Geospatial Technologies in Czech Forestry and Landscape Management Students Education

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Abstract

Spatial and temporal characteristics of forest complexes are important for sustainable management of forests, especially in Central Europe, where forests are damaged by air pollution and endangered by climate change. Contemporary geoinformation technologies provide powerful tools for evaluation of needed features. In Czech Republic, new forest management plans (including forest maps) are usually produced in digital format. All forestry and landscape management students have to master geospatial technologies, using digital data of University Forest (forest maps, satellite images, historical and topical aerial photographs, DTM, land use, GPS data, temperature records and other kinds of data.) Presentation and sharing of digital spatial data has been solved by implementing web mapping services (WMS) technology (MapServer of Minnesota University). Students obtain general theoretical and practical knowledge of geospatial technologies in "GIS fundamentals" course. Geoanalytic and image processing system IDRISI has been used as a main tool for essential education of students since 1993. Bentley MicroStation, ESRI ArcView, Intergraph GeoMedia, ERDAS Imagine, ER Mapper and other GIS and image processing systems are used at more advanced level. Advanced students are introduced to remotely sensed data processing, including multispectral data evaluation, vegetation indices, hard and soft classification methods, fuzzy sets, etc. They also learn advanced GIS analysis methods – multi-criteria and multi-objective evaluation, risk analysis, change and time series analysis, decision support methods and statistical modeling. Contextual classification software (eCognition) and satellite data of very high resolution (Ikonos) are used by doctoral students. All students elaborate semestral project that includes map composition, new thematic layers creation, skidding track optimization, flood modeling, etc. New curriculum focused on geoinformation technologies has been accredited last year.

Contemporary problems of sustainable forestry in Czech Republic

Forests carry out the important role in human life, producing timber and preserving an environment suitable for our livelihood. It is therefore important to maintain forest resources efficiently, and, where possible, to improve their quality. Important tasks for near-natural forest management include growing of healthy forests, preserving or increasing their ecological stability and keeping wood-producing and non-wood-producing roles of forests well-balanced.

In Czech republic, forests cover more than 1/3 of the country territory, influencing considerably the country environment. Czech forest management has, owing to its long history, a high technical and processing standard. Forest Management Guidelines, Forest Management Plans and Regional Plans of Forest Development provide important management rules for forest owners. In spite of that, contemporary forestry in Czech republic faces several problems. Air pollution, cause of collective forests dieback during second half of last century, has been substantially reduced since 1990. Nevertheless, although acid deposition is lower, NO_x deposition grows along with growth of mobile sources (automobile transport). As in the past pollutants have already seriously eroded forest stability, vitality of forests can be now easily endangered by a relatively low supply of polluting matter or by unfavorable abiotic or biotic factors. Increasing earth surface temperature and other effects of global climate change often contribute to unfavorable synergic impacts. Windblasts, heavy snow depositions, icing, floods and drought often disturb existing forest ecosystems. Sub-cortical and leaf-eating species of insects, fungal diseases and game damages are examples of most harmful biotic factors.

Remedies of forest damage depend on precise and timely damage detection. During every stage of forest management, foresters can use Remote Sensing and GIS data for detecting this kind of problems. But, if they want to make profit of contemporary digital imagery and digital map data, they need to be

familiar with certain principles and techniques used in digital geospatial data processing and manipulation.

Education of forestry and landscape management students at Mendel University Brno in Geoinformation technologies

Geoinformation technologies

At Mendel University of Agriculture and Forestry Brno, geoanalytic and image processing system IDRISI has been used as a main tool for essential education of students in geospatial technologies since 1993. Bentley Microstation, ESRI ArcView, Intergraph GeoMedia, ERDAS Imagine, ER Mapper and other GIS and image processing systems are used at more advanced level. Doctoral students can work also with eCognition (Definiens Imaging) contextual classification software.

Raster oriented system IDRISI, in its 14th release (Kilimanjaro) is an innovative and functional geographic modeling technology that enables and supports environmental decision making for the real world. The software has been developed by Clark Labs (Clark University, Worcester, Ma, USA). As a non-profit system IDRISI acquired a great many users all over the world. The software is supported by network of 15 IDRISI Resources Centers (IRC); they are situated in Argentina, Brazil, Chile, Czech Republic, Hungary, India, Italy, Morocco, Poland, Slovakia, South Africa, Spain, Switzerland, UK-Aberdeen and UK-Greenwich. These centers offer IDRISI-related resources for users outside United States. They make available basic information about IDRISI, offer training in IDRISI, host IDRISI User's Meetings, and represent Clark Labs at local conferences.

IRC in Czech Republic has been established at Mendel University in 1997; it is jointly administered with Technical University Zvolen, Slovakia. Since than, a lot of remote sensing and GIS data was created and interesting results of practical applications of geospatial technologies were acquired. Educational data concern mainly Mendel University forest called "Masaryk Forest" (10,400 ha), situated north of Brno that serves as a place of educational and practical training for students. Research data cover also several Czech mountains (the Beskids, the Giant Mountains, the Bohemian Forest).

Students obtain general theoretical and practical knowledge of geospatial technologies in "GIS fundamentals" course. At the beginning of practical exercises they familiarize themselves with various spatial data formats, data models and corresponding file structures, as well as with basic GIS functions. Students solve spatial problems using database queries, distance and context operators, cost distances and least-cost pathways, map algebra and spatial database management system. Beside that they work individually on a complex project related to given area of "Masaryk Forest" territory. At these specific plots they can demonstrate gained skills and produce operative results. Digital land use map and digital terrain model (DTM) provide basic working data. Forest management maps and numeric data of the forest management plan are also available. Map of tree species composition optimized for a given vegetation zone according to altitude and aspect, model of flood caused by torrent precipitation, or design of new skidding track connected to forest road in a given forest stand, all these tasks represent typical practical outputs of individual student projects.

Advanced students are introduced to remotely sensed data processing, including multispectral data evaluation, vegetation indices, hard and soft classification methods, fuzzy signatures, etc. They also learn advanced GIS analysis methods – multi-criteria and multi-objective evaluation, risk analysis, change and time series analysis, decision support methods and statistical modeling.

As Czech forest management planning rapidly proceeds from analog to digital methods, students also need to master graphic environment of the most important software used in Czech forestry – GIS TOPOL, product of Czech "Topol Software" company. Topol native data format (BLK) serves as a standard for digital Czech forest data. The newest product of the company, Topol 2001, has open modular architecture based on OLE/COM/ActiveX standards for Win32. Access to vector-oriented spatial data is based on database principles. The use of ADO (ActiveX Data Object) technology enables to convert GIS data into XML documents, which are currently applied as the most effective tool for data exchange on Internet. Topol 2001 currently supports following image formats without any need for conversion: TIFF, Windows BMP, CIT, JPEG, GIF, PCX and TopoL RAS (including RAK variant).

Digital spatial data

Digital forest management map, digital land use map and digital terrain model (DTM) represent the most important groundwork of the "Masaryk Forest" spatial database. Digitized historical and recent aerial photographs provide important information on spatial arrangement of forest stands and on their successive changes. Satellite data (Landsat, SPOT and Ikonos) acquired for the "Masaryk Forest" territory offer comparative material for various analyses.

New spatial information on "Masaryk Forest" is also produced as part of students' diploma and dissertation thesis. A diploma thesis focused on creation of DTM for the whole "Masaryk Forest" territory and on possibilities of using this model in various forestry disciplines can be given as an example.

The problem of presentation and sharing of digital spatial data has been fixed up by implementing web mapping services (WMS) technology. MapServer of Minnesota University (USA), developed in cooperation with NASA and Minnesota Department of Natural Resources, became an optimal solution. Beyond browsing GIS data, MapServer allows creating geospatial maps that can direct users to content. MapServer is an OpenSource development environment for building spatially enabled Internet applications that run on Linux, UNIX and Windows platforms. It serves also as powerful common gateway interface (CGI) application providing many services for map presentation and editing. It supports ESRI shapefiles, ESRI ArcSDE, TIFF/GeoTIFF, GIF, JPEG, ERDAS and ESRI Grid. MapInfo and DGN data formats can be read; Oracle and PosgreSQL databases can be used for data storage. For Czech republic users there is an important advantage in a feasibility to read and display vector data from several coordinate systems (e.g. S-42, S-JTSK and WGS-84) and to display concurrently both raster and vector data. Help Service – Remote Sensing Company of Benesov near Prague, has localized application MapServer into Czech language. Mendel University Faculty of Forestry MapServer can be visited on http://www-ldf.mendelu.cz/mapserv/krtiny/krtiny.html. This MapServer is fully compatible with MapServer of Help Service – Remote Sensing Company in Benesov and with MapServer of Forest Management Institute, Brandys nad Labem – a government organization established by the Ministry of Agriculture of the Czech Republic that manages the central forest database and forest and hunting archives in the Czech Republic.

Faculty of Forestry MapServer at present contains following digital data of "Masaryk Forest":

- Land use map, created by second author (Klimanek, 2001) from vectorised forest maps 1:10000, derived state maps 1:5000 and orthophotographs of the "Masaryk Forest" territory (see Fig. 3). Information on land use at forest land has been extracted from numerical forest database and classified according to tree species composition into 6 categories (3 conifers, 3 broadleaved, see Table 1). Non-forest land was classified from orthophotographs and derived state map 1:5000 into other 7 categories.

Table 1: Land use categories at "Masaryk Forest"

No.	Category	Description
1	Conifers 1	Spruce monocultures or mixed stands with prevailing spruce
2	Conifers 2	Fir stands or mixed stands (spruce, beech, fir), other conifers (Douglas fir, larch)
3	Conifers 3	Pine monocultures or mixed stands with prevailing pine
4	Broadleaved 1	Oak monocultures or mixed stands with prevailing oak
5	Broadleaved 2	Beach monocultures or mixed stands with prevailing beach
6	Broadleaved 3	Mixed stands of other broadleaved trees (hornbeam, linden, maple, birch)
7	Urban	Houses, industrial zones, villages, towns, cities
8	Water	Rivers, streams, ponds, water reservoirs
9	Fields, meadows	Agriculture land (fields, meadows), orchards, gardens
10	Communications	Roads
11	Railways	Two track electric railway
12	Power lines and pipelines	Electric lines, water pipes, gas pipes
13	Quarries, clay pits	Quarries, clay pits, dumping sites

- Raster digital terrain model (DTM) with 10 m resolution and its derivatives (slope, aspect), created from contours of analog Czech Republic base map 1:10000.

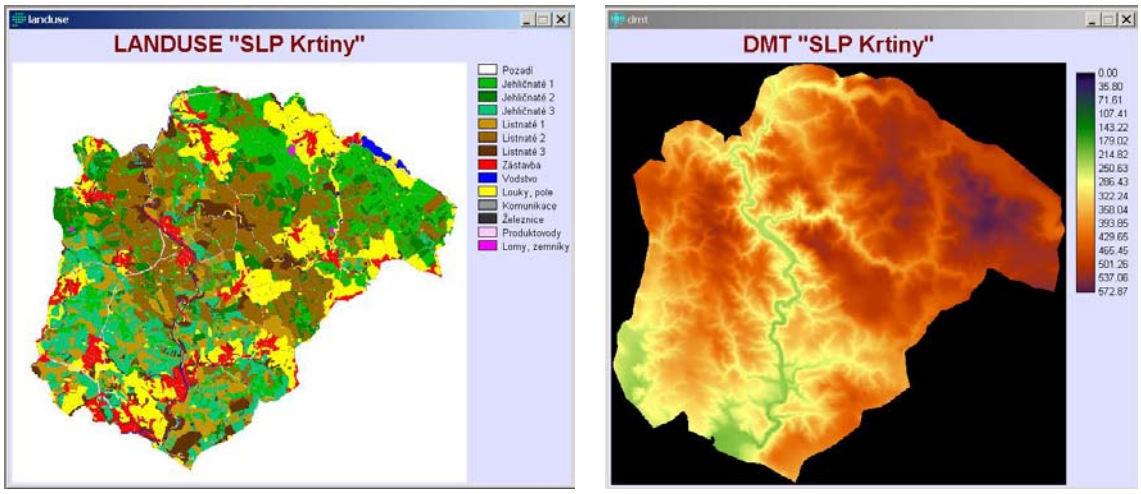

Figure 1. Left: Land use map of the "Masaryk Forest". Right: DTM of the "Masaryk Forest".

- Black and white and colour infrared aerial photographs acquired in August 2001(see Fig. 2, Fig. 5), digitized and converted into TIFF format. The original set contains 139 maps in 10 rows with 60% endlap and 25% sidelap. Photographs were scanned with resolution of 907 pixels/inch, orthorectified and mosaicked into seamless orthophotomap by Help Service – Remote Sensing Company. This data was used as input for new forest management maps, valid for 2003-2012 period.
- Forest management maps of 1993-2002 and 2003-2012 planning periods in TIFF format (see Fig. 2).

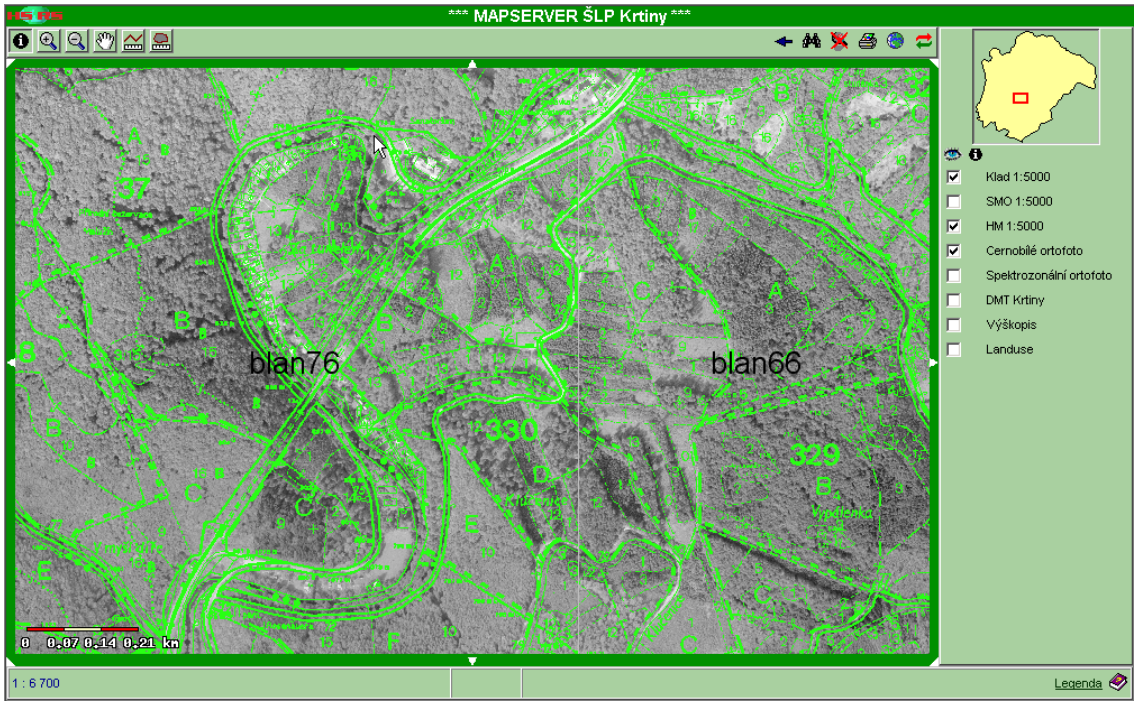

Figure 2. Zoomed forest map on a gray-scale orthophoto background (Svitava river valley near Adamov)

- Derived state maps 1:5000 in TIFF format, including map sheets layout in ESRI shape-file format.
- Vector elevation data are represented by contours (10 m interval) file in ESRI shape-file format (see Fig. 3).

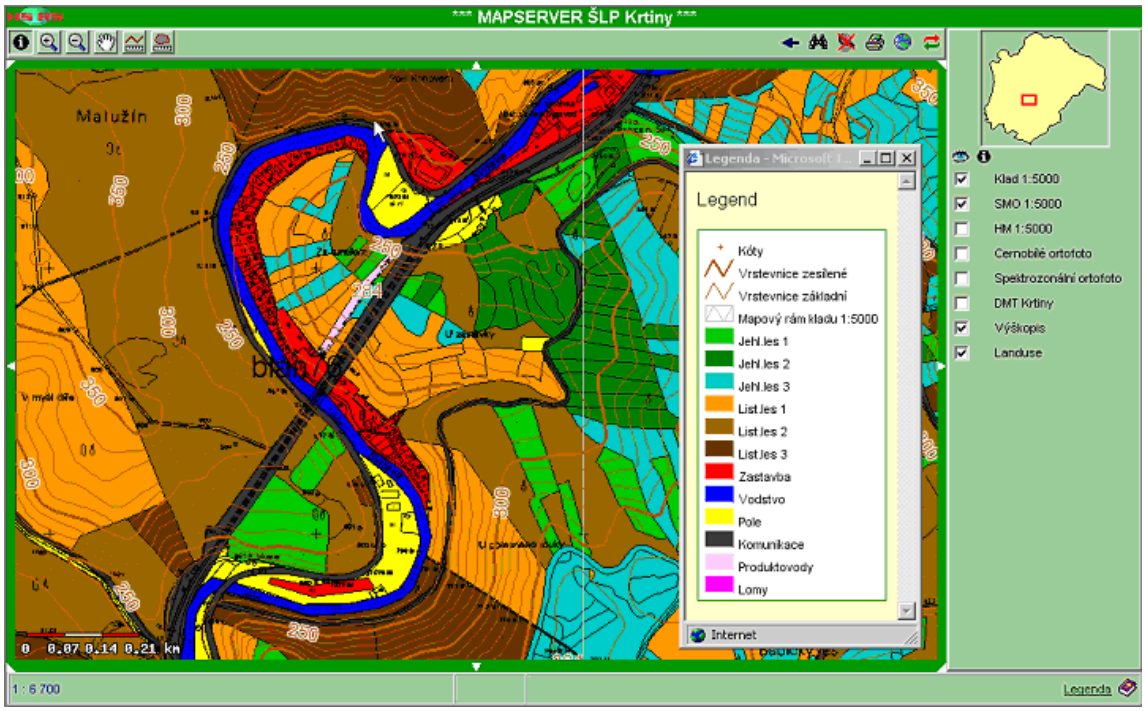

Figure 3. Zoomed land use map with contours (Svitava river valley near Adamov)

- Temperature map, computed from DTM according to a regression equation corrected by slope, aspect and by data from 13 climatic stations in the territory.

Data that will be placed to MapSever in nearest future:

- Map of forest types, classified according to the Czech forest typology standard.
- Historical BW aerial photographs of "Masaryk Forest" from summer 1927, details of the mission reported in Zidek 2003 (see Fig. 4).

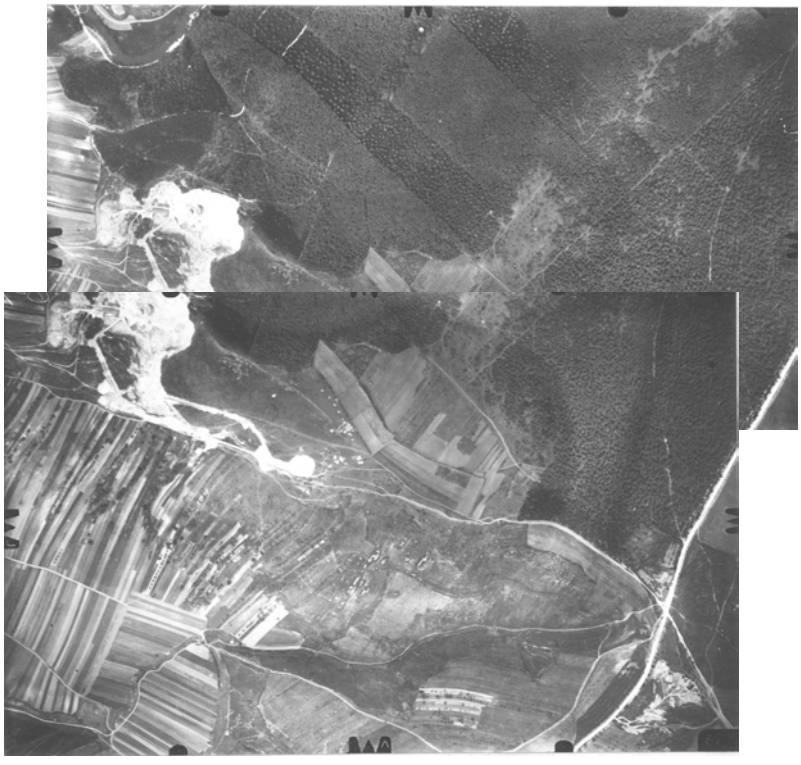

Figure 4. Digitized stereo-pair of historical aerial photographs set from 1927

- Landsat TM imagery – May 2001, October 2000; obtained courtesy of Prof. Barry Rock, University of New Hampshire, USA.
- SPOT imagery – April 2001; obtained courtesy of Ing. Raymond Nadal, GDTA Toulouse, France.
- Ikonos multispectral and panchromatic imagery – March 2002; obtained courtesy of Ing. Hervé Joannes, GDTA Toulouse, France (see Fig. 5).

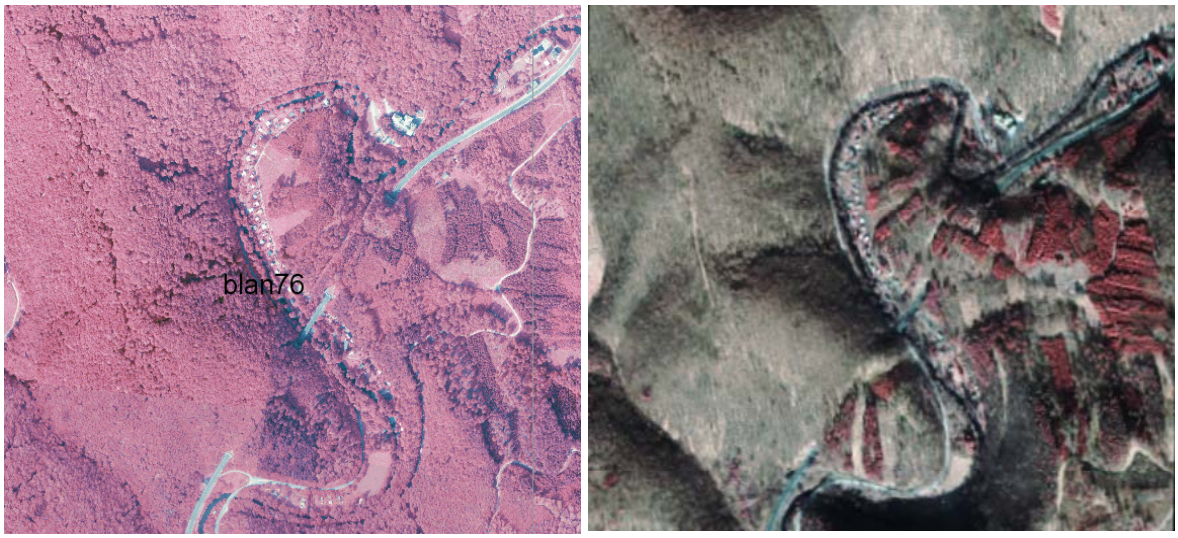

Figure 5. Left: Tree crowns on a scanned photo-mosaic of CIR aerial photographs (August 2001), resolution 0.33 m. Right: Tree crowns on pan-sharpened multispectral colour composite image (March 2002), resolution 1.0 m (Svitava river valley near Adamov)

- Digitized historical maps of "Masaryk Forest".
- Selected data of Regional Plans of Forest Development, produced by Forest Management Institute, Brandys nad Labem.
- Digital map outputs of diploma and dissertation student theses.

Conclusions

Importance of geoinformation technologies, enabling efficient digital data processing, gradually increases at present-day society. Nevertheless, their effective applications require users' skills. These skills are difficult and expensive to achieve in practice. Providing students with necessary knowledge and skills is therefore an important task of educational institutions, mainly academic ones. In contemporary Czech forestry, as well as in Czech landscape management, digital geospatial data begin to prevail. At Faculty of Forestry and Wood Technology, Mendel University of Agriculture and Forestry Brno, considerable effort is therefore invested to produce graduates that are fully prepared to use modern geoinformation tools in their professional lives. For that purpose, new Master curriculum focused on integrated landscape utilization and geoinformation technologies has been accredited last year.

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Appendix Structure "Questionnaire"

General information

Function; size and type of organization; number of GIS jobs, amount of time working with GIS

Mendel University of Agriculture and Forestry Brno: 5000 students
Faculty of Forestry and Wood technology: 1200 students
Department 411 (Geoinformation Technologies): 7 teachers (lecturing remote sensing, GIS, surveying and GPS), viz. 1 professor in Geoinformatics, one associate professor, and 5 lecturers.