4. REMOTE SENSING.

The main remote sensing activities in Slovakia during the period of past two years were concentrated in the following 4 institutes: ***Institute of Geography, Slovak Academy of Sciences; Slovak Environmental Agency (SEA) Remote Sensing Department; Forest Research Institute in Zvolen; Faculty of Electrical Engineering and Informatics, Department of Cybernetics and Artificial Intelligence, Technical University Košice.***

In the ***Institute of Geography, Slovak Academy of Sciences***, the following activities were carried out and selected results were obtained:

A Landscape changes in Slovak Republic 1970s–1990s.

The contemporary progress in the field of mapping, part of which are remote sensing and geographical information systems (GIS), offers new possibilities of observation the landscape changes in various scales - from local to global ones. This trend is characterised by the possibility rendered by remote sensing data to create compatible and comparable databases of extensive territories and in different time horizons that can be analysed using the GIS and presented as thematic maps.

Maps of *landscape changes* presented through the *land cover changes* are a suitable tool of the knowledge-gathering, analysis, planning intentions and decision-making processes. Map expression of the land cover changes represents an efficient document on the landscape development comprising the semi-natural and natural parts of landscape and simultaneously of the dynamics of the development of urbanised and agricultural landscapes.

One of the tasks of the EEA Phare Topic Link on Land Cover Consortium, co-ordinated by the GISAT company from Prague (including other members: HNIT Baltic from Vilnius, Romanian Geological Institute from Bucharest, and the Institute of Geography, Slovak Academy of Sciences from Bratislava) was to create land cover changes database in four Phare countries (Czech Republic, Hungary, Romania and Slovak Republic) representing the period of the 70's and 90's.

The inputs into the above mentioned database were the satellite images Landsat MSS from the second half of the 70's and the land cover data in scale 1:100 000 from the first half of the 90's achieved under the CORINE Land Cover Project (CLC). Using the methodology of computer assisted visual interpretation a new database at the second hierarchic level was created, which represents the state of land cover in the 70's. Its comparison with the CLC data

from the 90's led to creation of database of the land cover changes which took place in the territory of Slovakia over the period of approximately fifteen years.

The area of the identified landscape changes was 315 000 ha representing 6.4 % of the total area of the country (4 905 174 ha). Obtained results have shown the most extensive type ofchange in the period of the 1970s/1990s were areas of intensification of agriculture, deforestation and intensification of agriculture.

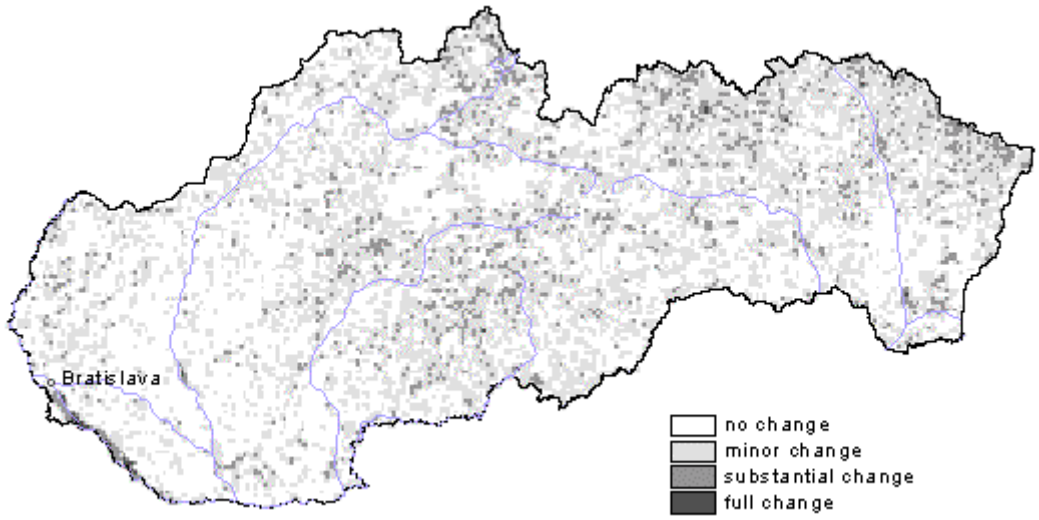

Fig. 10. The spatial intensity of landscape changes identified in Slovakia

b. Using CLC database for soil water erosion risk assessment in Slovak Republic

Soil water erosion is usually a complex process involving a number of contributing factors. The contemporary hardware/software possibilities, as well as new methodical approaches, enable to integrate effectively large data sets and to analyse this process at different levels of complexity.

In 1996 the Institute of Geography SAS in co-operation with Soil Fertility Research Institute were involved in Phare MERA Land Degradation project. In the frame of it the soil water erosion risk assessment at regional scale (1:500 000) was realised. The two aspects were studied - ***potential soil erosion risk*** (indicates the inherent susceptibility of land to erosion irrespective of existing land cover) and ***actual soil erosion risk*** (refers to estimated present risk, taking into account contemporary land cover and management practices that modify potential erosion risk).

The modification of Wischmeier and Smith's USLE model was applied for computation of soil erosion risk as the product of *rainfall erosivity* (R factor), *soil erodibility* (K factor), *topographic potential* (S factor) and *protective function of land cover* (C factor). The assessment methodology for the whole country was carried out in two steps - calculation of the *potential soil erosion risk* (E_P) and *actual erosion risk* (E_A). The applied procedure can be expressed in simple empirical formulae:

- potential soil erosion risk $E_P=R.K.S$
- actual soil erosion risk $E_A=E_P.C$

The first three input parameters (R, K and S factors) were derived from the climatic data, soil maps and digital elevation model. The CORINE Land Cover database at scale 1:100 000 was considered to be valuable information source for estimation the C factor. To derive the C factor the land cover classes (total 31 in the territory of Slovakia) were reclassified and applied in the model.

The results have confirmed that GIS data integration and analysis is an efficient approach for obtaining information on spatial variability of environmental risks (namely soil water erosion) at regional scale. They also revealed that more than 75 % of the territory of Slovakia is potentially endangered by soil erosion risk. A relative good protective function of forests subdues soil erosion in the mountains. Due to agricultural land management the highest actual erosion risk occurs in hillylands and intramountainous basins.

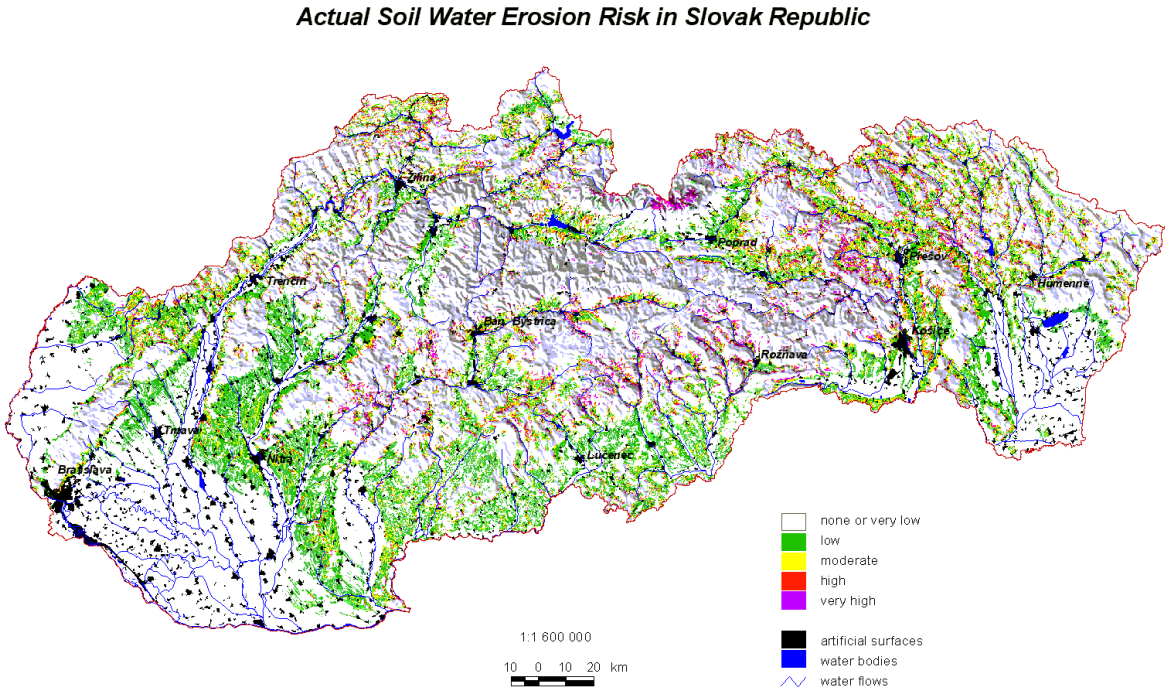

Fig. 11. Actual soil erosion risk in Slovakia

c. CORINE Land Cover Tourist Map of Slovakia

This map, which was produced at scale 1:500 000, is a specific example of combining thirty CORINE land cover classes identified in Slovakia with selected elements of topographic maps (e.g., communications, river networks, representative toponymy) and information of tourist importance (e.g., sites of special natural and cultural interest). Combining these sets of information significantly enhances the tourist attractiveness of the corresponding types of land cover and simultaneously increases awareness of the landscape (especially the links between the physiognomic and functional characteristics).

Through characterised map, visitors form their first impressions of the landscape, its use and its spatial organisation. Spatial differentiation and the size, shape and density of settlements indicate the concentrations (nodes) of social and economic activities. Agricultural areas, particularly arable land, relate closely to natural soil and terrain conditions - and wine-growing areas even more so, while simultaneously evoking the idea of hospitality and good regional wines. Large expanses of forest with their zonal differentiation (broad-leaved, mixed or coniferous; dwarf pine giving way to alpine meadows) can indicate the size of mountain chains, height above sea level, terrain elevation, as well as possible hunting, leisure and

recreation areas. Water bodies also suggest the attractiveness of the landscape for recreation purposes, while a potential for tracking and alpinism is promised by klippe terrain above alpine meadows.

Publishing the *CORINE land cover tourist map of Slovakia* at scale 1:500 000 demonstrates that the graphical output of the CORINE land cover database (which represents part of the European environmental database) can be used in combination with other thematic contents (e.g., those of a popular, cultural-recreational, or similar nature) for the benefit of a wide public.

Map was published in 1996 by the Institute of Geography of the Slovak Academy of Sciences in cooperation with the Institute of Geodesy and Cartography, Bratislava with financial support of the European Commission (Phare programme).

In the ***Slovak Environmental Agency (SEA), Remote Sensing Department in Banska Bystrica, supervised by the Slovak Ministry of Environment***, the main activities in 1998-1999 were devoted to the following projects:

a. DGPS service for environmental and GIS applications

Since 1997 regular DGPS service on working days since September 1999 daily 24 hour DGPS service based on LEICA reference station situated in Banska Bystrica (central Slovakia + circle buffer 400km perimeter) plus 6 mobile TOPCON Turbo GPS station are used mostly for GIS applications linked with monitoring systems datasets were published on Internet and INTRAnet regularly. More informations can be found at http://www.sazp.sk/DPZ

b. "REMP - Regional Environment Management Plan"

The area of the river Hron watercatchment (approx. 5000 sq.km), was analysed on the base of many data sources from meteorology, climatology, hydrology, pedology, geology, terrain, industrial & agricultural impacts and settlement structures. Preprocessing, modelling and presentation were done by the following GIS, RS and DTP software products : ArcInfo GRID, ArcView, EASI-PACE, Excell, PowerPoint. The project objectives were to collect, integrate, analyse existing datasources and subsequently propose and decide environmental management strategy for near future. More informations at http://www.sazp.sk/slovak/struktura/ceev/remp/remp.html

c.Forest health state monitoring.

The project is based continual cooperation between FRIS and SEA after the tree species composition completed in 1998 the health state will be assessed on the base of LANDSAT TM and terrain monitoring. several time horizons were georeferenced and prepared for time sequence analysis tha should be done in year 2000. Informations are at http://www.fris.sk, bucha@classic.fris.sk, http://www.sazp.sk/DPZ, machkova@sun.sazp.sk

d. Remote Sensing Dept. (RSD) at SEA continues in the support of multidisciplinar RS projects, GIS applications and education. RSD is responsible of the satellite archive datasets from sensonrs LANDSAT TM and SPOT Pan over the Slovakia. RSD preprocess subsets for several Slovak institutions universities and as well as for international projects.

The ***Forest Research Institute in Zvolen, supervised by the Ministry of Agriculture*** was working mainly on the problems of the classification of forest tree damage in Slovakia by using LANDSAT TM data.

The methodology for classification of forest tree damage on national level in Slovakia was developed. New coefficient of orthogonal transformation optimised for classification of forest damage and forest tree species composition were derived from original LANDSAT TM set. Two-phase sampling statistical approach was suggested for classification of forest damage. Calculation of two transformed images was 1st phase for evaluation of forest damage. The more precise assessment were carried out in second phase at 111 permanent monitoring plots and at 150 forest compartments. Regression model between 1st a 2nd phase data was derived and data from 1st phase was corrected on the base of this model. Result was processed in form of thematic map of forest damage in Slovakia in scale 1:500000.

In the frame of the project "Conservation of biodiversity of selected forest communities", and of its subproject "Ecological stability of forest communities" the main result was developing a satellite-based methodology for monitoring of selected parameters of forest biodiversity at regional scale.The project solves a problem of classification of ecological stability of selected forest communities on the base of set of indicators. Possibilities of the using remote sensing were investigated in model areas in Vajskovska and Lomnista valley in Low Tatras mountains. The satellite-based methodology was developed for assessing and monitoring of tree species composition, mixture of tree species and forest damage. For forest management practice it is necessary to use combination of satellite images with aerial photos and terrestrial data. Only this approach can provide cost-effective and objective system for obtaining regular and up-to-date information of described indicators.

In the frame of project of Environmental monitoring in 1998 according to the "Agreement between the Government of the Slovak Republic and the Government of Hungary about Certain Temporary Measures and Discharges to the Danube and Mosoni Danube, signed April 19, 1995" and its subproject " Aerial inventory of forest health condition in Gabcikovo region" the main results were obtained in classification of forest health condition under influence of Gabcikovo dam using colour IR photos. Forest Research Institute took 75 infrared aerial photos on 22 August 1999 from all area between river Danube and bypass canal. All photos were scanned , georeferenced in JTSK projection and mosaic (figure 11). Two-phase sampling statistical approach was used for classification of forest damage. There was carried out detailed assessment of forest damage (defoliation) in 56 forest compartments. Almost 76% of forest stands are healthy, 20% are slightly damaged and 4% severe damaged. Result were processed in form of thematic map of forest stand damage in scale 1:20000.

Figure 12. Part from mosaic of infrared aerial photographs with poplar (red colour) and willow (white to purple colour) forest stands overlay with boundaries of forest compartments.

The Computational Intelligence Group of the Department of Cybernetics and Artificial Intelligence***, Faculty of Electrical Engineering and Informatics, Technical University of Košice*** was involved in several projects dealing with remote sensing or related technologies. It involved also the cooperation with University of Minnesota, US on the project "Fuzzy classification and accuracy assessment of classification of remote sensed images" , as well as projects like "Education in Water Management" and " Computational Intelligence in Decision Procedures". During the period also cooperation with the Boston University, US and with the

University of Dortmund, Germany was active. The results are listed in refernecs. The computational intelligence tools were tested and development of their improvement and hybrid approaches research is underway. The research has been focused to enhancement of clasification results on Landsat (tm) data and on aireal videoimagery [5-11]. Cooperation with Boston University is done mainly in ART neural network area. The aim is to develop satelite image classifier with high adaptibility and performance. Accuracy assessment is estimated by the help of contigency tables. Also neural networks for prediction purposes were tested in urban water runoff prediction modeling [8].

Further research is in progress in development of Computational intelligent tools for classification of satelite images including SPOT image over city of Košice.

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