Statistics in focus

AGRICULTURE AND FISHERIES

THEME 5 – 4/2002

Contents

Changes in land cover and land use
1. Methods and tools

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Changes in land cover and land use are key elements in the evaluation of agricultural and environmental policies. They may be charted at two different levels (Figure 1). The first involves measuring the quantitative result in surface changes, whilst the second is based on time series (follow-up of identified elements). This allows changes to be qualified and spatial organisation to be analysed. A large number of tools are available for observing surface changes. Though many studies of changes have been carried out, not all tools provide detailed results at national level. Statistical representativeness allows land to be classified as Community, regional or local. The level of detail thus affects the interpretation, which is particularly important for rural development, the second pillar of the CAP.

General landscape indicators

Classes of land cover[1] and land use[2] allow a link to be established between human activity, its physical manifestation in space, and the environment. Changes in land cover/land use also include a temporal dimension.

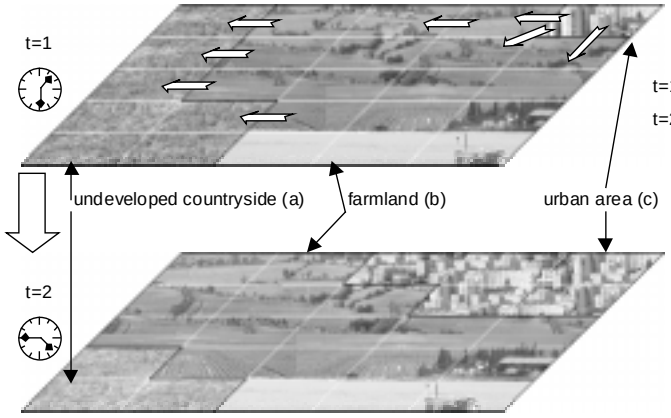

Figure 1: changes in land cover/land use

By charting changes in land cover and land use, we can take account of the environment - and landscape in particular - when framing policies at European level. Farming, which accounts for more than half of the land in Europe, is a key factor of change here. It prompts change, undergoes change and, more generally, contributes to change.

[1] *Land cover: biophysical cover of the earth's surface.*

[2] *Land use: the socio-economic use of land.*

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In the latest Communication from the Commission to the Council and the Parliament on agri-environmental indicators (COM/2001/144), two of the 38 chosen indicators relate to changes in land cover/land use (land cover change, matrices of land use changes). These form the basis for the compilation of other indicators (agricultural and global diversity, habitat, biodiversity, etc.).

Modification in land cover and land use

Modification in land cover/land use can be studied on various levels depending on the information available (**Box 2** opposite page).

Surface measurement is the first level, and provides a quantitative description of the evolution in land cover and land use. The territorial distribution of different types of land cover/land use varies over time, and these variations are analysed. The only prerequisite here is reproducibility in the collection of information (same methodology, same classification).

In terms of the observation of identified objects (second level), the data used are geo-coded or geo-referenced. This allows data from different dates to be compared (**changes**), from different sources and for different areas. Land cover or land use at different dates is compared using tables or matrices (**Box 1**). This provides a quantitative, but mostly qualitative record of on-going processes (afforestation, reinstatement, abandonment, etc.).

By inputting data into a Geographic Information System (GIS) and crossing them with information on other topics, we open up a number of possibilities (analysis of changes in land use according to topography or bio-geographic zone, etc.). However, this must be done at a level on which data are statistically significant.

These referenced data also allow spatial organisation to be analysed and different types of landscape or dynamic phenomena to be described. Spatial ►

Box 1: spatial configuration indicators

Spatial configuration is the term used to describe the pattern formed by different types of surface (in this case land use) within a given area. The indicators describe spatial configuration in relation to two extremes:

Simple configuration: **few patches, simple contours**, maximum surface area for each patch, length of contour minimal in relation to area, few classes represented;

Complex configuration: **numerous patches, irregular contours**, minimum surface area for each patch, maximum length of contour relative to area, numerous classes represented.

Since the number of classes represented depends on the classification used, indicators based on this number are compatible only if the classifications are so.

In all cases, the measured complexness, being called diversity, fragmentation, heterogeneity, etc. is relative to the observation tool (classification, spatial definition, temporal definition, etc.).

As part of a joint project between DG Agriculture, the Joint Research Centre and the European Environment Agency, Eurostat has employed a number of such indicators at Community level **[2]**.

organisation indicators are highly sensitive to changes in land use/land cover. Work on this subject differs according to the method used to collect data:

- texture indicators can be used for exhaustive coverages (images "raster"),
- similar methods can be applied for area or sampling surveys using point grids as images (co-occurrence matrix) **[1]**,
- morphological analysis (including the numbering and geometric measurements) is usable for vector coverages.

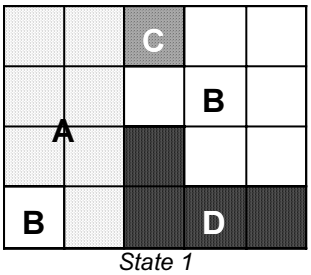
The work carried out has shown that these indicators are also sensitive to the observation tool used **[3]**.

Box 2: levels of description for changes in land cover/land use

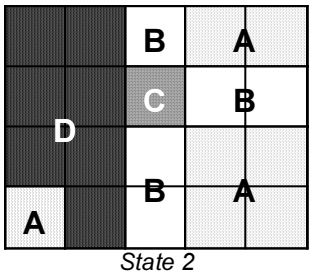
The following example illustrates the various levels at which changes to land cover/land use are analysed.

If we carry out an analysis on the basis of surface area alone, we will merely be investigating the balance of change. Thus, A and C remain stable, B decreases by three units and D (increases?) by three units (**Table 1**).

By analysing a set of identified objects in different states (in this case squares of land), we can obtain a good deal more information. The areas of categories A and C remain unchanged, since appearances offset disappearances. The diagonal of the changes matrix (shaded) shows the invariants. Only two B units are invariant. The only way of carrying out this type of analysis (**Table 2**) is by observing **objects that are stable in time** (time series).▼



State 1



State 2

	State		Trend	Change	
Land cover	1	2	Balance	Appea-rances	Disappea-rances
A	7	7	0	+7	-7
B	8	5	-3	+3	-6
C	1	1	0	+1	-1
D	4	7	+3	+7	-4

Table 1: changes in different classes of land cover/land use

Etat 1▶ ▼Etat 2	A	B	C	D	
A	**0**	5	0	2	7
B	0	**2**	1	2	5
C	0	1	**0**	0	1
D	7	0	0	**0**	7
	7	8	1	4	20

Table 2: Matrices of changes in land cover/land use

Spatial configuration may also be analysed at this level. Thus, the seven A units form a more compact area in state 1 than in state 2. Numerous indicators can be used to describe spatial configuration - heterogeneity, fragmentation, diversity, etc. These can only be constructed by identifying the **relative positions** of the points or zones (spatial information).

They are used as landscape descriptors or as indicators of dynamic phenomena.

The geo-referencing of survey points or zones provides an exact description of location on the earth's surface. This stable and spatialised definition of the observed points allows the above-mentioned indicators to be constructed.

The usefulness of this detailed approach lies in the efficacy of the study. For example, when agricultural land falls victim to development, farming generally moves on to undeveloped countryside in a bid to maintain stability in terms of area. Built-up areas increase and areas of undeveloped countryside decrease, but this information is not sufficient for an analysis of the changes that have occurred (**Figure 1, page 1**).

A varied approach to change

All Member States have surface data. These are stored in general or specific databases (agricultural, forestry, etc.) on land cover/land use. They are also centralised at European level (New Cronos, Regio, etc.), although the way data are obtained may vary from one Member State to another, as may classifications.

Changes can be analysed in a number of ways, and various types of work are under way at national level. In most cases, work on changes in land cover and land use forms part of larger programmes (harvest forecasts, state of the environment, landscape changes, etc.). Some of these national programmes are still being set up (Germany, Norway, Sweden) - in which case, the countries concerned will not have at least two sets of data on land cover/land use and will not yet have produced analyses of indicators of change (**Table 4**).

Name of project	LUCAS	CORINE Land Cover	LACOAST
Sampling	100 000 points spread evenly across Europe	exhaustive coverage of the territory	exhaustive coverage of a 10 km-wide strip along the coast of Europe
Classification	land cover: 57 classes on two levels land use: 14 classes on two levels	44 land cover classes on three levels	compatible with CLC
Period covered	first survey in 2001, then every two years	1986-1995 for CLC, 2000-2003 for CLC 2000	1975-1979 then CLC
Area covered	EU-15[a]	EU-15[b]	Countries with coastlines except Finland, Sweden and the United Kingdom

[a] Ireland and the United Kingdom were not covered during 2001 because of the foot-and-mouth epidemic.

[b] The first CLC covered the European Union except the United Kingdom, Sweden and Finland, plus the CEECs. The United Kingdom then produced a map that was compatible with the CLC. CLC 2000 will be produced for EU-15 as a whole and, no doubt, for the CEECs.

Table 3: Community projects designed to evaluate changes in land cover/land use

Box 3: MARS, agricultural land cover and remote sensing

Land cover, and changes in this, are also monitored on a short-term basis as part of the harvest forecasting mechanisms. The Monitoring of Agriculture by Remote Sensing (MARS) provides (i) forecasts of yields, based principally on agro-meteorological data and (ii) estimates of the areas under the principal types of crop. From March to October, harvest forecasts are drawn up at Community level (MARS STAT).

Similar work is done for sensitive regions around the world in order to forecast the risks of famine (MARS FOOD).

Finally, land cover is recorded in GISs for monitoring and control as part of the CAP. Remote sensing helps with short-term updates, or provides additional information by identifying parcels of agricultural land (MARS PAC).

Country	Project name	Sampling method	Period covered	Periodicity	Area covered	Indicators (if already calculated))
France	TERUTI	two-level random sampling (550 000 points)	since 1970	1 year	France	- predominant cover - spatial organisation (co-occurence matrices) - diachronic trends
Norway	Monitoring Norwegian Agricultural Landscape: Programme 3Q	1 450 squares of 1 km² distributed evenly across the territory	first survey in 1998	5 years	agricultural area in Norway	
United Kingdom	Countryside Survey 2000 (CS2000)	569 squares of 1 km² representative of the natural conditions in Great Britain (by land class)	1978 1984 1990 1998	6-8 years	Great Britain	- matrices of changes in land cover/land use - changes in linear components, field boundaries, etc.
United Kingdom	Northern Ireland Countryside Survey (NICS)	628 squares of 0.25 km² representative of the natural conditions in Northern Ireland	1986-1991 1998		Northern Ireland	- matrices of land cover changes (geared to vegetation)
United Kingdom	Land Cover Map 2000	exhaustive	1990-1992 1998		United Kingdom	
United Kingdom	National Countryside Monitoring Scheme (NCMS)	random stratified (bio-geographic)	1947 1973 1988		Scotland	- matrices of changes in land cover
Slovenia	Land Cover/Land Use GIS	exhaustive	1993 1997 2000	3 years	Slovenia	
Sweden	LiM project	3 levels: - national territory, - 20 reference zones (parish) - smaller areas	1991-1996 2001	5 years from 2002-2003	Sweden	
Switzerland	"The countryside under pressure. The transformation of the Swiss countryside"	256 rectangles of 12 km² based on administrative and bio-physical criteria	1972-1977 1978-1993 1984-1989	6 years	Switzerland	- matrices of changes in land cover/land use - changes in small structures, linear components, etc.
Switzerland	land use statistics	4.1 million evenly distributed points	1979-1985 1992-1997		Switzerland	- matrices of changes in land cover/land use (relative to altitude, gradient, etc.)

Source: Inventory of information systems on Europe's countryside – Eurostat 2000 **[4]**

Table 4: Examples of information systems used to produce second-level indicators on changes in land cover/land use

At European level (**Table 3**), the prime objective of the MARS project (**Box 3**) is not to provide information on changes in land cover/land use, though it does make this possible. As from 2003, the LUCAS survey will make it possible to obtain data of this type for the European Union as a whole (**Box 4**). The update of CORINE Land Cover (CLC 2000) should also ensure that this type of information has greater spatial and thematic definition (more accurate and based on a more detailed classification). The analysis of localised phenomena must still be possible (**Box 5**). CORINE Land Cover has already been used to carry out an exhaustive study of changes in land cover for European coastal areas (**Box 6**).

Box 4: LUCAS, statistically representative survey points

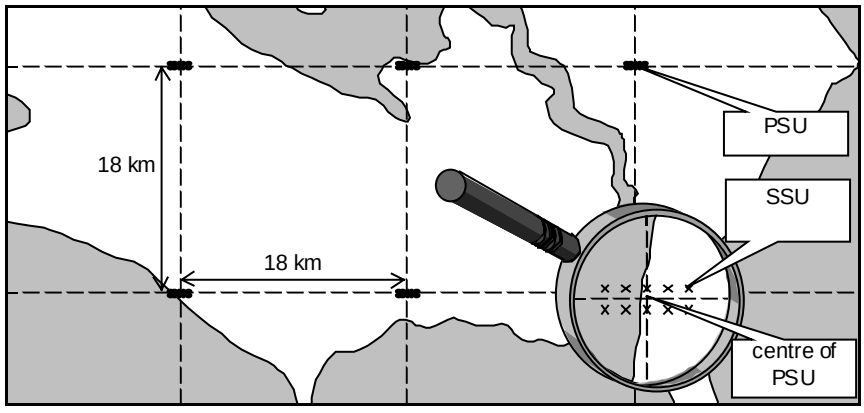
The LUCAS survey (Land Use/Land cover Area frame Statistical survey) was introduced in 2001 at European Union level. Its main objectives are:

- to produce harmonised data at European level on land use/land cover and changes in these;
- to cover the conventional aspects of an agricultural survey as well as areas such as the environment, multifunctionality and landscape;
- to provide a common sampling base (framework, classification, data processing) that Member States can use to obtain representative data at national/regional level by increasing sampling density.

The survey is divided into two phases:

- in the spring, data on land cover/land use and environmental data are collected *in situ* for around 100 000 points (10 000 2x5-point grids) spread systematically over the territory as a whole (two-level area sampling). From a point of each segment, four views are photographied.
- in the autumn, 5 000 visits are made to holdings based on parcels of arable land. Farmers are approached and asked to provide additional details on the parcel in question (management, yield, etc.) and on their holding.

The LUCAS is currently being carried out. The data collected in 2001 will be analysed and evaluated in 2002. A second field survey is scheduled for 2003, and on a regular basis thereafter.



PSU: primary survey unit – SSU: secondary survey unit

Figure 2: Example of two-level area sampling (LUCAS)

NB: In an **area** survey, surfaces are estimated using a point sample.

In **two-level** area sampling, the first-level sample is a set of segments (or grids). Each of these is sampled at the second level using points (**Figure 2**).

Box 5: CLC 2000, the CORINE Land Cover update

The objective of Corine Land Cover (CLC) 2000 is to update the first version of CLC, most of whose data come from satellite images taken between 1986 and 1995.

CLC 2000 retains the main methods and features of CLC (interpretation of satellite images at national level, 44 classes on three levels, scale 1:100 000, mapping unit of 25 ha minimum, etc.).

There are also plans to identify the changes between the two databases. This will be done by comparing images from the previous version of CLC using retropolation (*a posteriori* error correction). The soil map will serve as a common reference for the two coverages. This method was developed jointly by the Ispra Joint Research Centre and the European Topic Centre for Land Cover. It has already been successfully used in the LACOAST project and assessed by various national teams.

The whole European territory, including the Central and Eastern European Countries (CEEC), should be covered in 2003.

Box 6: LACOAST, environmental GIS

LACOAST (*LAnd cover changes in COASTal zones*) is designed to chart land cover changes in coastal areas of Europe, and covers the period 1975 to 1990. The project covers the coastal areas of all EU-15 countries except the United Kingdom, Finland and Sweden.

Landsat MSS images from 1975 to 1979 plus some aerial photographs were processed to make them compatible with the CLC database (geometric corrections, re-sampling, etc.).

The result is a geo-referenced database on coastal areas for 1975-1979 that is compatible with CLC, a working method for evaluating changes in land cover (authenticated changes rather than changes detected by photo-interpretation alone), statistics on changes in land cover and their spatial representation.

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