

>>> **Mapping Agricultural Lands by Means of GIS  
for Monitoring Use of Natural Resources  
(a Case Study of Landscapes in the South-Western Hungary)**

>>> Presented at:

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of Biological Resources*

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## >>> Study Area

### Location

Study area is located in the southwestern, agricultural part of Hungary (Mecsek Hills foothill area), between the coordinates of 46°6'0"N 18°50" E.



### Landscapes

The landscapes of the Mecsek region represent a unique part of the Hungarian environment belonging to the Carpathian basin

## >>> Environmental Settings



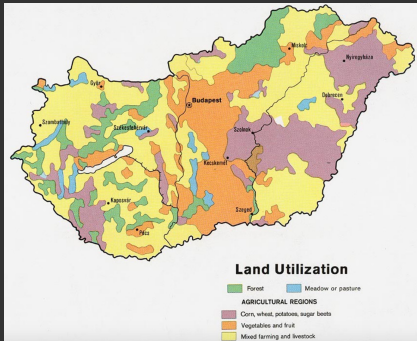
## Endemic Species

Areas of the Mecsek region: unique biogeographic zones with rare endemic protected species of vegetation of the Carpathian basin, a mixed composition of soils and types of natural vegetation.

## Forests

Dominant forests: beech-oak mixed. The soils of the Mecsek hills are rich in mineral and nutrient content (favorable environmental and geographical conditions of the area, its geomorphological and climatic factors).

## >>> Environmental Problems



### Aridification and Desertification

Main problem in agricultural regions of Hungary include aridification and desertification (increase in average annual temperature, decrease in annual rainfall).

### Landscape Changes

Altered hydrological and meteorological balance modifies landscapes. Anthropogenic factors also change the environment: land restructuring, increasing arable land, and industrialization since the 1960s have changed the face of Hungarian landscapes.

## >>> **Research Aims and Goals**

### **Landsat TM**

The aim of the work is the use of GIS and remote sensing data of the Earth (satellite imagery Landsat TM) for monitoring ecological conditions of the agricultural lands using visualization and mapping methods.

### **Questions**

Have landscapes within the test territory of the study region changed over the past 14 years (1992–2006)? Specifically, what types of land cover were previously available, and which are now ?

### **Methodology**

Using remote sensing data in combination with software ILWIS GIS to answer research questions

## >>> Data Import and Conversion

### Masking

To select study area, a mask was applied with coordinates 17°00' – 19°00'E, 45°00' – 47°00' N Selected images cover area of southwestern Hungary in 1992, 1999 and 2006.



### Landsat TM

3 Landsat TM images have a temporary gap of 14 years (1992–2006). The gap aimed to assess vegetation changes in the summer months (June). Satellite images in .tiff format were converted to Erdas Imagine .img format.

## >>> Spectral Signatures

### Image Classification

Image classification consists in grouping pixels into classes corresponding to the given types of vegetation cover (according to the tested area). The classification is based on using spectral brightness values of image pixels. In this way different types of agricultural crops and vegetation and other landscape objects (roads, rivers) were recognized

### Spectral Discrimination

Spectral reflectances show spectral reflectivity of objects and vegetation types recognized on a raster image, because spectral reflectance of various land cover and features of the individual properties of the objects vary.

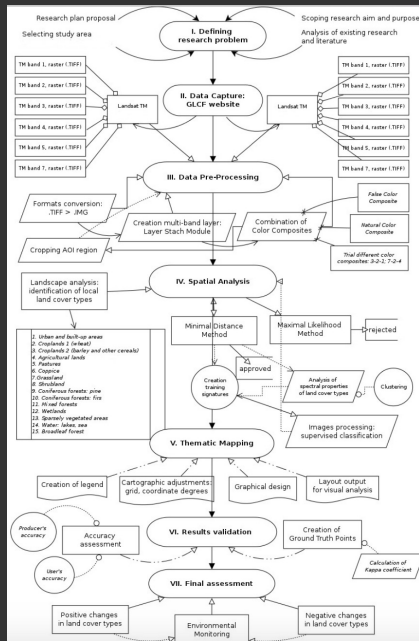


## >>> Algorithms

The study includes following methodological steps:

- \* Data collection: 3 Landsat TM images
- \* Data import and conversion.
- \* Data preprocessing: scenes of 1992, 1999 and 2006.
- \* Making color composites from 3 Landsat TM spectral channels (multi-band layers).
- \* Image segmentation and classification (clustering).
- \* GIS mapping and spatial analysis.
- \* Google Earth snapshot verification.
- \* Results interpretation.
- \* Results analysis.

# >>> Flowchart



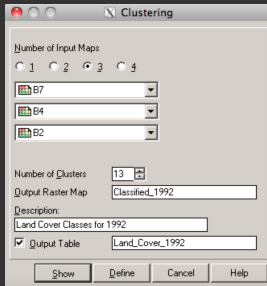
## >>> Clustering

### Statistical Procedure

Cluster analysis is a statistical procedure for processing objects (digital pixels in a raster image), organizing them into homogeneous thematic groups: clusters. Each pixel is assigned to a certain group of the corresponding landscape type based on the proximity of the value of its spectral brightness (Digital Number, DN) to the centroid in this group.

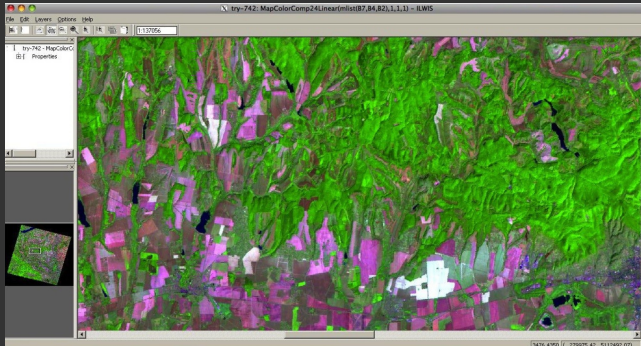
### Iterative Process

Pixels are grouped in a semi-automatic mode based on their distinguishability from the neighboring pixels. The process is repeated in a n iterative way until optimal values of classes and pixels is reached.



## Segmentation Algorithm:

consists of grouping pixels in a picture (merging pixels) into clusters. Spectral and texture characteristics of different types of land cover classes are displayed on the image as different spectral brightnesses of pixels



## >>> Mapping

### Cartography

Thematic mapping based on image classification results: visualization of the structure of landscapes and types of vegetation of the Earth within the tested area.

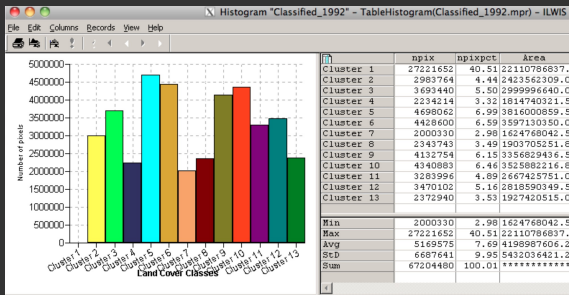
### Classification

To classify land cover types, pixels on the raster image were identified for each category and grouped into the following land categories:

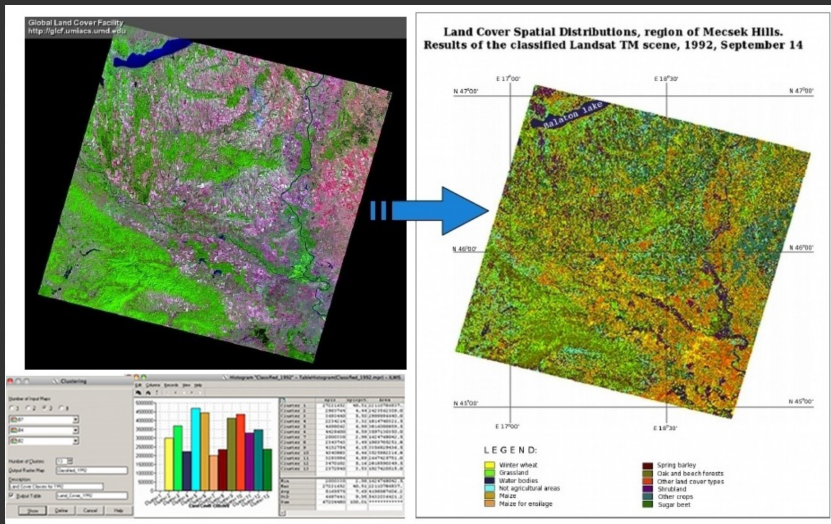
- \* Winter wheat;
- \* Barley
- \* Maize
- \* Silage corn
- \* Sunflower
- \* Sugar beet
- \* Other sowing
- \* Potatoes
- \* Water areas
- \* Areas not occupied by agricultural crops;
- \* Meadows
- \* Anthropogenic territories (settlements, cities)
- \* Other landscape types

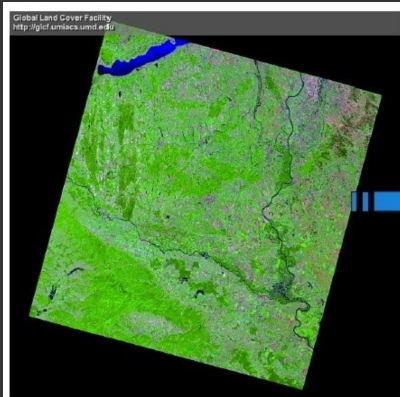
## >>> Land Cover Classes

After that, land cover types were visually evaluated and identified as respective vegetation types. The number of cluster groups is 13, which corresponds to the main number of agricultural types and types of the vegetation cover in Mecsek Hills:

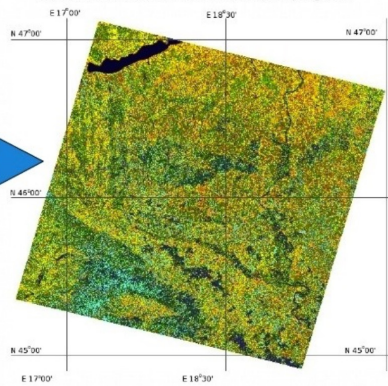


Final mapping (results) are shown on the next three slides.





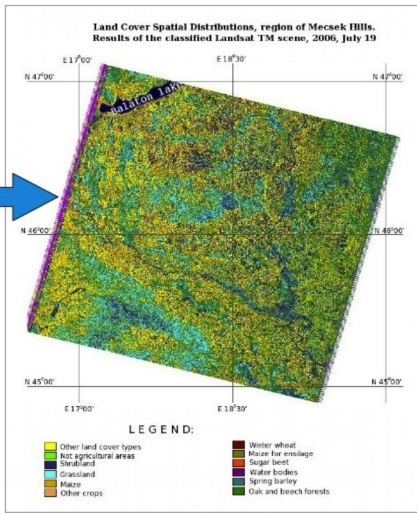
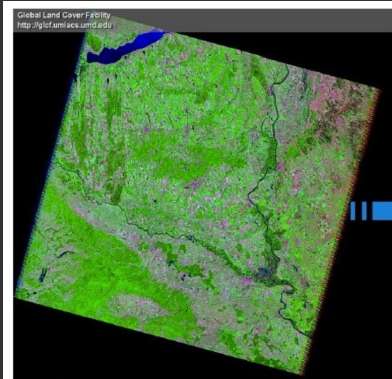
Land Cover Spatial Distributions, region of Mecsek Hills.  
 Results of the classified Landsat TM scene, 1999, August 09



- LEGEND:
- Other land cover types
  - Winter wheat
  - Not agricultural areas
  - Maize for ensilage
  - Shrubland
  - Sugar beet
  - Oak and beech forests
  - Water bodies
  - Maize
  - Spring barley
  - Other crops
  - Grassland

Cluster	NPIS	NPIS%	Area
Cluster 1	7244	0.01	5885543.5
Cluster 2	1548726	2.11	1237952499.5
Cluster 3	4200474	5.62	3337088006.5
Cluster 4	10047	0.01	8174920.8
Cluster 5	701	0.00	244487.3
Cluster 6	31545291	43.09	25638907415.1
Cluster 7	4803852	6.54	3901928787.0
Cluster 8	4783942	6.53	3885475644.5
Cluster 9	2767392	3.78	3147818152.0
Cluster 10	4949273	6.74	4022044994.1
Cluster 11	5411024	7.44	4337558840.5
Cluster 12	6209314	8.14	4942494421.8
Cluster 13	6981148	9.53	5470518488.0
Min	701	0.00	244487.3
Max	31545291	43.09	25638907415.1
Sum	543450	7.40	458909018.9





ID	NRPIX	NRPIXCT	Area	ID	NRPIX	NRPIXCT	Area
Cluster 1	7244	2.01	5861541.9	Cluster 1	4104609	6.42	3488228100
Cluster 2	1548974	2.11	1227952689.5	Cluster 2	3440413	0.87	3274117700
Cluster 3	4300474	0.81	337100004.8	Cluster 3	122460	0.02	14338200
Cluster 4	20047	0.03	8174920.0	Cluster 4	10217	0.02	8495300
Cluster 5	501	0.00	244487.9	Cluster 5	2140422	37.00	2131879900
Cluster 6	31548291	43.09	25438007415	Cluster 6	4512130	10.18	3841207000
Cluster 7	4803882	4.54	3901908797.0	Cluster 7	4398159	4.87	3958142200
Cluster 8	4703442	4.51	3885476444.4	Cluster 8	3890054	4.28	3595148400
Cluster 9	2747292	3.78	2147814152.0	Cluster 9	4424084	4.92	3981879400
Cluster 10	4948279	6.76	4620048994.2	Cluster 10	4215354	4.63	3829824000
Cluster 11	5411024	7.44	4557958649.1	Cluster 11	4052023	6.33	3448821500
Cluster 12	4109914	6.74	4942188442.1	Cluster 12	10217	0.02	8495300
Cluster 13	4901148	9.53	5470518688.0	Cluster 13	4912048	7.49	4423941992
Min	501	0.00	244487.9	Min	10217	0.02	8495300
Max	31548291	43.09	25438007415	Max	2140422	37.00	2131879900
Avg	5419150	7.46	4574400915.5	Avg	4912048	7.49	4423941992
Std	8157902	11.14	4424155574.8	Std	6184418	9.47	5547992010

Statistics for the classified Landsat images for years 1999 (left) and 2006 (right): clusters (land cover classes), number of pixels (absolute values), number of pixels (%) and area.

## >>> Computations

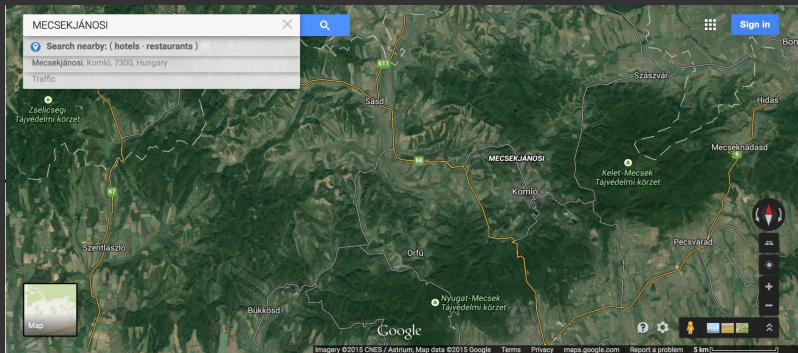
Table with calculation results. From left to right:

1. Cluster groups
2. Number of pixels
3. Percentage of pixel area of the total area
4. Areas of land cover types

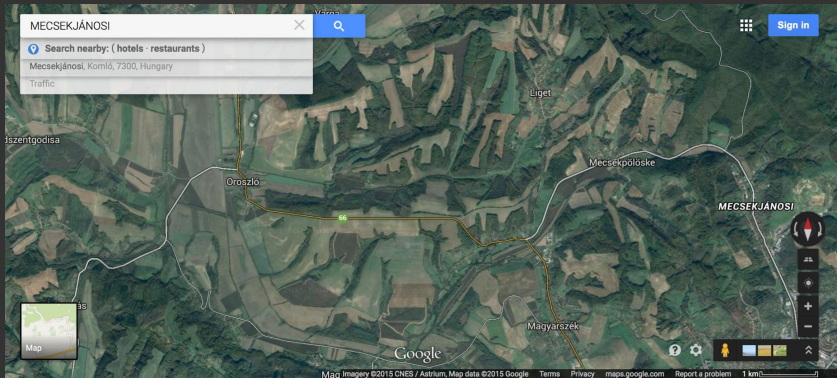
	npix	npixpct	Area		npix	npixpct	Area
Cluster 1	7246	0.01	5885563.5	Cluster 1	136874	0.21	123186600
Cluster 2	1548726	2.11	1257952693.5	Cluster 2	8019653	12.54	7217687700
Cluster 3	4108474	5.61	3337108006.5	Cluster 3	4104689	6.42	3694220100
Cluster 4	10067	0.01	8176920.8	Cluster 4	364013	0.57	327611700
Cluster 5	301	0.00	244487.3	Cluster 5	12598	0.02	11338200
Cluster 6	31565291	43.09	25638907615.	Cluster 6	10217	0.02	9195300
Cluster 7	4803852	6.56	3901928787.0	Cluster 7	23684422	37.02	21315979800
Cluster 8	4783842	6.53	3885675664.5	Cluster 8	6512330	10.18	5861097000
Cluster 9	2767392	3.78	2247814152.0	Cluster 9	4398158	6.87	3958342200
Cluster 10	4949273	6.76	4020046994.3	Cluster 10	3999054	6.25	3599148600
Cluster 11	5611026	7.66	4557555868.5	Cluster 11	4424084	6.92	3981675600
Cluster 12	6109814	8.34	4962696421.5	Cluster 12	4255504	6.65	3829953600
Cluster 13	6981248	9.53	5670518688.0	Cluster 13	4052025	6.33	3646822500
Min	301	0.00	244487.3	Min	10217	0.02	9195300
Max	31565291	43.09	25638907615.	Max	23684422	37.02	21315979800
Avg	5634350	7.69	4576500912.5	Avg	4921048	7.69	4428942992
Std	8157902	11.14	6626255576.8	Std	6186658	9.67	5567992030

## >>> Google Earth Verification

Study area represents the most diversified part of the agricultural landscapes of the Mecsek region of SW Hungary: diverse landscape structure and land cover types.



## >>> Google Earth Fragment



To control the most difficult areas, images were verified by the Google Earth: the same area on the satellite image and on the Google Earth were visualized simultaneously and visually compared. This enabled to check up heterogeneous areas where it was not clear, what type of vegetation does this site belongs to.

## >>> Discussion

### Vegetation Degradation

Increase in anthropogenic pressure and activities (agricultural work, urban sprawl, industrialization) affects the environment, causes negative effects on the surrounding ecosystems and contributes to changes in the vegetation cover (degradation).

### Species Extinction

Climate changes also affect landscapes to some extent: extinction of rare vegetation types and their replacement by other types. Significant changes in the land cover types were recorded and charted in the southwestern region of Hungary. As a result of the classification, types of agricultural land were identified based on the geospatial and temporal analysis.

## >>> Conclusions

### Approaches

Monitoring landscape changes is an important tool for assessing the ecological stability of a region.

**Spatial analysis** of the multi-temporal satellite images by GIS methodology is the most effective tool.

**Data** included Landsat TM satellite imagery covering agricultural region of SW Hungary. Image processing was carried out using classification algorithms.

### Outcome

The work demonstrated specific changes in the agricultural landscapes in a 14-year period of time (1992–2006).

The results shown landscape changes in 1992, 1999 and 2006, which proves certain anthropogenic impact on the environment.

### RS/GIS

The work demonstrated the successful application of remote sensing methods and spatial GIS analysis, effective for monitoring such heterogeneous landscapes in the region of the Mecsek foothills.

*Thank you for attention !*

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