INTRO

Primary condition in making decisions directed to land cover and natural resources management is presence of knowledge and high quality information about biosphere and its changes. For this reason European Union accepted the program for COoRDination of INformation on the Environment – CORINE program.

The CLC inventory and its updates are key reference data sets, which provide the basis for the development of spatial analysis and integrated environmental assessment. From 1985 to 1990, the European Commission implemented the CORINE Program (Co-ordination of Information on the Environment). During this period, an information system on the state of the European environment was created (the CORINE system) and nomenclatures and methodologies were developed and agreed at EU level.

CORINE

The purpose of CORINE program is identification and meaningful categorisation of land cover that includes defined nomenclature of coding and production of the quality database needed for supervising, organizing and managing natural resources on regional and national level.

Data on land cover, in combination with other thematic data, give new insight on condition and changes of natural resources in different areas such as agricultural fields, forestry, regional space planning, inventory of natural resources and monitoring of environment and its changes.

CORINE HRVATSKA

CORINE Land Cover Croatia (CLC Croatia) is a project which resulted in digital up-to-date land cover database according to CORINE nomenclature, which is consistent and homogeneous with data across entire Europe. The project was implemented as the Croatian national part of the joint European Environment Agency – EEA, which is entrusted with database managing at the European level. Ministry of Environmental Protection, Physical Planning and Construction was project coordinator and co-financier along with partner companies, GISDATA and OIKON.
CLC Croatia was also supported by the European Union in the framework of LIFE III –Third countries programme.

The objective of the Ministry of Environmental Protection, Physical Planning and Construction is to provide policy makers with timely and relevant environmental information.

Croatian Environment Agency is entrusted with database managing at the national level.

Preparatory work to establish the CLC database for the reference year 2000, 1990 and 1980 started in 2002. The Image 2000, 1990 and 1980 are based upon the options available for satellite images and the processing and management requirements for the vast amount of data. The overall aim of updating is to produce the database of CLC-Changes between the 1980's 1990's and 2000. To guarantee full coverage and to maximize consistency with the previous inventory in EU, the CORINE Land Cover (CLC) CRO project calls upon existing local expertise and requires access to both the ancillary data and the satellite data used for any kind inventory. The CORINE Land Cover project consist of two main components, which are interconnected (ref. EEA-ETC/TE, 2002):

- MAGE2000, IMAGE1990 and IMAGE1980: covering all activities related to satellite image acquisition, ortho-rectification and production of European and national mosaic and
- CLC2000, CLC1990 and CLC1980: covering all activities related to establish CLC inventory based on IMAGE and detection and interpretation of CLC-Changes

THE NATIONAL CLC CRO TEAMS

OIKON Ltd and GISDATA Ltd. are responsible for the CLC interpretation to produce the CLC databases and the CLC-Changes database by using the satellite images (IMAGE 1980, IMAGE90 and IMAGE2000). National teams collaborate with IMAGE2000 team for image selection and validation of IMAGE2000. Also, national teams are responsible for IMAGE1990 and IMAGE1980 products. The national team leader is responsible for the project implementation, organization of the training and verification missions with the CLC Technical Team and delivery of final databases to the LIFE and EEA.

TECHNOLOGY

CORINE land cover is based on the photointerpretation of satellite images by the national teams of the participating countries. Raw satellite images first have to be pre-processed and enhanced to yield a geometrically correct document (satellite image map) in national projection: Gauss Krueger. Ortho-correction of Landsat-7 ETM and Landsat-5 TM satellite images were provided by the IMAGE2000 (90, 80) component with an RMS (Root Mean Square) error not higher than 25 meter. Detailed topographic maps and in some cases orthophotos were used to achieve this goal.
Computer aided methodology for production of CLC database and change detection was developed by the FÖMI institute in behalf of European Union. Newly created database is consistent in its geometric and attribute information, on account of new technologies and methods for collecting data of land cover changes, which enables digital processing of satellite images, digital collecting of vector database in GIS (Geographic Information Systems), with possibility of making control subprograms. Hungarian Institute of Geodesy, Cartography and Remote Sensing (FÖMI) developed program solutions based on ESRI ArcView platform; Interview - used for interpretation of the referent CLC2000 and Interchange - used for change detection on years 1990 and 1980.
Mentioned GIS software program packages enable automatic calculation of polygon area, automatic detection of polygons smaller than 25 ha (5ha), detection of neighbouring polygons with same code, detection of polygons with null code. That simplifies detection in tracking and correcting errors. Resulted database is based on standard methodology and nomenclature, and it's comparable between itselfs and iterative in time cycle. To detect change through time period, 44 classes were used, each representing different land cover.

Croatia started work on CORINE project in year 2002, when Landsat 7 ETM images for 2000 and 1990 were ortho-rectified and used for land cover interpretation. The basis for orthorectification was 100m DTM for IMAGE2000 and 25m DTM for IMAGE1990 with 1:50000 topographical maps. The interpretation was based on digital satellite images in combinations of channels 4, 5, 3.

Basic Specifications For Land Cover Database:

The basic aim of the CLC project is to provide an inventory of the Earth surface features for managing the environment (Heymann et al., 1994). Only features that are relatively stable in time are mapped. CLC is not interested in diurnal changes (tide), seasonal changes (e.g. vegetation cycle) or short-term changes (e.g. flooding). The approach of computer assisted visual interpretation of satellite images have been chosen as mapping methodology.
Basic specifications for Land Cover database 2000:

- The mapping scale is 1:100 000; mapping accuracy is at least 100 m
- The minimum unit for inventory is 25 ha
- Minimum width of unit is 100 m
- The CLC nomenclature distinguishes 44 classes at the third level, 15 classes at the second level and 5 classes at the first level
- No unclassified areas should appear in the final version of the data set.

During production of database, 38 out of 44 classes according to CORINE nomenclature were detected on Croatian territory.

Basic specifications for land cover change database:

- The minimum unit for inventory is 5 ha
- Minimum width of unit is 100 m

Table 1. The CORINE Land Cover nomenclature

<table>
<thead>
<tr>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Artificial Areas</td>
<td>1.1 Urban fabric</td>
<td>1.1.1 Continuous urban fabric</td>
</tr>
<tr>
<td></td>
<td>1.1.2 Discontinuous urban fabric</td>
<td>1.1.2 Discontinuous urban fabric</td>
</tr>
<tr>
<td></td>
<td>1.2 Industrial, commercial and transport units</td>
<td>1.2.1 Industrial or commercial units</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.2.2 Road and rail networks and associated lands</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.2.3 Port areas</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.2.4 Airports</td>
</tr>
<tr>
<td>1.3 Mine, dump and construction sites</td>
<td>1.3.1 Mineral extraction sites</td>
<td>1.3.2 Dump sites</td>
</tr>
<tr>
<td>1.4 Artificial, non-agricultural areas</td>
<td>1.4.1 Green urban areas</td>
<td>1.4.2 Sport and leisure facilities</td>
</tr>
</tbody>
</table>
These are grouped in a three level hierarchy. The five level-one categories are: 1) artificial surfaces, 2) agricultural areas 3) forests and semi-natural areas, 4) wetlands, 5) water bodies. All Croatian national teams had to adapt the nomenclature according to their landscape conditions. Special features of the nomenclature are the categories of “Heterogeneous agricultural areas”. They are formed by objects, (e.g. plots of arable land, areas of natural vegetation, etc.) which themselves would be smaller than the minimum mapping unit (25 hectares). E.g. category 242 have been introduced to characterize mixed agricultural areas: mixtures of small plots of any of two or more of the following cover types: arable land, pastures, vineyards, fruit trees and berry plantations and olives. Category 243 has the aim to characterize agricultural areas with significant amount of natural formations (e.g. patches of forests, areas of shrub, grasslands, wetlands or water bodies). These are very useful tools to characterize a heterogeneous landscape at scale 1:100.000.

<table>
<thead>
<tr>
<th>2. Agricultural Areas</th>
<th>2.1 Arable land</th>
<th>2.1.1 Non-irrigated arable land</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.1.2 Permanently irrigated land</td>
<td></td>
</tr>
<tr>
<td>2.2 Permanent crops</td>
<td>2.2.1 Vineyards</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.2.2 Fruit trees and berry plantations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.2.3 Olive groves</td>
<td></td>
</tr>
<tr>
<td>2.3 Pastures</td>
<td>2.3.1 Pastures</td>
<td></td>
</tr>
<tr>
<td>2.4 Heterogeneous</td>
<td>2.4.2 Complex cultivation patterns</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.4.3 Land principally occupied by agriculture with significant areas of natural vegetation</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Forest and Semi Natural Areas</th>
<th>3.1 Forests</th>
<th>3.1.1 Broad leaved forest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.1.2 Coniferous forest</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.1.3 Mixed forest</td>
<td></td>
</tr>
<tr>
<td>3.2 Scrub and / or herbaceous vegetation</td>
<td>3.2.1 Natural grasslands</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.2.2 Moors and heathland</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.2.3 Sclerophyllous vegetation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.2.4 Transitional woodland-shrub</td>
<td></td>
</tr>
<tr>
<td>3.3 Open spaces with little or no vegetation</td>
<td>3.3.1 Beaches, dunes and sands</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.3.2 Bare rocks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.3.3 Sparsely vegetated areas</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.3.4 Burnt areas</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4. Wetlands</th>
<th>4.1 Inland wetlands</th>
<th>4.1.1 Inland marches</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4.1.2 Salt marshes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.1.2 Salines</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.1.2 Intertidal flats</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5. Water Bodies</th>
<th>5.1 Inland waters</th>
<th>5.1.1 Water courses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5.1.2 Water bodies</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.2 Marine waters</td>
<td>5.2.1 Coastal lagoons</td>
</tr>
<tr>
<td></td>
<td>5.2.3 Sea and Ocean</td>
<td></td>
</tr>
</tbody>
</table>
PROJECT RESULTS

CORINE Land Cover resulted with national land cover which is implemented in unique European land cover map.
The results of the CORINE Land Cover project for Croatia are following 5 digital databases with its metadata:

- CLC2000, representing the land cover of year 2000 (CLC00_CRO)
- CLC90, representing the land cover of year 1990 (CLC90_CRO)
- CLCchange, containing land cover changes between 1990 and 2000 (CHANG_CRO)
- National CLC 1980 database analogue map sheets in a scale 1:100.000,

Other products:

- National mosaic of orthorectified satellite images 2000 (Image 2000),
- Satellite 2000 photomap sheets in a scale 1:100.000 (PDF format)
- National CLC 2000 analogue map sheets in a scale 1:100.000, (PDF format)
- National 1990 mosaic of orthorectified satellite images,
- Satellite 1990 photomap sheets in a scale 1:100.000, (PDF format)
- National CLC 1990 analogue map sheets in a scale 1:100.000, (PDF format)
- National 1980 mosaic of orthorectified satellite images,
- Satellite 1980 photomap sheets in a scale 1:100.000, (pdf format)

INTERPRETATION OF RESULTS – ANALYSIS

According to data from all three databases, we have come to conclusion that the highest portions of land in all three datasets are occupied by following classes:

1. Class 311 – broadleaved forest (30.1 %, 29.9 % and 29.8 % in years 80, 90 and 2000)
2. Class 242 - complex cultivation patterns (18.3 %, 17.9 % and 17.7 %)
3. Class 324 - transitional woodland/shrub (10.0 %, 10.5 % and 10.6 %).

All other classes are below 10 % and changes in their areas do not reflect general trends.
It is visible that the areas of intensive human influence (settlement and traffic network expansion...) increase as well as inland waters and marshes (accumulation...), intensive agriculture decrease. The difference in trend of changes from 1980 – 1990 and 1990 – 2000 is visible in categories extensive agriculture and forest vegetation. That means that artificial areas have increasing trend - settlements, accumulations of water, traffic network etc.).

Another recognized trend is intensive agriculture abandonment and extensive agriculture increase. Interpretation of change database confirms previously described trends. Change database shows that in both period, 1980/1990 and 1990/2000, major changes occurred in areas covered by forest vegetation. On one side, cause for this is regular forest management and on the other is high influence of human activities, such as construction works, transportations networks, spread of settlements etc. Next highest change recorded is within agricultural areas, especially areas of intensive agriculture (classes 211 and 242). Agricultural area classes that have been changed (231, 242, 243) shows the trend of intensive agriculture abandonment.

**CONCLUSION**

The inventory of land cover changes is necessary for the analysis of trends, causes and consequences of natural and artificial processes, impact assessment, maintenance of ecological stability and its observation in decision-making processes. The change detection process and the mapping of the land cover changes is carried out by means of image comparison, using computer assisted image interpretation tools.

The presentations of the project and its results raised the awareness of the use of aerial and satellite images interpretation and GIS technology in the process of physical planning, landscape
management, forestry, agriculture, tourism, etc. The use of verified CORINE land cover products become necessity in spite of lack of other relevant and up to date information about land cover and land use for the all territory. The interest about use of CLC products of Croatia raised and several inquiries have been already set to the MEPPPC and CEA. There are several projects that use CLC data for their purposes:

- Preparation of national assessment on state of the environment (CEA)
- National action plan for the reduction of effects of desertification (MEPPPC)
- The state of the soil condition of the Zagreb county (Faculty of Agronomy, University of Zagreb) etc.

CORINE Land Cover database provides actual land cover data of Croatian territory based on European standards. CLC databases are implemented on standard classification and production methodology, which enables making of European land cover studies and simplifies data and results comparison between countries.

References:


MZOPUG and national team: Final Report for CORINE Land Cover Database for Croatia LIFE02 TCY/CRO/015, 2005 Croatia