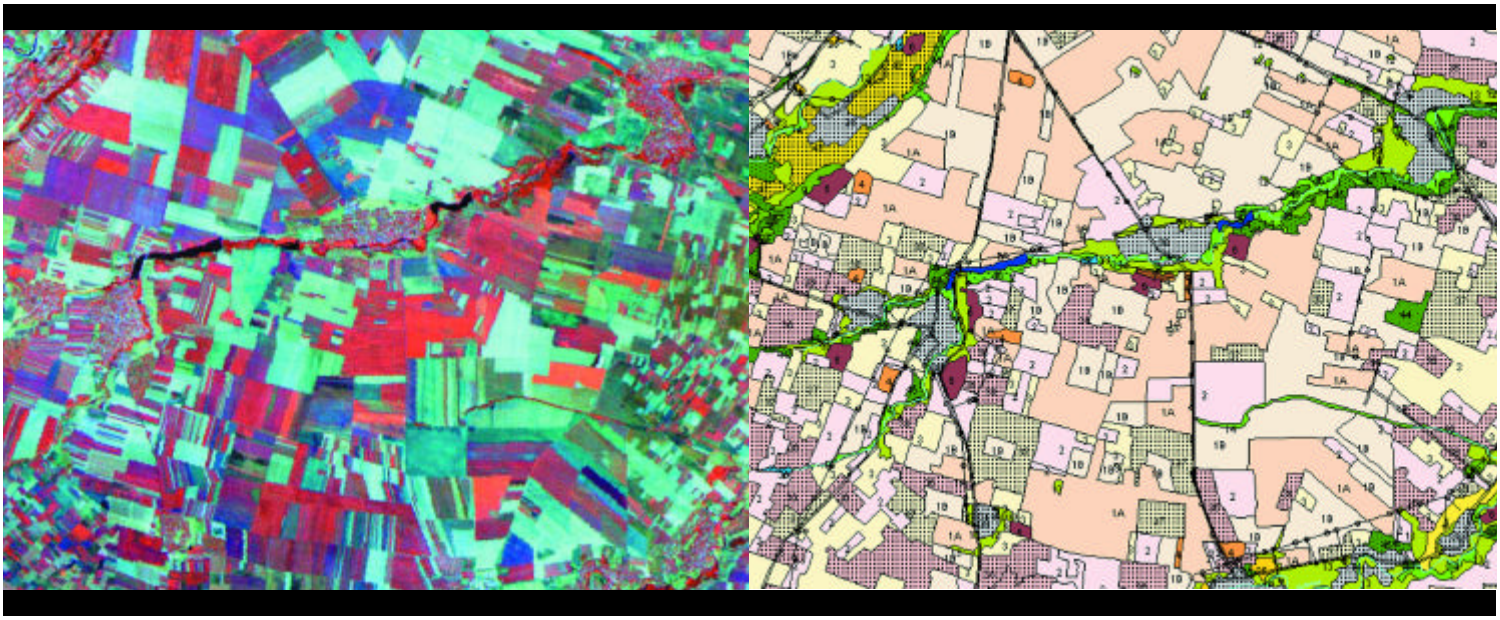
Remote Sensing for Decision-Makers Series N° 21

PREPARATION OF A LAND COVER DATABASE THROUGH REMOTE SENSING AND GIS

Pilot study in Bulgaria



THE DECISION-MAKERS SERIES: FOR WHOM AND FOR WHAT?

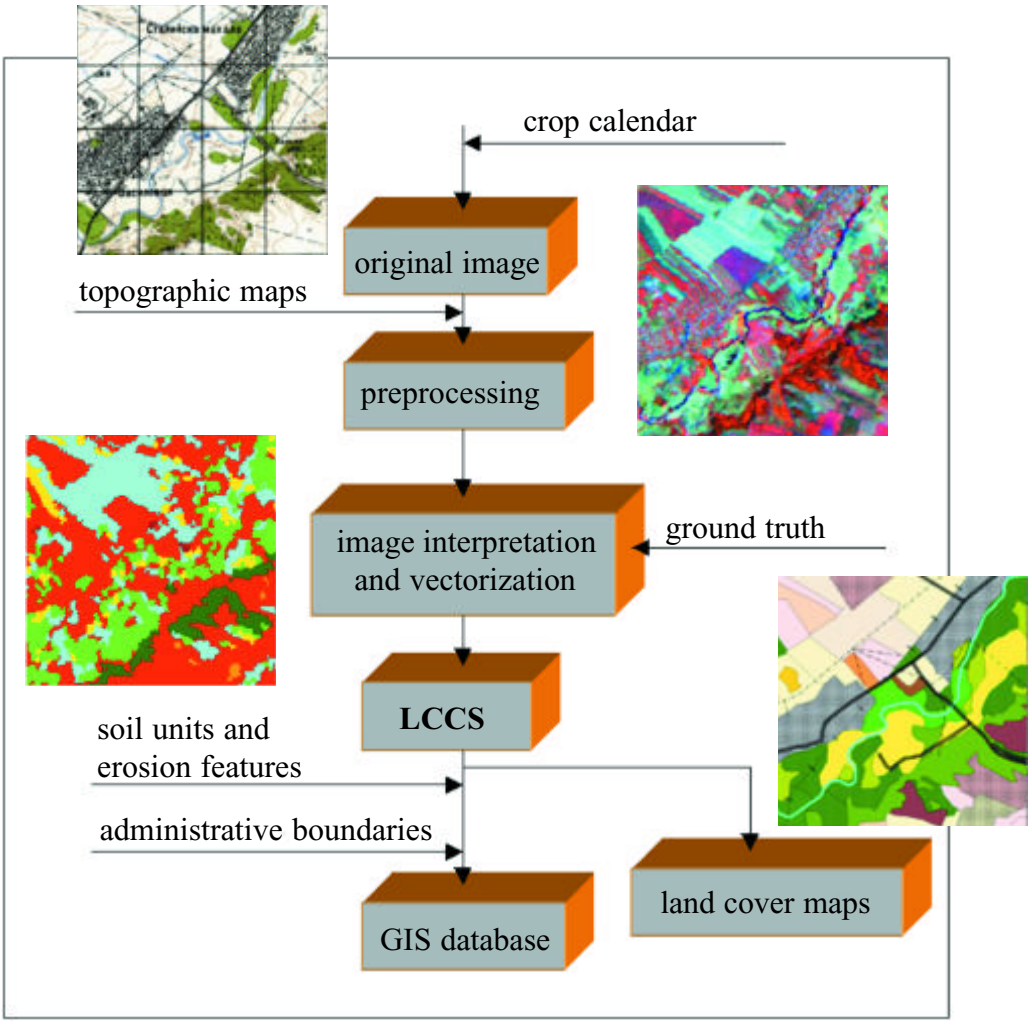
This series, produced by the FAO Environment and Natural Resources Service, is intended for such decision-makers as heads and division directors of national and international organizations and administrations, as well as for project managers, planners and policy-makers of development institutions. Its aim is to present new possibilities of using remote sensing and geographic information system (GIS) techniques to aid planning for, and management of, renewable natural resources in agriculture, forestry and fisheries. This issue is specifically intended for decision-makers concerned with land cover mapping and land management.

THE NEED FOR UPDATED LAND COVER INFORMATION

Land cover maps constitute necessary tools for development planning and management of the territory. Furthermore, land cover maps depicting the current reality are essential in countries where, due to political changes, rapid dynamic phenomena have taken place, resulting in a complete restructuring of the agricultural and other sectors, as in the case of Bulgaria.

The scale of such maps should be large enough to provide detailed information; however, it should allow for regional assessment, statistics and subsequent planning. The 1:50 000 scale is the most suited for this exercise.

For optimal use, land cover maps should be in digital format, which allows easy updating, and associated with a GIS including other information such as soil units, erosion features and provincial/municipal boundaries. The resulting database is an essential tool for decision-making in land management.



Methodological approach

WHAT IS REMOTE SENSING?

Remote sensing covers all techniques related to the analysis and use of data from environmental and earth resources satellites (such as Meteosat, NOAA-AVHRR, Landsat Thematic Mapper (TM), SPOT and ERS-SAR) and from aerial photographs.

The main function of remote sensing is to map and monitor the earth's resources. Compared with traditional survey techniques, satellite remote sensing is accurate, timely and cost-effective.

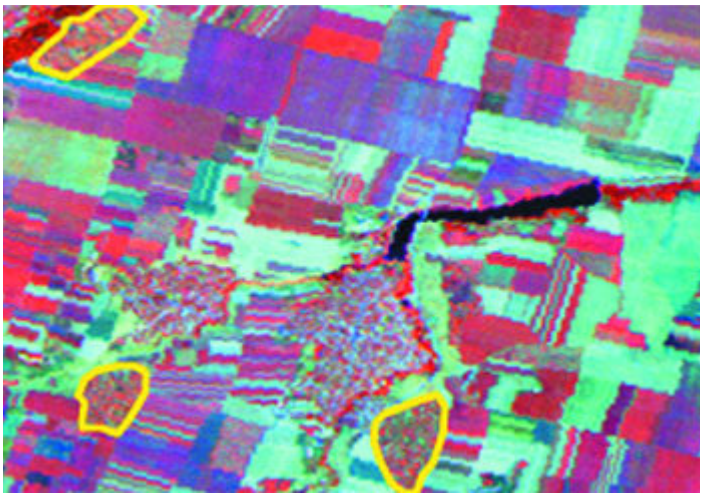
WHAT IS GIS?

The term "geographic information system" is currently applied to computerized information storage, processing, analysing and retrieval systems that have hardware and software specifically designed to cope with geographically referenced spatial data and corresponding attribute information. Spatial data are commonly in the form of maps depicting topography, water availability, soil types, forests and grasslands, climate, geology, population, landownership, administrative boundaries, infrastructure (highways, railways, electricity or communications systems), etc. The capability of combining different maps in a single operation, known as "overlaying", is one of the most important GIS functions, together with modelling and site selection.

HIGH RESOLUTION SATELLITE IMAGERY

The operational availability of high-resolution satellite imagery, namely Landsat TM, SPOT, Soyouz, ERS-SAR, RADARSAT and others, opens up new possibilities for investigating and monitoring natural resources. Compared with information acquired by traditional methods, these data offer a number of advantages:

- They provide synoptic coverage and therefore give an exhaustive view of vast areas at the same time.
- They can be acquired for the same area at a high rate of repetition (two to three times a month), thus permitting selection of the most appropriate seasonal data.
- Satellite imagery is recorded in various wavelengths, visible and non-visible, which provide accurate information on ground conditions.
- They can be obtained for any part of the world without encountering administrative restrictions.



Vineyards and their appearance on Landsat TM (interpretation key)

K-3-34-B (BOITCHINOVTZI)

1:50 000

3 0 3 6 Km

LEGEND

	GIS CODE
ROADS	
Unpaved roads	5002-5
Roads	5002-4
Highways	5002-4(1)[Z019]
RIVERS	
Temporary rivers	8003-1
Rivers	8002-1
Major rivers	8002-1(1)[Z020]
Railways	5002-6
Electric network	5002-7(1)[Z021]
Irrigation channels	7001-1
LCCS-CLASSES	
CULTIVATED AND MANAGED LAND	
1. Very large herbaceous fields	10657-11375(1[Z16]
1.A. Very large herbaceous fields (active crop)	10657-11375(3[Z1)(1)[Z16]
1.B. Very large herbaceous fields (not active crop)	10657-11375(3[Z2)(1)[Z16]
2. Large size herbaceous fields	10657-11375(1[Z15)(3[Z4]
3. Medium size herbaceous fields	10657-12005(3[Z4]
4. Horticultures	11015-50510(2[Z3)
5. Gardens	11135
6. Vineyards	10586-1891-50510
7. Orchards	10494-1891-WE
8. Rice fields	2079-50308
NATURAL VEGETATION	
9. Deciduous forest	20097
10. Coniferous forest	20099
11. Mixed forest	20097-15045
12. Patches of trees	20097(3[Z5]
13. Grassland	20194
14. Riverine deciduous forest	20097(3[Z8]
15. Mountain grassland	20194-P3
16. Flooded forest	40156
17. Wetlands	40217
18. Peat bogs	40219-4732
ARTIFICIAL SURFACES	
19. High density urban areas	5003-13
20. Medium density urban areas	5003-14
21. Residential complexes	5003-14-A44Z7
22. Industrial and other associated areas	5003-8
23. Airports	5003-A21
24. Cemeteries	5003-A23
25. Built-up areas	5003-A44[Z9]
26. Dump sites	5004-1
27. Extraction sites	5004-2
28. Tailing ponds	5004-1(2)[Z012]
29. Sport facilities	5003-A38
30. City parks	11177
31. Park "Vrana"	11177(3)[Z10]
32. Greenhouses	5003-A44[Z11]
BARE AREAS	
33. Rocky river beds	6002-1(3)[Z13]
WATER BODIES	
34. Artificial lakes	7002-5
35. Ponds	7002-5(3)[Z14]
MIXED UNITS	
36. Large/Medium size herbaceous fields	10657-11375/10657-12005
37. Medium/Large size herbaceous fields	10657-12005/10657-11375
38. Low density residential areas/Gardens	5003-15/11135
39. Gardens/Low density residential areas	11135/5003-15
40. Vineyards/Grassland	10682-1801-50510(1)/20203[Z017]
41. Orchards/Grassland	10510-1891-W8(1)/20194[Z018]
42. Gardens/Grassland	11135/20203
43. Grassland/Gardens	20203/11135
44. Grassland/Shrubs/Trees	20194/20023/20015
45. Grassland/Shrubs	20027/20023
46. Trees/Shrubs/Grassland	20007/20023/23203
47. Bare areas/Grassland	6005/20203
48. Bare rocks/Grassland	6002-1/20203
49. Woodland/Grassland	20008/20233

FOOD AND AGRICULTURE ORGANIZATION of THE UNITED NATIONS

Bulgarian Aerospace Agency / Българска аерокосмическа агенция — BASA

TCP/BUL/8922

"Strengthening capacity in agricultural development through remote sensing and GIS"

LAND COVER MAP

Land Cover Classification System - FAO

Main data source: LANDSAT TM acquired 2 August 1998.

Example of a land cover map 1:50 000 scale

PILOT STUDY IN BULGARIA: PREPARATION OF LAND COVER MAPS AND ASSOCIATED DATABASE

• Production of land cover maps

Three large areas in different regions of Bulgaria were selected by the FAO Project TCP/BUL/8922 as representative of the agricultural production of the country. An operative methodology for the preparation from recent satellite data of land cover maps specially devised for agricultural applications, was tested and finalized. The most recent Landsat TM data, cloud-free and acquired over the test areas according to the local crop calendar, were used.

The land cover was classified according to the FAO **Land Cover Classification System (LCCS)**, a comprehensive, standardized *a priori* classification system, created for mapping exercises and independent of the scale or mapping method. The classification uses a set of independent diagnostic criteria that allow correlation with existing classifications and legends. The system could therefore serve as an internationally agreed reference base for land cover. The methodology is applicable at any scale and is comprehensive in the sense that any land cover identified anywhere in the world can be readily accommodated.

As a result, 14 land cover maps at 1:50 000 scale were completed for a total area of 5600 km^2. The map legend includes the 49 land cover classes which were identified for the three study areas. The methodological approach indicated in the figure is described in the FAO technical paper: *Preparation of land cover database of Bulgaria through remote sensing and GIS*, Environment and Natural Resources Working Paper No 6.

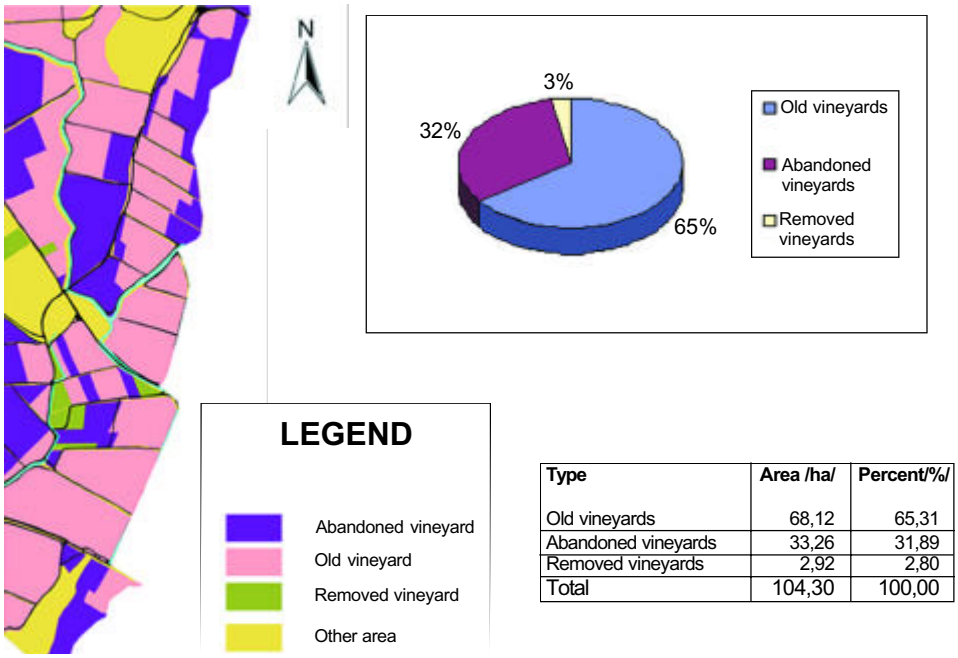
• Database development

Soil types and erosion features, obtained from traditional sources, were linked to each land cover mapped unit as attributes into a GIS system. This resulted in a comprehensive database, which provides useful information for agriculture, forestry and urban development planning, for environment protection, and for many other applications. The data collected in the database allow for different kinds of spatial analyses, which are necessary in land management. As the database has been developed using ArcView, a common GIS software package, it will be easy to combine the database with other data sets, existing or in preparation, for a variety of different applications.

• Large scale mapping

The flexibility and accuracy of satellite mapping were demonstrated by using a different kind of satellite data, which is more expensive but offers the possibility of mapping at a large scale (1:5 000). For an area of particular interest, IKONOS very high-resolution satellite data (1 m - pan sharp) were used successfully to:

- update existing large-scale soil and topographic maps (drainage system, road network...);
- update large-scale land cover/land use inventory and monitoring of permanent crops such as vineyards and orchards.



Type	Area /ha/	Percent/%/
Old vineyards	68,12	65,31
Abandoned vineyards	33,26	31,89
Removed vineyards	2,92	2,80
Total	104,30	100,00

State of vineyards for part of the Sandanski region, using IKONOS very high-resolution data acquired in August 2000

EVALUATION AND RECOMMENDATIONS

Costs and delivery times

	Cost (US$/km^2)	**Time** (months)	
Acquisition of satellite data: Landsat	2.9	1	
Image processing and interpretation	0.5	1	
Ground survey	0.5	1.5	
GIS/Database preparation	0.8	2	Map
preparation	0.2	0.5	
Total	4.9	6	
Acquisition of satellite data: IKONOS	24.0	1	

Note: Landsat data were purchased for more than one agricultural season; IKONOS was used only for a small area.

Advantages of land cover maps and associated database

- Land cover maps constitute necessary tools for the development planning and management of the territory. As land cover/land use maps require more frequent revision than topographic maps, which is particularly true in countries with ongoing transformation of their economies, revision at five-year intervals may be adequate. Satellite remote sensing provides a cost-effective and accurate tool for their updating and, by using the FAO LCCS, the map legend is developed in parallel with the satellite data interpretation, as opposed to land cover classifications using a predefined legend. This underlines the flexibility and precision of the LCCS methodology.
- When a comprehensive database is also prepared, the land cover maps and associated database form the baseline information for the correct application of agricultural statistics.
- As the maps and database are georeferenced to the national topographic grid, for each mapped unit (polygon) it is possible to ascertain the exact location, its surface coverage, its inherent land cover, the soil type occurring there and the forms of erosion affecting the site.
- By adding municipal and district boundaries to the database, it will be possible to extract interesting statistics concerning the land cover features.

Conclusion

The pilot study in Bulgaria demonstrated the accuracy, flexibility and cost-effectiveness of satellite remote sensing, coupled with LCCS methodology, for land cover mapping. The preparation of a database adds further value to the exercise.

The above approach is now implemented in many countries worldwide.

Project undertaken by the Bulgarian Aerospace Agency (BASA), assisted by FAO Environment and Natural Resources Service, in the framework of project TCP/BUL/8922 “Strengthening Capacity in Agricultural Development through Remote Sensing and GIS”.

The Remote Sensing for Decision-Makers Series can be obtained from:

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