness, 2009



Data derived from further analysis and computation of elementary data

Source: Eurostat (online data codes : lan_lcs_ric, lan_lcs_diss)

Figure 8: Countries by average number of structural elements and richness, 2009



Data derived from further analysis and computation of elementary data

Source: Eurostat (online data codes : lan_lcs_str, lan_lcs_ric)

Conclusions

The EU is a huge diverse region with one of the most fragmented landscapes of all continents.

Infrastructure development has a direct influence on biodiversity. Dissection elements linked to transport and energy infrastructure cause landscape fragmentation and consequent biodiversity loss.

The proposed indices reflect various aspects regarding diversity and structure of the landscape along a transect. To evaluate the pressure on biodiversity loss, these indicators should be combined with land cover and land use change. They might be used as a starting point to measure and monitor changes in landscape composition and configuration at EU level in forthcoming LUCAS surveys.

METHODOLOGICAL NOTES

The LUCAS Survey 2009, a multipurpose platform for land cover and land use

Eurostat database: LAN

The **LUCAS (Land Use/Cover Statistical Area Frame Survey)** survey is a field survey based on an area-frame sampling scheme. Data on land cover and land use are collected and landscape photographs are taken, enabling detection of changes in land cover/use and in European landscapes. Moreover the transect, a 250 meters walk along which linear elements and land cover changes are recorded, offers comparable indicators on the fragmentation, richness and dominance of the landscape.

The surveyors walking the transect are requested to register all the land cover changes they can observe according to a list of codes including both areal land cover classes and linear elements (Table 1). The results are then aggregated in such a way that different environments (agricultural areas, forestry areas, grassland, etc.) have approximately the same number of items. This procedure was adopted to avoid a bias in terms of heterogeneity being introduced in the results. For a detailed land cover transect classification, see Table 2.

Eurostat carried out the largest ever LUCAS campaign in 2009, covering 23 countries (EU countries less Bulgaria, Cyprus, Malta and Romania). It collected data on the ground on land cover, land use and landscape diversity on approximately 234,000 points[4]. Those points were selected from a standard 2 km grid with in total 1 million points all over the EU. The land cover and the visible land use data were classified according to the harmonized LUCAS land cover and land use nomenclatures. The resulting dataset is unique as it is fully harmonised and comparable with the same definitions and methodology among Member States.

These data are published for the first time by Eurostat, the statistical office of the European Union.

[4] *BG and RO were covered by the LUCAS survey in 2008 with different methodology for the transect; CY and MT were excluded for methodological reason*

Table 1: List of transect linear elements, LUCAS 2009

Code	Label
1	Grass margins<3 m
2	Heath/Shrub, tall herb fringes<3 m
10	Single tree, single bushes
11	Avenue trees
12	Conifer hedges<3 m
13	Bush/tree hedges/coppices, visibly managed (e.g. pollarded) <3 m
14	Bush/tree hedges, not managed, with single trees, or shrubland deriving from abandonment<3 m
15	Grove/Woodland margins (if no hedgerow) <3 m
21	Dry stone walls
22	Artificial constructions (other than dry stone walls)
23	Fences
24	Electric lines
31	Ditches, channels<3 m
32	Rivers, streams<3 m
41	Ponds, wetland<3 m
51	Rocks outcrops with some natural vegetation
61	Tracks
62	Roads
63	Railways
71	Other linear elements

Source: Eurostat
All elements above are to be coded irrespective their width except for 01, 02, 12, 13, 14, 15, 31, 32, 41 (less than 3 m).

Table 2: Land cover transect classification, LUCAS 2009

Code	Label
AAA	Artificial land
BS0	Straw cereals
B16	Maize
B17	Rice
B20	Root crops
B31	Sunflower
B32	Rape and turnip seeds
B33	Soya
B34	Cotton
B36	Tobacco
BC0	Other ind crops
B40	Dry pulses, vegetables and flowers
B50	Fodder crops
B70	Fruit trees and berries
B81	Olive groves
B82	Vineyards
BP0	Other permanent crops
C10	Broadleaved and evergreen woodland
C20	Coniferous woodland
C30	Mixed woodland
D10	Shrubland with sparse tree cover
D20	Shrubland without tree cover
E10	Grassland with sparse tree/shrub cover
E20	Grassland without tree/shrub cover
E30	Spontaneous vegetation
F00	Bare land
G10	Inland water bodies
G20	Inland running water
G30	Coastal water bodies
G50	Glaciers, permanent snow
H10	Inland wetlands
H20	Coastal wetlands

Source: Eurostat

GLOSSARY

Correlation coefficient: a correlation coefficient is a number ranging between -1 and 1 which measures the degree to which two variables are linearly related. If there is perfect linear relationship with positive slope between the two variables, we have a correlation coefficient of 1; if there is positive correlation, whenever one variable has a high (low) value, so does the other. If there is a perfect linear relationship with negative slope between the two variables, we have a correlation coefficient of -1; if there is negative correlation, whenever one variable has a high (low) value, the other has a low (high) value. A correlation coefficient of 0 means that there is no linear relationship between the variables.

Dissection Linear Elements (DLE) dissection of landscape caused by transport infrastructure, artificial constructions (other than dry-stone walls), fences and electric lines.

Diversity indexes: a diversity index is a mathematical measure of land cover diversity in a selected area.

EU-23 average: EU aggregates are computed as the population weighted averages of national indicators.

Land cover: land cover corresponds to the physical coverage of the earth's surface.

Land use: refers to the socio-economic purpose of the land.

Landscapes: Landscapes are spatially defined units, whose character and functions are defined by the complex and region-specific interaction of natural process with human activities that are driven by economic, social and environmental forces and values.

Linear feature: they consist in linear elements of the landscape such as walls, hedges, roads, railways or irrigation channels, etc. intersecting the transect; these features are taken into account if their width is larger than 1 meter (exceptions are walls, ditches, electric lines and fences) and at least 20 m long.

Richness diversity indicator: it is computed as the number of different land cover codes in each transect.

Shannon Diversity Index: the Shannon Diversity index (SDI) provides more information about area composition than simply area richness (i.e., the number of types of land cover present). It takes into consideration both the number of different land cover types (m) observed on the point and their relative abundances (P_i).

$$SDI = -\sum_{i}^{m}\left(P_i * \ln\left(P_i\right)\right)$$

Shannon Evenness Index: The Shannon Evenness index is obtained dividing the Shannon Diversity Index by its maximum $\left(\left(SDI_{MAX}\right)\right) = \ln(m)$. Therefore it varies between 0 and 1 and is easier to interpret.

$$SEI = -\sum_{i}^{m}\left(P_i * \ln\left(P_i\right)\right) / \ln\left(m\right)$$

Structure Linear Elements (SLE): linear features which structure the countryside: grass and tree margins, shrub, water courses and dry-stone wall.

Symbols and acronyms for country codes: For the purpose of this publication the European Union is abbreviated to EU-23 (23 countries participated in the survey) and includes Belgium (BE), the Czech Republic (CZ), Denmark (DK), Germany (DE), Estonia (EE), Ireland (IE), Greece (EL), Spain (ES), France (FR), Italy (IT), Latvia (LV), Lithuania (LT), Luxembourg (LU), Hungary (HU), the Netherlands (NL), Austria (AT), Poland (PL), Portugal (PT), Slovenia (SI), Slovakia (SK), Finland (FI), Sweden (SE) and the United Kingdom (UK).

Transect: a transect is a 250 m straight line in an easterly direction from a specific point. The data collected along the transect refers to land cover and the occurrence of linear features in the order that the features are encountered.

All graphs and figures mentioned in the text are derived from further analysis and computation of elementary data (not in Eurobase); elementary data can be downloaded from the dedicated section of the LUCAS web site.

Further information

Eurostat Website: http://ec.europa.eu/eurostat

Data on LUCAS
http://epp.eurostat.ec.europa.eu/portal/page/portal/lucas/data/database

Further information about LUCAS:
http://epp.eurostat.ec.europa.eu/portal/page/portal/lucas/introduction

LUCAS — a multi-purpose land use survey

Reference Publications:

Lucas- a multi-purpose land use survey (Statistics Explained)

Results of EU land cover and use published for the first time - Eurostat news release 145/2010 of 4 October 2010

New insight into land cover and land use in Europe - Martino L., Fritz M. (2008) Eurostat SIF 33/2008

'Use of auxiliary information in the sampling strategy of a European area frame agro-environmental survey' - Martino L., Palmieri A. & Gallego J. (2009): in: *Proceedings of the First Italian Conference on Survey Methodology (ITACOSM09).* Specialized Session 5: Agricultural Surveys in European countries, 10-12 June 2009, Siena, Italy.

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