

CORINE Land Cover 2006 project in Macedonia

Final report

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TABLE OF CONTENTS

| | |
|--|-----------|
| 1. OBJECTIVE | 3 |
| 2. BACKGROUND | 3 |
| 3. PROJECT ORGANIZATION | 3 |
| 3.1. ORGANIZATION OF THE WORK AT NATIONAL LEVEL..... | 3 |
| 3.2. NATIONAL TEAM IN MACEDONIA | 4 |
| 4. PROJECT FRAMEWORK | 4 |
| 4.1. NATIONAL PROJECTION PARAMETERS | 4 |
| 4.2. BASIC WORKING UNITS..... | 4 |
| 5. METHODOLOGY APPLIED | 5 |
| 5.1. BASIC PRINCIPLES | 5 |
| 5.2. TECHNICAL SPECIFICATION | 6 |
| 6. PRODUCTION PROCESS | 6 |
| 6.1. PREPARATORY PHASE | 6 |
| 6.1.1. <i>Training of interpreters</i> | 6 |
| 6.1.2. <i>Collection of ancillary data</i> | 7 |
| 6.1.3. <i>Revision of Image2000</i> | 7 |
| 6.1.4. <i>Revision of the CLC2000 database</i> | 9 |
| 6.3. IMAGE2006 DATASET | 10 |
| 6.5. PRODUCTION OF THE CLC CHANGES 2000-2006 DATABASE..... | 11 |
| 6.6. PRODUCTION OF THE CLC2006 DATABASE | 12 |
| 6.7. DATA VERIFICATION AND VALIDATION | 12 |
| 6.8. DATASETS INTEGRATION | 13 |
| 7. METADATA | 15 |
| 8. LAND COVER IN MACEDONIA | 15 |
| 9. ANALYSIS OF CLC CLASS DYNAMICS | 17 |
| 9.1. CLC CLASS DYNAMICS IN MACEDONIA | 17 |
| 11. CONTACTS | 19 |
| NATIONAL COMPETENT AUTHORITY | 19 |
| NATIONAL TEAM CONTRACTED | 19 |
| 12. REFERENCES | 20 |

1. OBJECTIVE

The CLC2006 project's objective in Macedonia is to provide information about land cover changes during the period 2000 – 2006 years, as well as land cover maps for the reference year 2006 (CLC2006).

The CLC2006 project implementation in Macedonia started on September 2007 and was completed on November 2008.

In accordance with the to the "EEA Project Implementation Plan, GMES Land FTS 2006-2008 reference document", the CLC2006 project in Macedonia delivered the following products:

Product 3 – Corine land cover changes 2000-2006 (including metadata);
Product 4 – Corine land cover map 2006 (including metadata);

2. BACKGROUND

The CORINE Land Cover project as a part of CORINE programme is intended to provide consistent localized geographical information on the land cover of the European countries through creating of the CORINE Land Cover (CLC) databases.

The CLC2006 project is implemented in Macedonia in the frames of the CARDS programme.

Macedonia disposes only one CLC inventory which was completed in 2000 year, based on the images of 1995-1996 year. However, this data set was accepted as CLC2000 for the purpose of CLC2006 project.

3. PROJECT ORGANIZATION

3.1. Organization of the work at national level

The overall implementation of the CLC2006 update in West Balkan countries was managed by European Topic Centre for Land Use and Spatial Information (ETC-LUSI).

On the national level, the company GOVe doo was sub-contracted to provide the following services related to the project:

- CLC changes 2000-2006 (including metadata);
- CLC map 2006 (including metadata);
- Verification of FTS soil sealing layer
- Verification of FTS forest layer

3.2. National team in Macedonia

The members of national team are:

- Zoran Velickov, project manager
- Casle Tosevski, photointerpreter
- Gjorgji Gjorgjiev, photointerpreter
- Vanco Gjorgjiev, photointerpreter

4. PROJECT FRAMEWORK

4.1. National projection parameters

All satellite images in IMAGE2000 and IMAGE2006 datasets that were used in the project were georeferenced in the National projection system. This is a geodetic system based on datum – Hermanskogel with prime meridian in Greenwich and ellipsoid Bessel (major axis – 6 377 397.155 m, semi major axis – 6 356 078.963 m). Projection is defined as Transverse Mercator (Gauss-Kruger) with the following parameters:

| | |
|----------------------------------|----------------|
| Central Latitude: | 0°00'00.00" |
| Central meridian: | 21°00'00.00" |
| scale factor at central meridian | 0.9999 |
| false easting | 500 000.00 m |
| false northing | 0 000 000.00 m |

-

4.2. Basic working units

The basic working units for the CLC2006 project in Macedonia correspond to the sheets of the national map series 1:100.000. The coverage of the working units through the territory of Macedonia is shown in Figure 1.

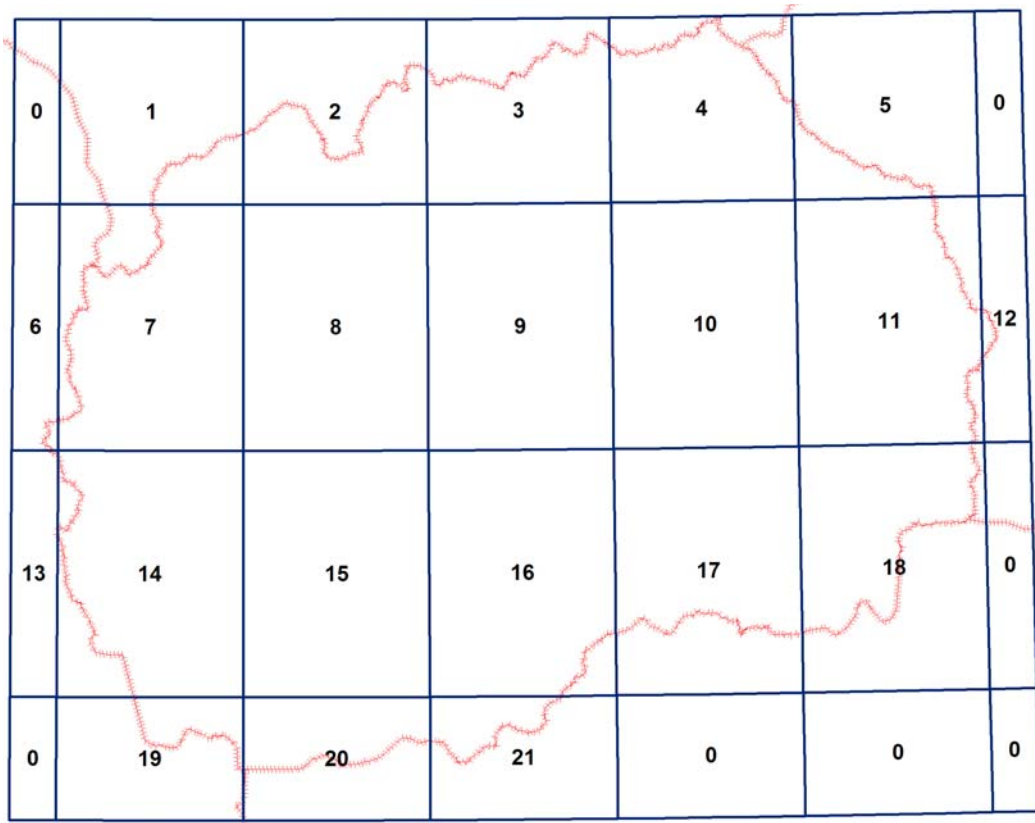


Figure 1

5. METHODOLOGY APPLIED

5.1. Basic principles

CLC2006 is a direct continuation of previous CORINE Land Cover mapping campaigns. It means that general technical characteristics of the CLC mapping (scale 1:100.000, 44 land cover classes, 25 ha minimum mapping unit, 5 ha minimum mapping unit for LC change..), as well as the mapping method of visual interpretation of multispectral high resolution satellite imagery, remained the same. However, there are also particularities of CLC2006 mapping that have to be underlined:

- The focus is on mapping of CLC changes between 2000 and 2006. The CLC2006 database is then generated in a mostly automatic way with some human interaction by combining CLC2000 and the visually interpreted CLC-Change databases.
- Revision of CLC2000 database must be undertaken during the mapping of CLC changes. It means that every mistake found in CLC2000 must be corrected.
- The novelty in the mapping methodology is application of multitemporal imagery. Each area is covered by two images acquired in the 2006 +/- 1 year period. Coverage 1, a set of

imagery acquired during summer months, represents the basic imagery for interpretation. Coverage 2 consists of images acquired in spring or autumn. Involving multitemporal dimension in interpretation of images obtains information on annual changes of biophysical features in land cover and thus improves accuracy of land cover (or, in this case, land cover change) mapping.

5.2. Technical specification

Topologic and attribute specifications for **CLC 2006 vector data**:

- No lines can be presented more than once.
- All polygons are closed, no dangles.
- The number of polygons is equal to the number of labels.
- The feature ID must be unique; it should not contain the CLC code.
- Each polygon of CLC 2006 must have a character attribute: the 3-digit CLC code.
- Each polygon of the CLC change database must have three attributes: a 3-digit CLC code for both 2000 and 2006 datasets as well as change type (from-to CLC code).
- Unclassified polygons (0 code) are not permitted, only codes compatible with nomenclature.
- The neighboring polygons should not have the same CLC code.
- A seamless digital database should be produced without any non-coded gaps; this means a perfect edge matching between the working units without visible map sheet boundaries.
- The final delivery of the National CLC 2006 and CLC changes products of each country is produced in the national projection system.
- The coordinates of the data delivered to the EEA should be in 'double precision'.
- There should be no gaps between data sets from adjacent countries or deliveries.
- The area of smallest polygon should be => 25 ha for CLC 2006 database.

6. PRODUCTION PROCESS

6.1. Preparatory phase

6.1.1. Training of interpreters

As some of the experts in the national team also took part in the 1st CLC inventory in the country between 1999 and 2000, there were no necessity for an intensive training.

2-days session was organized on February 2008 by members of the Technical Team with the national team. During the meeting, specific approach and background of the CLC2006 update project were presented and discussed.

6.1.2. Collection of ancillary data

National CLC team used the following ancillary data, for the whole territory of Macedonia, in the process of interpretation:

- Scanned and geo-oriented topographic maps in scales 1:25000. These maps are outdated (older than 30 years) and was used mainly for image checking (spatial accuracy) and pre-processing
- Panchromatic orthophotos with 50 cm spatial resolution, for the whole territory of the Country, based on aerial images from 2004 year. These orthophotos are produces by the State Department of Geodesy. These images have been provided by the Ministry of Environment and Physical Planning (MoEPP). This is the main ancillary material used for the purpose of image interpretation.
- Vector data for the whole territory on the Country, including:
 - Settlements boundaries;
 - Water bodies (rivers and lakes);
 - Roads;
 - Administrative boundaries
- The Google Earth is used for CLC polygon overlay.

6.1.3. Revision of Image2000

Image2000 was found not acceptable in terms of the geometry. The geometric fit between Image2000 and CLC2000 was correct, but compared to the IMAGE2006 and other ancillary data it shows geometric displacement. The left Image on the Figure 2 shows the overlapping between the IMAGE2000 and CLC2000, while the right image illustrates the shift between the IMAGE2006 and CLC2000.

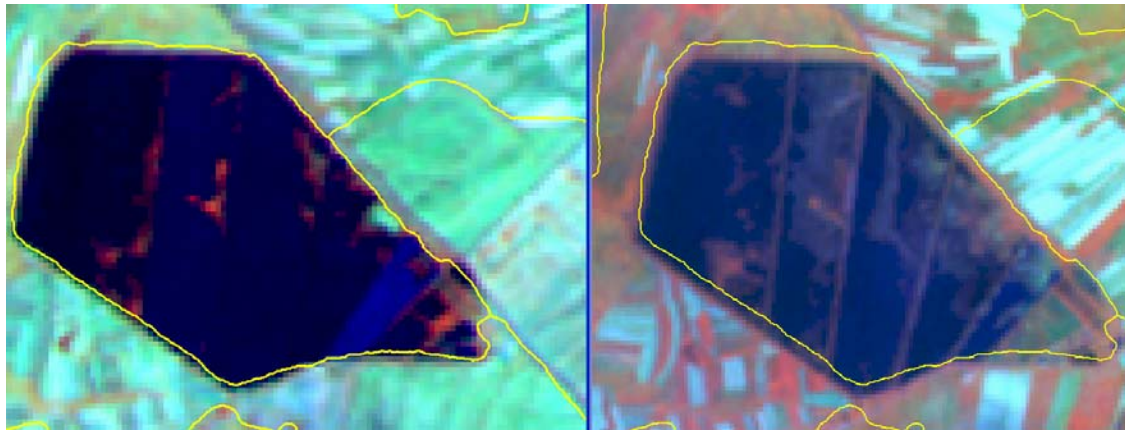


Figure 2

The numerical figures that present the shift are presented on the Table 1. The average displacement is 67 meters. Both data sets, Image2000 and CLC2000 database, has been spatially corrected using the same transformation parameters.

| # | Y | X | 2000 | Y_2 | X_2 | Ancillary data | DY | DX | d | |
|----|-----------|------------|------|-----------|------------|----------------|-------|-------|-------|---------------|
| 1 | 566491.13 | 4620875.73 | 75 | 566495.24 | 4620805.73 | 3326 | -4.1 | 70.0 | 70.1 | |
| 2 | 577135.11 | 4607333.77 | 75 | 577135.11 | 4607257.88 | 3326 | 0.0 | 75.9 | 75.9 | |
| 3 | 582184.64 | 4601754.76 | 75 | 582209.14 | 4601697.20 | 3326 | -24.5 | 57.6 | 62.6 | |
| 4 | 552399.78 | 4644090.24 | 75 | 552392.44 | 4644002.06 | 3326 | 7.3 | 88.2 | 88.5 | |
| 5 | 531017.12 | 4651725.66 | 75 | 530975.48 | 4651657.09 | 3326 | 41.6 | 68.6 | 80.2 | |
| 6 | 529214.27 | 4651024.45 | 75 | 529182.43 | 4650966.89 | 3326 | 31.8 | 57.6 | 65.8 | |
| 37 | 501575.89 | 4650395.52 | 75 | 501528.52 | 4650362.14 | 3326 | 47.4 | 33.4 | 57.9 | |
| 7 | 521298.39 | 4613874.68 | 75 | 521278.81 | 4613855.08 | 3326 | 19.6 | 19.6 | 27.7 | |
| 8 | 498910.72 | 4650257.64 | 75 | 498883.77 | 4650206.20 | 3326 | 26.9 | 51.4 | 58.1 | |
| 9 | 585268.32 | 4630696.22 | 75 | 585252.39 | 4630604.36 | 3326 | 15.9 | 91.9 | 93.2 | |
| 10 | 571424.21 | 4668074.03 | 75 | 571370.30 | 4667982.17 | 3326 | 53.9 | 91.9 | 106.5 | |
| 11 | 545365.24 | 4672666.63 | 75 | 545301.56 | 4672602.95 | 3326 | 63.7 | 63.7 | 90.1 | max= 144.7 |
| 12 | 495172.28 | 4628150.77 | 75 | 495142.89 | 4628084.64 | 3326 | 29.4 | 66.1 | 72.4 | min= 27.7 |
| 13 | 582275.04 | 4641659.20 | 75 | 582257.89 | 4641583.26 | 3326 | 17.2 | 75.9 | 77.9 | average= 74.1 |
| 14 | 513732.90 | 4694610.61 | 75 | 513696.16 | 4694556.72 | 3326 | 36.7 | 53.9 | 65.2 | STDEV= 24 |
| 38 | 563787.01 | 4688387.91 | 75 | 563687.81 | 4688282.59 | 3326 | 99.2 | 105.3 | 144.7 | RMSQ= 79.6 |
| 15 | 470126.05 | 4673659.25 | 75 | 470138.30 | 4673618.83 | 3326 | -12.3 | 40.4 | 42.2 | |
| 16 | 457832.99 | 4664654.47 | 75 | 457825.65 | 4664598.13 | 3326 | 7.3 | 56.3 | 56.8 | |
| 17 | 556820.42 | 4611819.65 | 75 | 556816.23 | 4611756.61 | 3326 | 4.2 | 63.0 | 63.2 | |
| 18 | 486183.42 | 4689470.16 | 75 | 486126.64 | 4689422.84 | 3326 | 56.8 | 47.3 | 73.9 | |
| 19 | 511109.75 | 4663703.50 | 75 | 511039.29 | 4663659.34 | 3326 | 70.5 | 44.2 | 83.2 | |
| 20 | 483698.21 | 4617556.67 | 75 | 483669.65 | 4617513.84 | 3346 | 28.6 | 42.8 | 51.5 | |
| 21 | 461438.44 | 4591533.48 | 75 | 461429.35 | 4591471.17 | 3346 | 9.1 | 62.3 | 63.0 | |
| 39 | 482676.10 | 4551974.71 | 75 | 482668.31 | 4551939.67 | 3346 | 7.8 | 35.0 | 35.9 | |
| 22 | 516875.38 | 4555878.32 | 75 | 516820.87 | 4555875.72 | 3346 | 54.5 | 2.6 | 54.6 | |
| 23 | 530374.91 | 4579461.56 | 75 | 530387.88 | 4579394.07 | 3346 | -13.0 | 67.5 | 68.7 | max= 85.2 |
| 24 | 546036.15 | 4547413.55 | 75 | 545951.78 | 4547425.23 | 3346 | 84.4 | -11.7 | 85.2 | min= 28.6 |
| 25 | 563443.20 | 4564206.20 | 75 | 563425.03 | 4564184.13 | 3346 | 18.2 | 22.1 | 28.6 | average= 48.3 |
| 26 | 520349.96 | 4595879.50 | 75 | 520355.16 | 4595835.37 | 3346 | -5.2 | 44.1 | 44.4 | STDEV= 17 |
| 27 | 511863.14 | 4570693.03 | 75 | 511847.56 | 4570651.50 | 3346 | 15.6 | 41.5 | 44.4 | RMSQ= 53.0 |
| 28 | 497633.60 | 4596606.05 | 75 | 497608.94 | 4596560.62 | 3346 | 24.7 | 45.4 | 51.7 | |
| 29 | 469825.98 | 4577047.64 | 75 | 469823.38 | 4577017.79 | 3346 | 2.6 | 29.8 | 30.0 | |
| 30 | 578716.18 | 4584701.77 | 75 | 578695.41 | 4584678.41 | 3346 | 20.8 | 23.4 | 31.3 | |
| 31 | 536201.54 | 4563688.83 | 75 | 536172.98 | 4563662.87 | 3346 | 28.6 | 26.0 | 38.6 | |

| | | | | | | | | | | | |
|----|-----------|------------|----|-----------|------------|------|--------|-------|-------|----------|-------|
| 32 | 631494.78 | 4649014.55 | 75 | 631428.58 | 4648937.96 | 2942 | 66.2 | 76.6 | 101.2 | max= | 186.2 |
| 33 | 600336.80 | 4637517.96 | 75 | 600329.02 | 4637471.23 | 2942 | 7.8 | 46.7 | 47.4 | min= | 47.4 |
| 34 | 617480.90 | 4582154.90 | 75 | 617428.97 | 4582152.31 | 2942 | 51.9 | 2.6 | 52.0 | average= | 87.4 |
| 35 | 627422.89 | 4622017.24 | 75 | 627380.04 | 4621991.28 | 2942 | 42.8 | 26.0 | 50.1 | STDEV= | 60 |
| 36 | 642348.53 | 4684966.28 | 75 | 642187.54 | 4684872.80 | 2942 | 160.99 | 93.48 | 186.2 | RMSQ= | 114.4 |
| | | | | | | | | | | max= | 186 |
| | | | | | | | | | | min= | 28 |
| | | | | | | | | | | average= | 67 |
| | | | | | | | | | | STDEV= | 31 |
| | | | | | | | | | | RMSQ= | 74.8 |

Table 1

6.1.4. Revision of the CLC2000 database

The CLC2000 database is a foundation for generating the CLC2006 database. Therefore, it was essential to have correct database from both points of view: geometry and thematic content.

The sources of errors in the database appeared due to the two main reasons:

- The fact that CLC2000 project was not implemented in Macedonia and CLC1990 database was accepted as CLC2000. In the most of the participating Countries this source of errors has been eliminated in CLC2000 phase.
- The weaknesses of the previous technology, which include manual drawing of interpretation results on transparent overlaid on printed images and digitizing of this transparencies afterwards.

It was decided the geometrical errors to be corrected for the whole Country before the interpretation starts, in parallel with corrections to Image2006, while the correction of the thematic errors to be performed in parallel with the CLC2006 changes mapping.

The total area of corrections is about 136000 ha, which is about 5% of the whole territory of the Country.

The overall map of corrections is given on the Figure 3

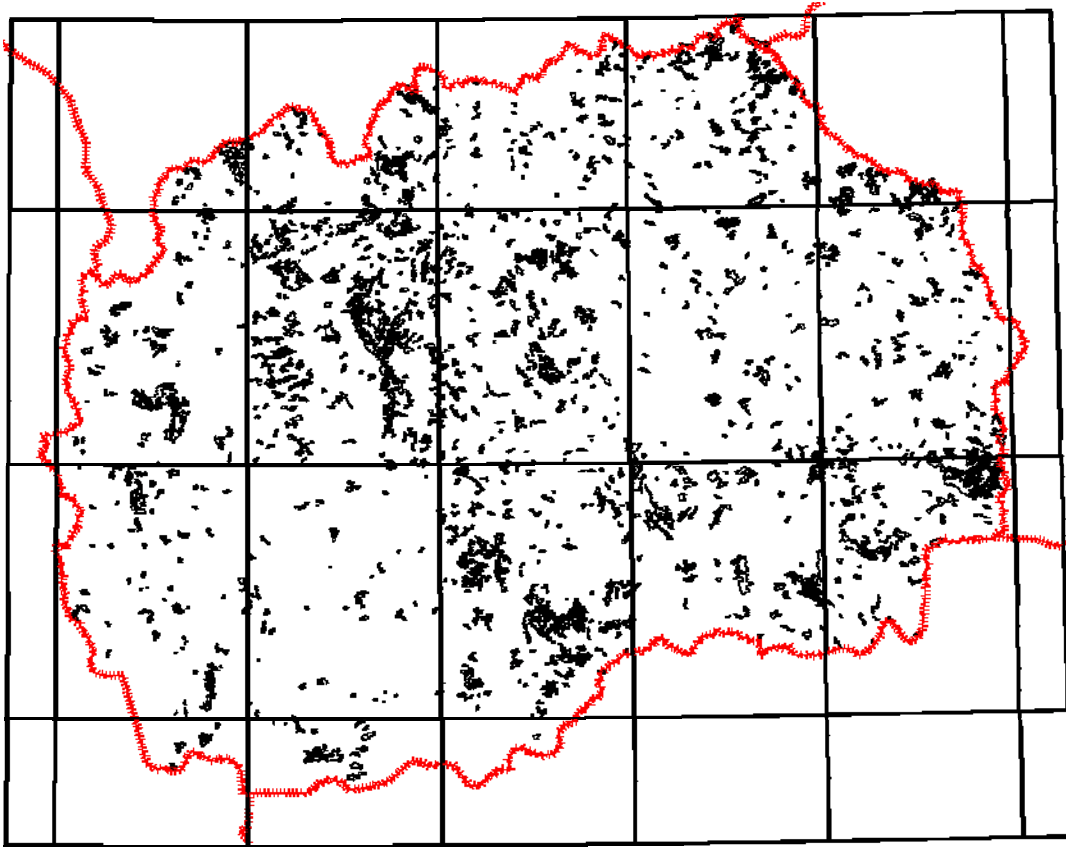


Figure 3

6.3. IMAGE2006 dataset

IMAGE2006, acquired by SPOT-4, 5 and Indian IRS P6 satellites, has correct geometry and good quality in terms of image colours. SPOT images cover only small areas near the Country border.

Two image sets (multitemporal imagery) for each area was acquired in the 2006 +/- 1 year period, in order to provide an opportunity for improved photointerpretation. It was specified narrow and extended time windows for the basic image- Coverage 1, and another time window for the second image-Coverage 2. Images are not closer than 6 weeks in time.

The Figure 4 shows the both coverages.

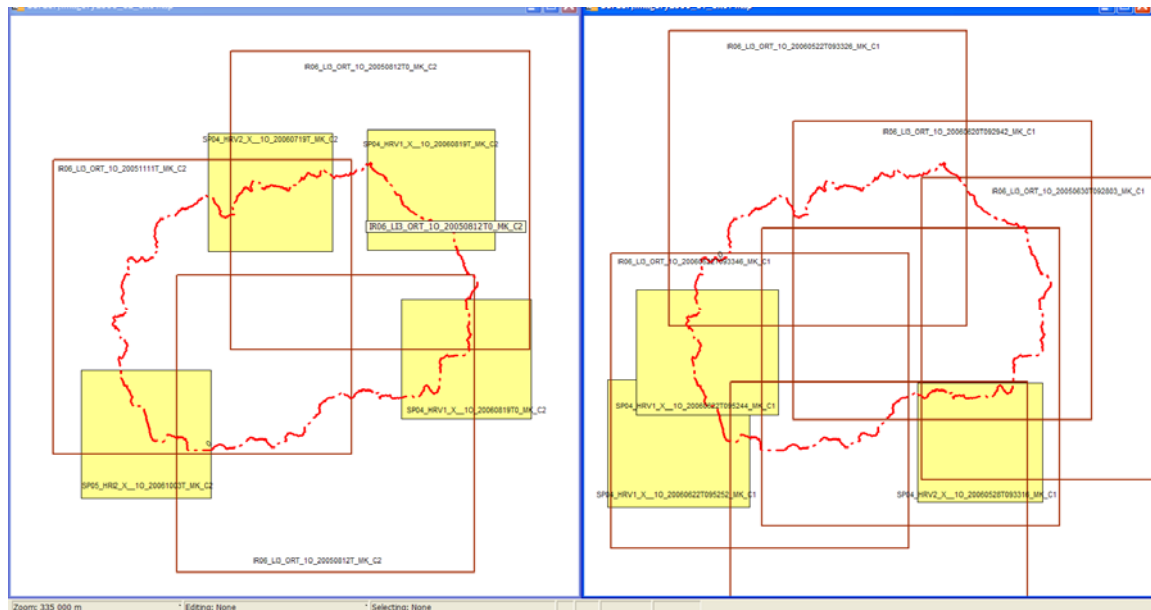


Figure 4

6.5. Production of the CLC Changes 2000-2006 database

The CLC-Change database is produced according to the standard technical parameters for this product:

- Changes are larger than 5 ha;
- Linear changes are wider than 100 m,
- Change occurred between 2000 and 2006;
- Changes are detectable on satellite images;
- 3 types of changes can be interpreted:
 - o Real changes, that represents a change between land cover classes that occurred in reality. This change does not have to inherit the CLC2000 classes;
 - o Technical change polygon, that represents no actual land cover change (it has the same code for 2000 and 2006), but is necessary to generate correct CLC2006 database ;
 - o Elementary changes, that map one or more neighboring changes that can be less than a 5 ha and same CLC2006 code, but all together make up more than 5 ha.

CLC-Change database is produced directly with the method of computer-aided photointerpretation. The photointerpretation includes visual comparison of satellite images, detection of real land cover changes visible on the images and delineation of change polygons based on former CLC2000 polygon boundaries.

For the purpose of the CLC2006 changes mapping the MapInfo Professional software has been used, with a customized tool provided for the project implementation. This tool provides:

- Working with many synchronized windows to display IMAGE2000/2006 data, CLC2000 data and ancillary data;
- Editing tools for creation of CLC changes as well as CLC corrections (geometrical and thematic) on the old datasets;
- Integration of the link to the Google Earth for fast and automatic overlay of the selected polygons to Google Earth. The tool automatically transforms polygon's (national) projection to the Google Earth projection.

6.6. Production of the CLC2006 database

CLC2006 is synthesized in a GIS process as:

$$\text{CLC2006} = \text{CLC2000}_{\text{revised}} + \text{CLC-Changes}_{2000,2006}$$

Where:

- CLC2006 means CLC database for 2006 (25 ha MMU, 100 m minimum mapped width, standard level-3 classes)
- CLC2000_{revised} means the corrected / revised CLC database for 2000 (25 ha MMU, 100 m minimum mapped width, standard level-3 classes)
- CLC-Changes_{2000,2006} means CLC changes between 2000 and 2006 (5 ha MMU, 100 m minimum mapped width, two attributes, each according to standard level-3 nomenclature).
- "+" means a GIS process, including semi-automatic generalization and some actions of a photointerpreter.

An Arc/Info macro program was obtained by the Technical Team as a support for work to be done in a semi-automatic way. The aim of the program is to generalize CLC2006 polygons under the 25 ha size limit according to uniform rules. The program gives an opportunity to set this size limit to less than 25 ha, which leaves the possibility of manual handling of polygons just under the size limit, which allows the interpreter to enlarge the polygon or make a generalization decision based on human expertise.

6.7. Data verification and validation

Verification of the databases consisted of thematic verification and checking topological, geometric and attribute specifications. It was carried out in two levels, internal and external.

The internal verification was carried out by technical manager and leading interpreter. The external verification was carried out by CLC Technical

Team. There was one, so called, "remote verification" (June, 2008) and one "regular" verification (October, 2008) by CLC Technical Team.

The verification missions were conducted by following the standard verification procedure, defined by the CLC Technical Team:

- Verification of at least 8 % of the total area.
- CLC-Changes (between 2000 and 2006) and revised CLC2000 databases are to be verified.
- Verification is to be carried out on a sample of verification units selected by the CLC Technical Team.
- The size of the verification units are 10x10 km, which is to be checked in a systematic way.
- Working units have to be selected to cover all landscape features, different CLC classes and change/no change areas.

6.8. Datasets integration

The data sets corresponding to mapping units were merged into seamless database for the whole territory of Macedonia. However, since each interpreter worked in a seamless database for his region, the merging process has been done only between the different interpreter's data sets. This approach reduces the possibility of error due to the edge matching process.

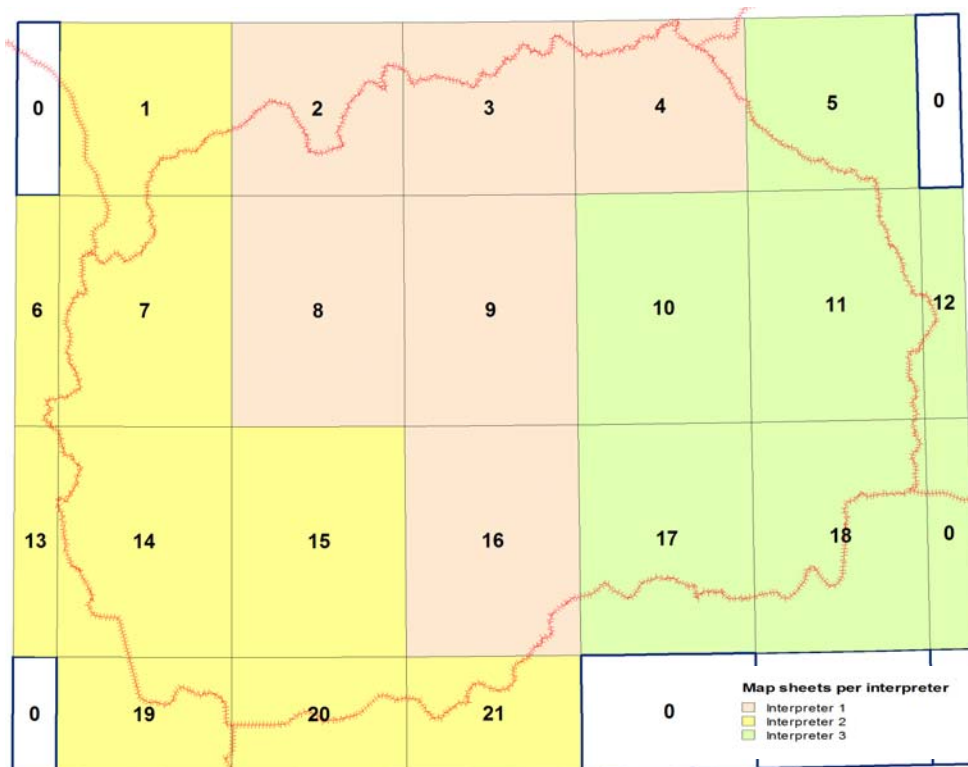


Figure 5

The revised CLC2000 and CLC_Change databases has been checked to met database quality requirements:

- Topology consistency;
- Area limits – (25 ha, 5 ha);
- Valid codes based on the nomenclature, not '0' code permitted;
- Database continuity (no gaps);
- ArcInfo vector file format, polygon topology, double precision;

Table 2. Structure of CORINE Land Cover databases.

CHA06

| attribute name | attribute type | attribute length | comment |
|----------------|------------------|------------------|-----------------------------|
| Area | Floating | | internal, no need to define |
| Perimeter | Floating | | internal, no need to define |
| <name># | Binary | | internal, no need to define |
| <name>-ID | Binary | | internal, no need to define |
| ID | Character | 18 | 'xx'-'<name>-ID' |
| Code_00 | Character | 3 | |
| Code_06 | Character | 3 | |
| Change | Character | 7 | <code_00>-<code_06> |
| <i>Chtype</i> | <i>Character</i> | <i>1</i> | <i>See note below</i> |
| Area_ha | Floating | 18,11 | 'Area'/1000 |
| Remark | Character | 20 | |

CLC06

| attribute name | attribute type | attribute length | comment |
|----------------|----------------|------------------|-----------------------------|
| Area | Floating | | internal, no need to define |
| Perimeter | Floating | | internal, no need to define |
| <name># | Binary | | internal, no need to define |
| <name>-ID | Binary | | internal, no need to define |
| ID | Character | 18 | 'xx'-'<name>-ID' |
| Code_00 | Character | 3 | |
| Area_ha | Floating | 18,11 | 'Area'/1000 |
| Remark | Character | 20 | |

CLC00

| attribute name | attribute type | attribute length | comment |
|----------------|----------------|------------------|-----------------------------|
| Area | Floating | | internal, no need to define |
| Perimeter | Floating | | internal, no need to define |
| <name># | Binary | | internal, no need to define |
| <name>-ID | Binary | | internal, no need to |

| | | | |
|---------|-----------|-------|------------------|
| | | | define |
| ID | Character | 18 | 'xx'-'<name>-ID' |
| Code_00 | Character | 3 | |
| Area_ha | Floating | 18,11 | 'Area'/1000 |
| Remark | Character | 20 | |

7. METADATA

The CLC2006 datasets metadata is based on metadata structure provided by CLC Technical Team (*CLC2006 Technical Guidelines, 2006*) which guarantees that the metadata is recorded in a standardized way in all the countries. This specification assumes working unit and country level metadata information.

This specification defines the format and content of the metadata information that include:

- A. General information of contractors, imagery used, topographic maps and ancillary data;
- B. Data used: IMAGE2000 and IMAGE2006;
- C. Interpretation of CLC Changes and creation of CLC2006: photo-interpretation, internal control and border matching;
- D. Final technical quality control (applied by CLC TT): topology, database consistent, codes and minimum area
- E. Software/hardware used.

8. LAND COVER in Macedonia

Land Cover in Macedonia has been characterized by 31 out of 44 classes of the CORINE Land Cover nomenclature.

The analysis of the Land Cover database revealed that Semi-natural and forest areas dominate in the country with about 60% of coverage. Agriculture land occupies about 37% of the territory. Water bodies occupied 2.2%, Artificial areas 1.6% and Wetlands with 0.1%.

These figures are presented in the Table 2 and Figure 6, below:

| Area (ha) | Percentage (%) | Description |
|-----------|----------------|---------------------|
| 41,480 | 1.6 | Artificial surfaces |
| 939,013 | 36.9 | Agriculture |
| 1,548,855 | 59.8 | Semi-natural areas |
| 2,015 | 0.1 | Wetlands |
| 56,444 | 2.2 | Water |

Table 3

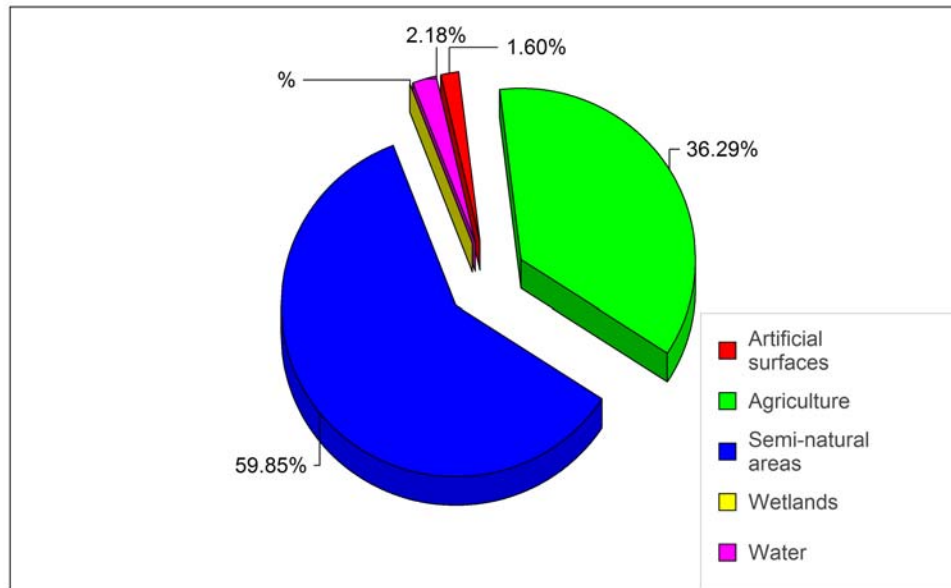


Figure 3

Table 4. CORINE Land Cover classes for the year 2006.

| | Code | CLC class | Area (ha) | Polygons | Percentage % |
|----|------|---|-----------|----------|--------------|
| 1 | 111 | Continuous urban | 109 | 1 | 0.004 |
| 2 | 112 | Discontinuous urban | 32 135 | 348 | 1.242 |
| 3 | 121 | Industry, commercial | 3 842 | 63 | 0.148 |
| 4 | 122 | Road /rail network | 108 | 3 | 0.004 |
| 5 | 124 | Airports | 388 | 3 | 0.015 |
| 6 | 131 | Mineral extraction sites | 2 834 | 30 | 0.110 |
| 7 | 132 | Dump sites | 1 118 | 16 | 0.043 |
| 8 | 133 | Construction sites | 207 | 4 | 0.008 |
| 9 | 141 | Green urban area | 302 | 5 | 0.012 |
| 10 | 142 | Sport and leisure facilities | 437 | 11 | 0.017 |
| 11 | 211 | Non-irrigated arable land | 255 252 | 428 | 9.864 |
| 12 | 212 | Irrigated arable land | 25 900 | 7 | 1.001 |
| 13 | 213 | Rice fields | 5 261 | 10 | 0.203 |
| 14 | 221 | Vineyards | 27 698 | 152 | 1.070 |
| 15 | 222 | Fruit trees and berry plantations | 2 282 | 41 | 0.088 |
| 16 | 231 | Pastures | 204 016 | 1 620 | 7.884 |
| 17 | 242 | Complex cultivation patterns | 230 730 | 1 306 | 8.916 |
| 18 | 243 | Land occupied by agriculture with significant natural areas | 187 874 | 1 654 | 7.260 |
| 19 | 311 | Broad-leaved forest | 748 365 | 1 329 | 28.919 |
| 20 | 312 | Coniferous forest | 48 000 | 407 | 1.855 |
| 21 | 313 | Mixed forest | 51 352 | 466 | 1.984 |
| 22 | 321 | Natural grassland | 197 393 | 796 | 7.628 |
| 23 | 322 | Moors / heathland | 14 794 | 97 | 0.572 |
| 24 | 323 | Schlerophyllous vegetation | 30 086 | 131 | 1.163 |
| 25 | 324 | Trans. woodland-shrub | 449 413 | 3 178 | 17.367 |
| 26 | 331 | Beaches, dunes, sand plains | 580 | 9 | 0.022 |

| | | | | | |
|----|-----|-------------------|--------|----|-------|
| 27 | 332 | Bare rocks | 419 | 12 | 0.016 |
| 28 | 333 | Sparse vegetation | 8 453 | 85 | 0.327 |
| 29 | 411 | Inland marshes | 2 015 | 17 | 0.078 |
| 30 | 511 | Water courses | 850 | 6 | 0.033 |
| 31 | 512 | Water bodies | 55 594 | 30 | 2.148 |

9. ANALYSIS OF CLC CLASS DYNAMICS

9.1. CLC class dynamics in Macedonia

The CLC Changes between 2000 and 2006 covers territory of about 35565 Ha, which is about 1.4% of the territory of the Country. The exact changes between CLC classes in hectares are given in Table 6.

During the period 2000-2006, there is similar trend of increase of artificial surfaces and water bodies and decrease of agricultural areas and forests and semi-natural areas as during the previous decade.

Table 5. CORINE Level 1 changes 2000 – 2006 (in hectares)

| Class | Decrease | Increase | Total change |
|-------------------------------|----------|----------|--------------|
| Artificial Surfaces | 385 | 2624 | 2239 |
| Agricultural Areas | 7423 | 4516 | -2907 |
| Forest and Semi-natural Areas | 27564 | 26720 | -844 |
| Wetlands | 60 | 84 | 24 |
| Water Bodies | 81 | 1569 | 1488 |

Table 5. Land cover changes in Macedonia 2000-2006

| C O D E | CODE_06 | | | | | | | | | | | | | | | | | | | | | | | | | | | | Total area | | |
|-------------------|---------|------|-----|-----|-----|-----|-----|-----|-----|-----|------|------|-----|-----|-----|-----|-----|-----|------|-----|-----|-----|-------|-----|-----|-----|-----|-----|---------------|------|-------|
| | 111 | 112 | 121 | 122 | 123 | 124 | 131 | 132 | 133 | 141 | 142 | 211 | 213 | 221 | 222 | 231 | 242 | 243 | 311 | 312 | 313 | 321 | 324 | 331 | 332 | 333 | 334 | 411 | | 511 | 512 |
| 111 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 112 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 121 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 122 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 123 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 124 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 131 | | | | | | | | | | | | | | | | 376 | | | | | | | | | | | | | | | 376 |
| 132 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 133 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 141 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 142 | | 9 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 9 |
| 211 | | 348 | 199 | | | | 12 | 141 | 9 | | | | 58 | 837 | 11 | | 153 | | | | | | | | | | | | 14 | | 1783 |
| 212 | | | | | | | | | | | 62 | | | | | | | | | | | | | | | | | | | | 62 |
| 221 | | | 26 | | | | | 8 | 38 | | 1348 | | | | | 355 | 38 | | | | | | | | | | | | | | 1812 |
| 222 | | | | | | | | | | | 450 | | | | | 125 | | | | | | | | | | | | | | | 575 |
| 231 | | 50 | 8 | | | | 205 | 126 | 56 | | 52 | | 24 | | | 227 | | 47 | | | | | 604 | | | | | | | 40 | 1441 |
| 242 | | 513 | 18 | 11 | | | 156 | 37 | 7 | | 45 | 5 | | | | | | | | | | | 20 | | | | | | 9 | 82 | 902 |
| 243 | | 132 | | | | | 110 | 3 | 2 | | | | 19 | 19 | | | | | 64 | 6 | | | 141 | | | | | | 20 | 332 | 849 |
| 311 | | | | | | | 26 | | | 112 | | | | | | 6 | | | | 5 | 102 | 94 | 18101 | | | | | | | 221 | 18667 |
| 312 | | 6 | | | | | 12 | | | | | | | | | | | | | | | | 674 | | | | | | | | 692 |
| 313 | | | | | | | 22 | | | | | | | | | | | | | 41 | | | 231 | | | | | | | 76 | 370 |
| 321 | | | | | | | 87 | | | | | | | | | | | 100 | 126 | | | | 479 | | | | | | | 194 | 987 |
| 322 | | | | | | | 16 | | | | | | | | | | | | | | | | | | | | | | | | 16 |
| 323 | | | | | | | | | | | | | | | | | | | | | 5 | | | | | | | | | | 5 |
| 324 | | 25 | | | | | 71 | 14 | | | 8 | | | | | 137 | 4 | | 4297 | 930 | 747 | | | | | | | | | 594 | 6827 |
| 331 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 332 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 333 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 334 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 411 | | 1 | | | | | | | | | | | | | | | 58 | | | | | | | | | | | | | | 60 |
| 511 | | | | | | | | | | | | | | | | | | 5 | | | | | | | 5 | | | | | | 11 |
| 512 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 70 | | 70 |
| Total area | | 1085 | 250 | 11 | | | 717 | 328 | 224 | | 8 | 1957 | 82 | 881 | 11 | 519 | 923 | 143 | 4586 | 988 | 849 | 94 | 20250 | 5 | | | | 84 | 29 | 1540 | |

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