# Combined Method for Thematic Update of the Land Use Inventory by Remote Sensing/GIS technology, Support for the Implementation of the European Agriculture and Environment Programs

*Adina-Ana MAMULEA, PhD. Stud., Romanian Centre for Remote Sensing Apply in Agriculture, Romania, adina.mamulea@rosa.ro*
*Iulia Florentina DANA, PhD. stud. eng., Romanian Space Agency, Romania, iulia.dana@rosa.ro*

***Abstract:*** *The diversity of the inventory/monitoring methods of land use/land cover has determined the European Environment Agency to promote development activities for the analysis and creation of data, Corine Land Cover (CLC) being designed to achieve this goal. Today, it is necessary to elaborate a new approach for land use/land cover, using GMES Core Service Land Cover. Based upon the 2000 and 2003 coverage of Landsat satellite images, two datasets were created following the Food and Agriculture Organisation - Land Cover Classification System (FAO-LCCS) concepts. The outcome of these projects consisted of a set of methods for data processing and validation. By adding the third coverage (2007) to the series, the testing of numeric methods for studying the landscape dynamics and the self-acting classification processing limits will be possible.*

***Keywords:*** *methods, land use/land cover, GMES Core Service Land Cover, data processing.*

## 1. Introduction

Land cover is the observed physical cover, as seen from the ground or through remote sensing, including natural or planted vegetation and human constructions which cover the Earth's surface.

Land use is based upon function, the purpose for which the land is being used. A land use is defined as a series of activities undertaken to produce one or more goods or services. Land use provides a basis for precise and quantitative economic and environmental impact analysis [1].

In Romania, two datasets were built based upon these different concepts: CLC and FAO-LCCS. The FAO-LCCS project consists of two dataset created upon the coverage of Landsat TM satellite images corresponding to the years of 2000 and 2003. The project allowed the study of the agricultural and forest dynamics in a manner complementary to CLC. The compulsoriness of the CLC update for all EU state members and also the conclusions of the dual CLC/LCCS 2000 analysis imposed the parallel continuation of the LCCS activities. The result was the elaboration of a new project, LCCS07, which allows both the homogenization of the LCCS 2000 and LCCS 2003 geoinformation series and the preparing and interpretation of the satellite images acquired in 2007.

Recently, European Space Agency (ESA) established an international partnership, including UN Food and Agriculture Organisation (FAO), Environmental Agency (EEA), UN Environment Programme (UNEP), European the International Geosphere-Biosphere Programme (IGBP), European Commission's Joint Research Centre (JRC) and Global Observations of Forest Cover and Global Observations of Land Dynamics (GOFC-GOLD), in order to create a global and detailed portrait of Earth’s land cover with a resolution never obtained before (Globe Cover).

Globe Cover was elaborated based on 20 Terabytes of imagery acquired from May 2005 to April 2006 by Envisat’s Medium Resolution Imaging Spectrometer (MERIS) Fine Resolution (300m) instrument. Globe Cover's thematic legend is compatible with LCCS. Globe Cover is

extremely useful for climate change study (modelling of the climate change extent and impacts), ecosystem management (study of the natural and managed ecosystems) and worldwide land-cover trends identification [2].

## 2. Corine Land Cover

Corine Land Cover (CLC) represents a collection of databases that contain information on land cover, biotopes (habitats), soil maps and acid rain for almost each European country. Corine (Coordination of Information on the Environment) was established in 1985 by the European Union and it is created based on the interpretation of satellite images. The Corine digital maps of land cover (original scale 1:100.000) allow the study of the European environmental landscape. Three Corine datasets were created over time (1990, 2000 and 2006), being a considerable basis for monitoring and analysis of the land cover changes [3].

The first Corine dataset (CLC1990) was based on the interpretation of satellite images acquired in 1989 and 1990. The second one (CLC2000) was created by first assessing and correcting the existing CLC1990 land cover database and images for geometric and thematic content, then land cover changes were mapped using 2000 satellite imagery and ancillary data. Romania was one of the countries that have established the CLC2000 database (Figure 1 & Figure 2).

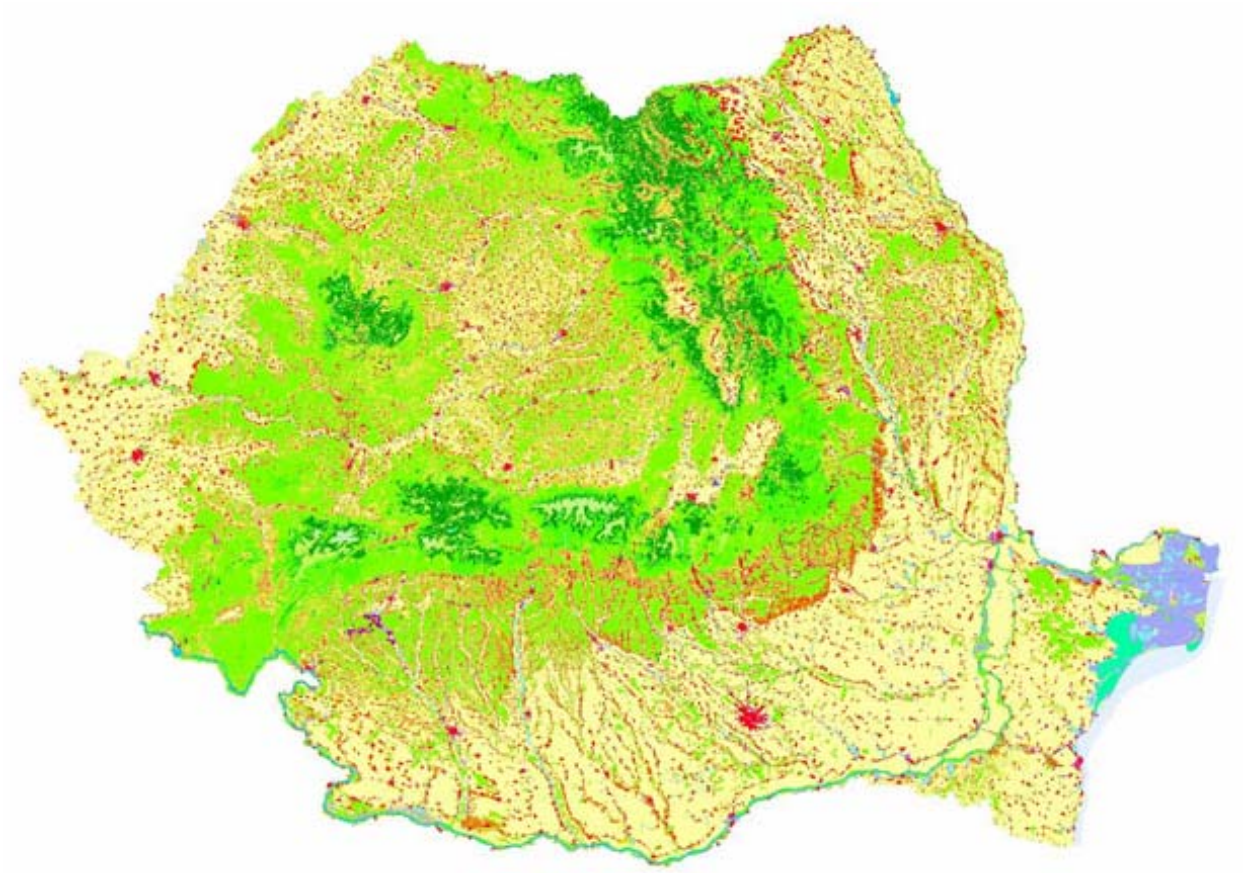

Fig. 1 CLC Romania


Fig. 2 CLC Romania - Legend

Corine Land Cover 2006 represents a full inventory for 2006 (the snapshot database) produced by applying a change dataset for the period 2000-2006 to the CLC2000 dataset. The update of the European CLC database was decided to be done in the framework of the *Global Monitoring for Environment and Security* (GMES) initiative - Fast Track Service on Land Monitoring – designed by the European Environment Agency (EEA) in partnership with the European Space Agency (ESA), the European Commission and other member countries [4].

## 3. Land Cover Classification System

The Land Cover Classification System (LCCS) is a comprehensive, standardized a priori classification system, designed to meet specific user requirements, and created for mapping exercises, independent of the scale or means used to map. Any land cover identified anywhere in the world can be readily accommodated. The classification uses a set of independent diagnostic criteria that allow correlation with existing classifications and legends.

Land cover classes are defined by a combination of a set of independent diagnostic criteria - the so-called classifiers - that are hierarchically arranged to assure a high degree of geographical accuracy.

Because of the heterogeneity of land cover, the same set of classifiers cannot be used to define all land cover types. The hierarchical structure of the classifiers may differ from one land cover type to another. Therefore, the classification has two main phases (Figure 3):

- an initial *Dichotomous Phase*, where eight major land cover types are distinguished;
- a subsequent *Modular-Hierarchical Phase* where the set of classifiers and their hierarchical arrangement are tailored to the major land cover type.

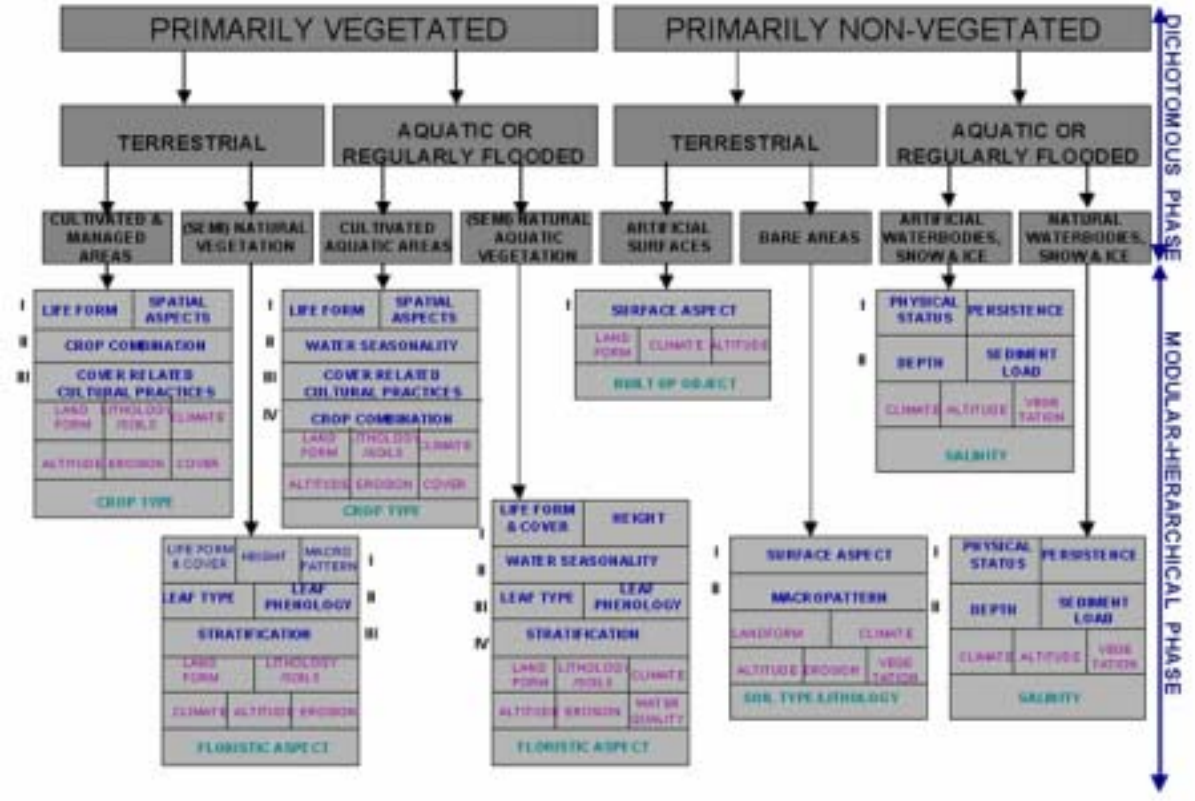


Fig. 3 Dichotomous Phase and Modular-Hierarchical Phase- LCCS

This approach allows the use of the most appropriate classifiers and reduces the total number of impractical combinations of classifiers. Because of the complexity of the classification and the need for standardization, a software application has been developed to assist the interpretation process. This reduces heterogeneity between interpreters and between interpretations over time. Because of the flexible manner in which the classification is set up, with creation of classes at different levels of the system and the optional use of modifiers, environmental attributes and specific technical attributes in combination, coupled with the tremendous number of classes

possible, this innovative software application assists the user to select the appropriate class using a step-by-step process.

The classification system leads to mutually exclusive land cover classes, which comprise: a unique Boolean formula, a standard name and a unique numerical code. Both the numerical code and standard name can be used to build an automatically generated Legend, with the classes created grouped according to the main land cover categories and their domains according to the level of detail. The nomenclature can be linked to a user-defined name in any language.

Further definition of the Land Cover Class can be achieved by adding attributes. Two types of attributes, which form separate levels in the classification, are distinguished:

- *Environmental Attributes*: these are attributes (e.g., climate, landform, altitude, soil, lithology and erosion) which influence land cover but are not inherent features of it and should not be mixed with "pure" land cover classifiers;
- *Specific Technical Attributes*: these are associated with specific technical disciplines (e.g., for (Semi-) Natural Vegetation, the Floristic Aspect can be added; for Cultivated Areas, the Crop Type; and for Bare Soil, the Soil Type).

The advantages of the classifier, or parametric, approach are manifold. The system created is a highly flexible *a priori* land cover classification in which each land cover class is clearly and systematically defined, thus providing internal consistency. The system is truly hierarchical and applicable at a variety of scales. Re-arrangement of the classes based on re-grouping of the classifiers used facilitates extensive use of the outputs by a wide variety of end-users. Accuracy assessment of the end product can be generated by class or by the individual classifiers forming the class. All land covers can be accommodated in this highly flexible system; the classification could therefore serve as a universally applicable reference base for land cover, thus contributing towards data harmonization and standardization [5].

## 4. Objectives and Results

In the framework of the LCCS07 project, images of different geometric and radiometric resolutions will be acquired; these images allow a multi-temporal and detailed analysis adapted to specific characteristics of landscape.

The data regarding the land use represent an important feature for the environment monitoring and for political decisional initiative. For example, the Kyoto Protocol and Biological Diversity Convention are depending on detailed information about the actual land use. The land cover is the most important characteristic of nature and it is used for the following processes: diagnosis and forecast for sustainable management at the level of regions and countries; monitoring and use the natural resources (agriculture, water and forest), etc. The indicators, who can accurate define the landscape, are not so developed because of high costs necessary to determine them. In order to reach a real level of quantification of the landscape, high efforts are made at European and international level. More than 200 legends, elaborated by famous "schools" were identified, until now, describing the object classes identified more or less accurate.

An objective analysis for the evaluation of the land use/land cover categories was facilitated by the initiative of creation of the European Topic Centre Land Use and Spatial Information (ETC-LUSI) in Paris, France. The European Corine Land Cover Project allowed the creation of some rather homogeneous databases (CLC90 and CLC00), based on a predefined legend (legend based mostly on the representation of the Mediterranean landscape, who is unfortunately in total discordance with the specific Romanian excessive temperate continental landscape. Therefore, Romania oriented its attention on the FAO-LCCS method, accepted now as a standard in several countries due to its suppleness and opening towards the accurate quantification of the landscape in order to be possible to complete the CLC appreciation limits.

One of the project's objectives is the elaboration of a set of methods and rules for data processing and validation applied for data coverage obtained once in 3 or 4 years. By adding the third coverage to the series – 2000 (Figure 4) – 2003 (Figure 5) - 2007 - the testing of numeric methods for studying the landscape dynamics will be possible. This research project takes into account the evolution of data acquired by the new Earth Observation satellites, as well as the advanced methods of the semi-automatic and automatic processing of these data, operational since the last actualization RO-LCCS-2003.

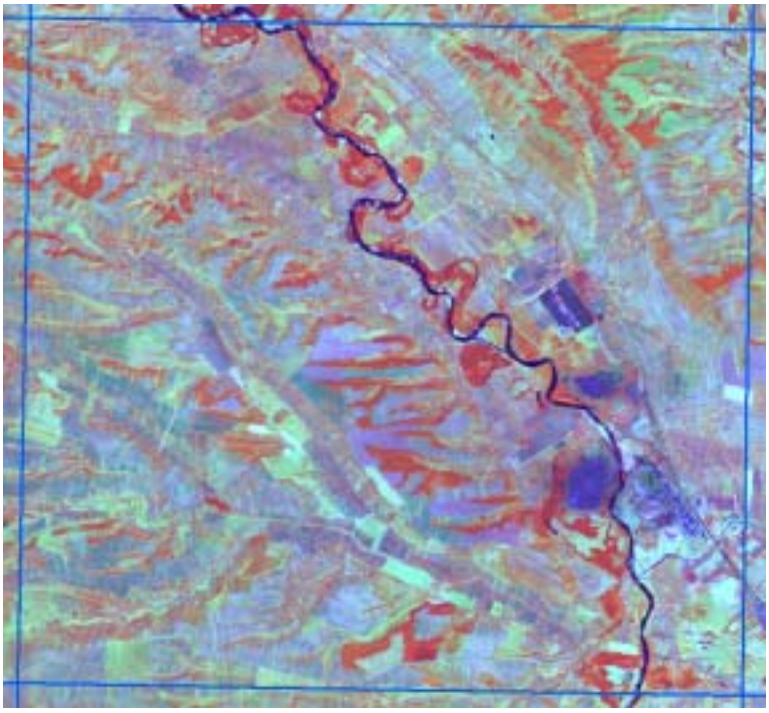

Fig. 4 Landsat 2000 coverage

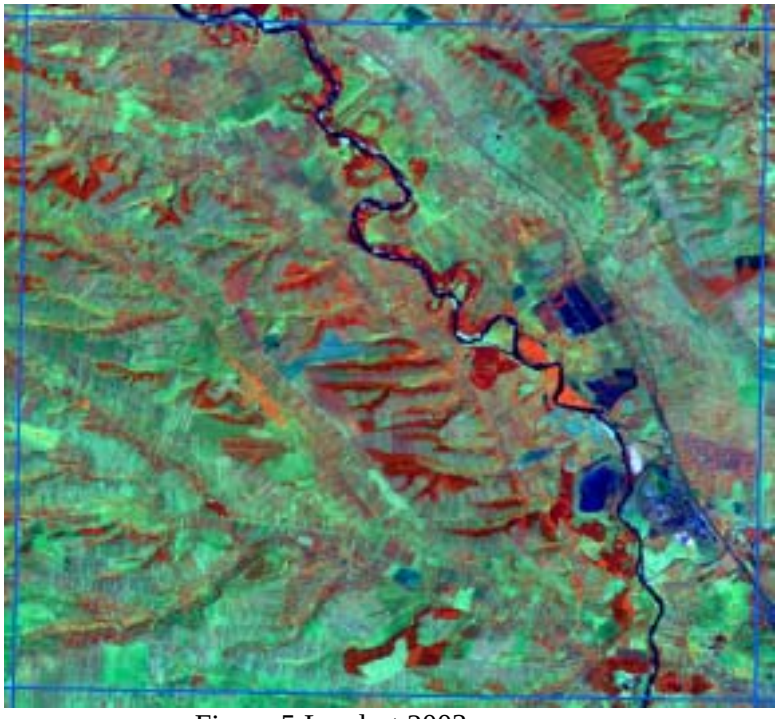

Figure 5:Landsat 2003 coverage

A synthetic chart of the operations is presented as following (Figure 6):

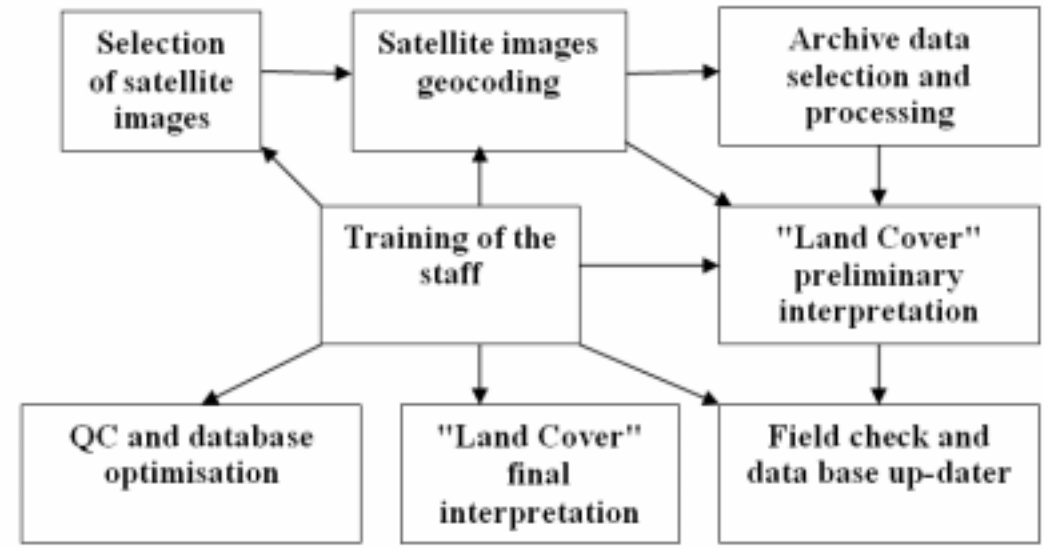


Fig. 6 Processing steps for LCCS07

The GIS interactive database, which will be used to guide the photo interpretation process, is land use/land cover orientated and contains a description of the interpretation procedures according with the adopted methodology and also a more detailed classification of the identified classes. The geographic interface contains field data, pictures, satellite images, aerial photos, vegetation index images and other georeferenced information (geology, relief, soils, etc.).

Real time direct analysis on display will be made for areas of interest such as administrative boundaries, geographical coordinate, etc. The results will be exported in vector format, compatible with the most known GIS systems. Practically, at the end of the Project, it will be obtained the first FAO-LCCS multi temporal database in the world, realised by interpretation at 1:50.000 scale, which describes in detail a substantial area like the territory of Romania (3 series of data: 2000, 2003, 2007).

The LCCS07 Project approach is in the light of the GMES (Global Monitoring for Environment and Security) actions in Romania, according with the development and use of remote sensing techniques for national environment protection and rehabilitation. Also, the resulting data base can be integrated in the Integrated Administration and Control System/ Land Parcel Identification System (IACS/LPIS) database and the other already functional data bases from the Minister of Environment. Indirectly, correlated with the statistical data produced by the National Institute for Statistics, using the data base will offer the possibility to analyze the socio economical relations from more objective positions.

## 5. Conclusions

The LCCS07 project offers the possibility to obtain the 3rd updated series of the FAO-LCCS database by using recent advanced technologies, adapted of the Romanian conditions. In this way, Romania will possess a dataset unique at global level. Also, orthorectification and direct image interpretation on display will be correlated with modern methods of automatic image classification obtained with the support of the most performing existing software solutions. In the framework of LCCS07, the automatization limit that can be achieved without jeopardizing the quality of relevant information will be evaluated.

## 6. References


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