Jombach S., Sallay Á., 2011. Remote sensing and GIS in Landscape Character Assessment. The Problems of Landscape Ecology. Vol. XXX. 209-216.

Remote sensing and GIS in Landscape Character Assessment

Sándor Jombach, Ágnes Sallay

Corvinus University of Budapest, Department of Landscape Planning and Regional Development
1118 Budapest, Villányi út 35-43,
e-mail: sandor.jombach@uni-corvinus.hu, agnes.sallay@uni-corvinus.hu

Abstract: Landscape character is considered by the article as "distinct, recognizable and consistent pattern of elements that makes one landscape different from another" concurring with the most relevant landscape character literature of Europe (Swanwick 2002). The spatial dimension and the territorial significance of the landscape pattern itself (pattern of landscape elements and land use) make it reasonable to use remote sensing and GIS in landscape character assessment. The article gives an overview of the remote sensing techniques and GIS methods used in theory and practice. It provides exemplary study area applications and proposals for further development. The significance of landscape character assessment can be raised, and the specific measures, activities addressed in European Landscape Convention can be strongly supported by these combined tools.

Key words: landscape character, remote sensing, characterisation, GIS, landscape assessment

Introduction

We experience renewal of our scientific activities, and even our everyday life driven by Geographic Information Systems (GIS) and Remote Sensing (RS) day by day. Various combinations of GIS and RS applications spread all around the world, which make our geographical sensibility more intensive, make our spatial relations more definite, make our interest towards unique local features more wide and make our movements in space more quick and easy. These are used from medical sciences to transport planning. So we can experience the revolutionizing effect of remote sensing and GIS in landscape assessment. This paper summarises the present and potential use of these tools in landscape character assessment.

Landscape character assessment is a complex method to describe, assess, and manage landscape characteristics. Historically it is partly developed from landscape travel memoirs or guides of the 18th-19th century, but its basic methodological elements can be found already in landscape monographs of the early 20th century and also in the examples of landscape cadastres, or landscape element inventories of the late 20th century (various examples in Wascher 2005). Even then, landscape character assessment has very important practical foundations nowadays. Besides that it describes landscapes of the 21st century, it even wants to manage, sustain characteristics of them.

The examples of describing the landscapes mentioned above (travel memoirs, landscape monographs, landscape cadastres or inventories) did and do frequently use a set of tools like maps and other visual information from sketches to satellite images, from historical photographs to digital spatial data. These tools are usually involved in the landscape management process to visualise the landscape or to provide spatial reference. Today landscape character is perceivably changing and the most proper tools to keep up with this rapid change seem to be remote sensing and GIS.

Challenges

European landscapes are changing very dynamically in the last few decades and the management of landscape characteristics can have enormous role in preserving, or in enhancing distinct landscape character. The sustained diversity of landscapes and the well interpreted character of landscapes can provide extra touristic income, support adequate land use. It can secure ecosystem processes and the preservation of habitats, specialise agriculture, food production and lift food industry, can strengthen local identity of inhabitants and farmers, and these all mean further steps towards a sustainable future.
The dominant changes of landscapes in Europe are driven by land use or land cover changes and coming from transformation of social, economic and ecologic attitudes towards landscape sites are:
- increase of built up land (sprawling settlements, industrial, logistical and commercial sites);
- development of built linear infrastructure (highway, railway, energy and information transport;)
- appearance or increase of power plants (wind, water, atomic power, bioenergy plants);
- increase of wastelands (waste dump sites, abandoned mines or agricultural sites);
- biomass energy plantations (forest, crop, grass);
- decrease of pastures (disappearance of grazing animals and increase of meadows);
- various impacts of climate change (disappearing glaciers, snow surface or aridity symptoms);
- habitat rehabilitation sites (increase of semi-natural vegetation and wetlands);
- transformation of touristic sites (adventure and wellness parks, mass and rural tourism);
- increasing role of suburban green (green belts and greenways, park forests in suburbs);
i- ncreasing social, economic and ecological function of city parks (multifunctional city parks).
Of course landscapes are continuously changing as the definitions and the general idea of European Landscape Convention highlights (ETS No. 176). But many of them are transformed by enhancing or loosing characteristics. As the European Landscape Convention sentences in the 6th article there is need for specific measures to manage landscapes and landscape identification and assessment is one of these. The countries besides raising awareness, training and education, need to:
- identify landscapes throughout the territory;
- analyse landscapes' characteristics;
analyse the forces and pressures changing landscapes and their characteristics;
- take note of changes;
- assess the landscapes (taking into account the particular values assigned to them by the interested parties and the population concerned).
As the landscape character assessment has very similar procedure it is more likely that these ongoing changes or possibly upcoming transformations, should be handled by landscape character assessment as the key measure of identification and assessment. Remote sensing and GIS could be a suitable tool to give a spatial frame to the management of landscapes.

Methods, materials and study area

Landscape character is a "distinct, recognizable and consistent pattern of elements that makes one landscape different from another" as the most relevant landscape character literature in Europe sentences (Swanwick, 2002). This definition highlights that landscapes are not better or worse than others but have different characteristics and they need special management one by one or type by type. The definition also highlights that the elements of the landscape and their spatial location, arrangement and relation to each other, or their visual pattern in space is definitely important concerning landscape character.
The method of landscape character assessment is based on five steps. The steps like (1) defining the scope (general focus) of the assessment, (2) execution of a desk study in the office, or (3) preparation for field survey are steps of character assessment and definitely need a set of remote sensing data and GIS use (fig. 1).
The last two steps of landscape character assessment are: (4) characterisation and (5) making judgements. Characterisation is the step when the landscape units or types are identified and described. Making judgement step is when the landscape is assessed and the result can inform decisions. These two steps can be variously

assisted by remote sensing and GIS.
Landscape character changes are mostly driven by land use changes and the disappearance of landscape features. As previous studies and results of projects expose, these were especially relevant in Eastern Europe in the last twenty years. Southern Buda-Side study area of landscape characterisation is the southwestern "gate" of the Budapest Agglomeration (fig. 2). Most of the above mentioned processes did or do appear in the area and continuously transform the character of the landscape. The most dominant process is suburbanisation and decrease of rural landscape.

Step in landscape character assessment	Use of remote sensing data and GIS	Examples
1) Defining the scope (general focus and extent of the assessment	**Overview** of the area: maps of different scale and focus	
2) Execution of a landscape **desk study** (literature and dataset overview) in the office	**GIS database** development of thematic maps, dataset and remote sensing data like: satellite images, aerial photographs, historical photos etc. **Landscape change analysis**	
3) Preparation for **field survey**	**Printing** of field survey **maps** from geo-database, **Taking photographs** on the field, **Using GPS** during the survey	
4) Characterisation	**image or spatial data analysis**: visual image interpretation, unsupervised classification, supervised classification, use of secondary remote sensing, segmentation, catchment definition, waterflow definition, maximum slope definition etc.	
5) Making judgement	**use is varied** depending upon the particular issue **assessment** (suitability, visibility, sensitivity) **visualisation**, modelling, scenario development, **monitoring**, result control,	

Fig. 1. Role of GIS and RS in landscape character assessment (based on Swanwick 2002)

Basically Southern Buda-Side has a suburban type of landscape and a rural agricultural landscape type, and to translate Swanwick's definition into practice, none of them is better than the other, but have different characteristics. The present dominant transformation in Southern Buda-Side is that the built elements of the suburban landscape sprawl over the region and take over the rural landscape continuously. As the landscape change process in Southern Buda-Side is very diverse and rapid we used various dataset of multiple dates to analyse present landscape developing tendencies. In analysis and characterisation we used the following dataset and materials:

- Land cover data (CLC100 of years 1990, 2000, 2006 and CLC50 of 2000);
- Aerial Photographs, orthophotographs, (1940-2010);
- Satellite images (1985-2010);
- Historic maps (of military survey);
- Digital elevation model (slope, relief, aspect);
- Catchment and water flow database;
- Digital Topographic Maps (M = 1: 50 000, 1: 10 000);
- Municipality borders, Micro-region borders;
- Climatic map information;
- Landscape units of Hungarian Landscape Cadastre;
- Soil database and geology database (Soil types and base material - Agrotopo);
- Landscape Value Cadastre (TÉKA).

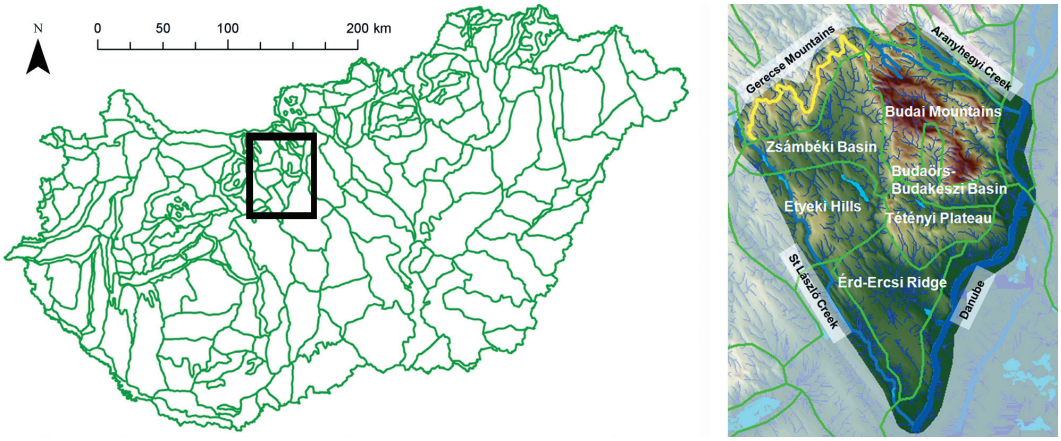


Fig. 2. Southern Buda-Side landscapes in the gate of Budapest Agglomeration

Results

The spatial dimension and the territorial significance of the landscape pattern itself (pattern of landscape elements and land use) make it reasonable to use remote sensing and GIS in landscape character assessment. The transformation of land use and the existence of characteristic landscape elements can be measured, surveyed, analysed, assessed, modelled, and visualised with remote sensing and GIS assistance.

The step of characterisation can be assisted at the phase of dividing landscapes into landscape parts/elements, in phase of landscape part/element classification, in identification, mapping, and description of landscape areas or landscape types (fig. 3.). The applicable methods of remote sensing are visual interpretation, classification and image segmentation as the LANMAP approach proves (Mücher et al., 2010) generating landscape character types for all over Europe based on four relevant datasets (Topography, Parent material, Environmental zone, Land use).

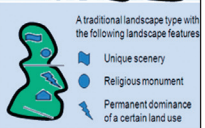
Steps in Characterisation	Use of remote sensing data and GIS	Examples
4.a) landscape **parts,** landscape **elements**	• developing landscape element **inventory** / landscape element **cadastre,** • **dividing** landscapes **into landscape parts** based on continuous landscape characteristics like: land use, climate, elevation, soil types etc. • development of **landscape feature database** based on single landscape features like: buildings, sculptures, tree lines, roads, rivers, catchments, steep slopes (represented by points, lines, polygons)	
4.b) **classification**	• **classification** of landscape parts and elements • with **visual grouping** of landscape parts and elements • **image classification,** image **segmentation,** classification of polygons	
4.c) **identification**	• **review** of all visual, written and spoken information and digital data according to landscape units • **highlighting** the most dominant / most representative / most identical features	
4.d) **mapping**	• defining **borders of** landscape character **areas** by visual association, using borders of landscape parts • defining **borders of** landscape **types** by redefining existing borders, classification, segmentation	
4.e) **description**	• **joining** all digital information, (spatial data, spatial information: key elements, features, landscape parts) to the defined landscape areas and types. • **describing / characterising** landscape areas and landscape types, according to the joined information	

Fig. 3. Role of remote sensing and GIS in characterisation step (based on Swanwick 2002)

After the exemplary application of remote sensing and GIS it can be sentenced that the dominant transformation process in Southern Buda-Side is, that the built elements of the suburban landscape sprawl all over the region and take over the dominance in rural landscape continuously (table 1). The tendency of transformation is documented by historical maps from the 18th century, aerial photographs from the 1940-ies and satellite images from the 1980-ies up till today (fig. 4).

Table 1. Changing landscape elements as key characteristics in Southern Buda-Side scenery

Rural landscape elements disappearing	Suburban elements sprawling
Arable lands	Roads and Highways
Wineyards and orchards	Various residential areas
Pastures	Commercial, store or logistic areas
Artificial landscape elements related to rural life and agriculture (wells, bridges, granary, dirt roads, cellars, grazing animals etc.)	Artificial landscape elements related to urban / suburban landscapes (traffic lights, billboards, petrol stations, noise barriers, fences, parking lots, etc.)

The landscape characterisation of Southern Buda-Side was done to provide rural character enhancement and preservation. Besides the analysis of possible designation of "green" (non-motoric) transport lines, it included the assessment of rural landscape scenery and characteristics of agricultural activities and production. The characterisation as a basic step of the assessment was assisted with GIS and remote sensing especially in the classification and mapping phase (4b, 4d), because the landscape boundaries in the Hungarian Landscape Cadastre were too rough for the work in local scale. The cadastre is developed for the country level but at micro-region level further analysis, boundary revision and correction was necessary. The boundaries were revised, based on the digital geo-database developed from the materials and dataset mentioned above.
In the exemplary characterisation of Southern Buda-Side landscapes the manual classification method of landscape elements was used, based on visual interpretation of analysed (e.g. classified) remote sensing data (Landsat TM5) or other spatial data. The mapping of landscapes along existing landscape elements, landscape part boundaries was driven by river beds, catchment boundaries, slope maximum lines, land use boundaries, municipality boundaries, aspect of slopes, road network, built structures etc. Additionally the list of key characteristics were prepared, greenway development potential of landscape is described, and proposals for further character maintenance were prepared.

Discussion

The Southern Buda-Side case study proved that three different kinds of innovative remote sensing and GIS applications can be used in characterisation step (4):
1. Describing characteristics - Description of different landscapes of predefined boundaries by spatial landscape information gained from remote sensing and GIS
2. Boundary selection – Classification of landscape parts/elements by selecting the most suitable landscape boundaries from many boundary alternatives,
3. Boundary definition – Mapping by classifying spatial data or using image segmentation methods, and thus definition of new landscape boundaries.
In future the automatic image analysis methods like image classification and image segmentation could be tested to be used not only in the preparatory phase of characterisation but also in the phase of classification and mapping (4b, 4d) supporting automatic classification of landscape elements and automatic mapping of landscapes. The results of these automatic methods should be compared to the results of manual classification methods of landscape characterisation. For this kind of comparison the case of Europe's Living Landscapes (Pedroli et al. 2007) provides good examples.
From planning or development point of view it seems almost impossible to reach the same results with automated image analysis and with characterisation driven by human perception. Even then automatic methods

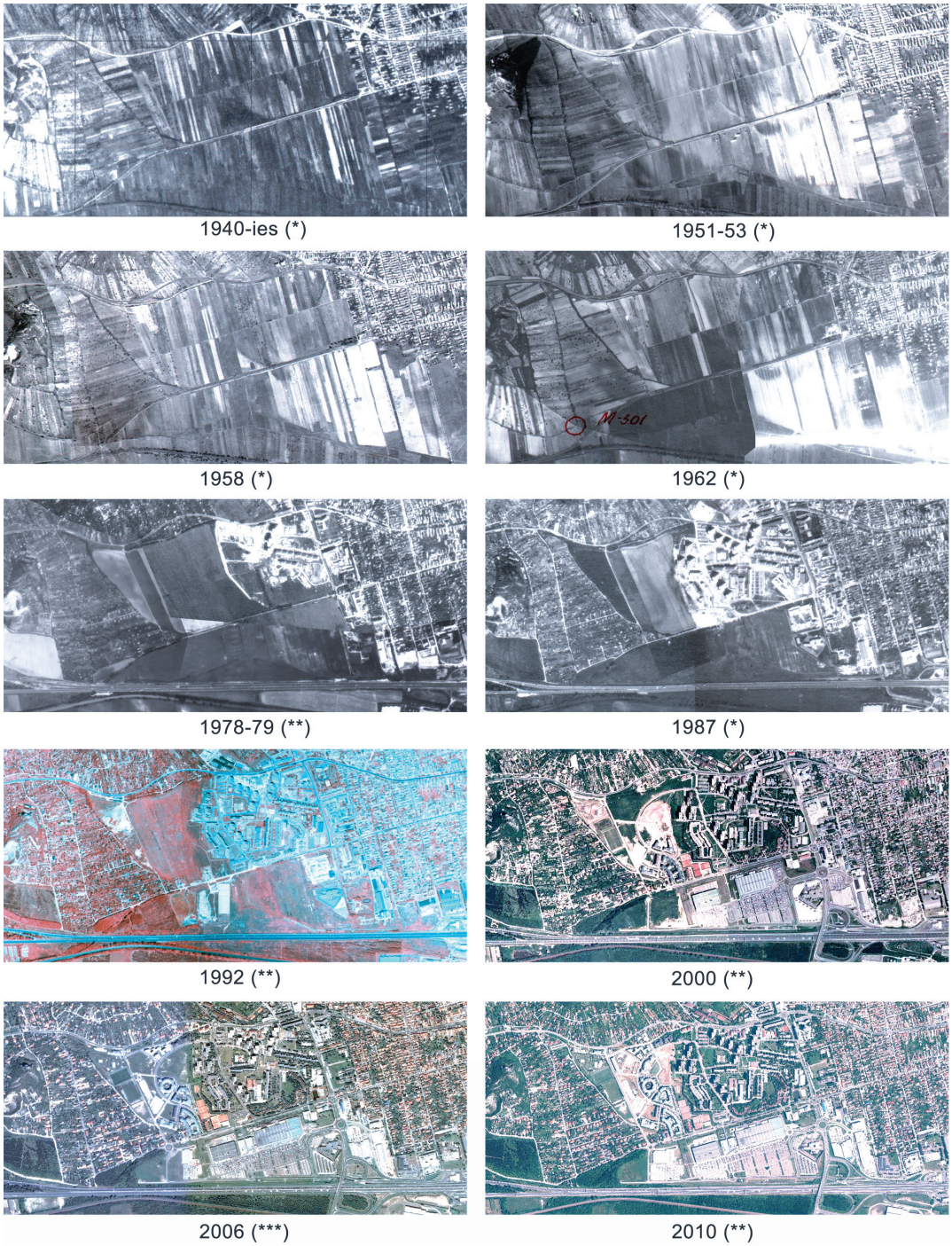


Fig. 4. Exemplary application of aerial photo and very high resolution satellite data representing landscape changes in Buda-Side study area at the edge of suburban and rural landscapes
Source of aerial photographs, orthophotographs and very high resolution satellite images:*Military Museum,** Institute of Geodesy, Cartography and Remote Sensing, ***GoogleEarth

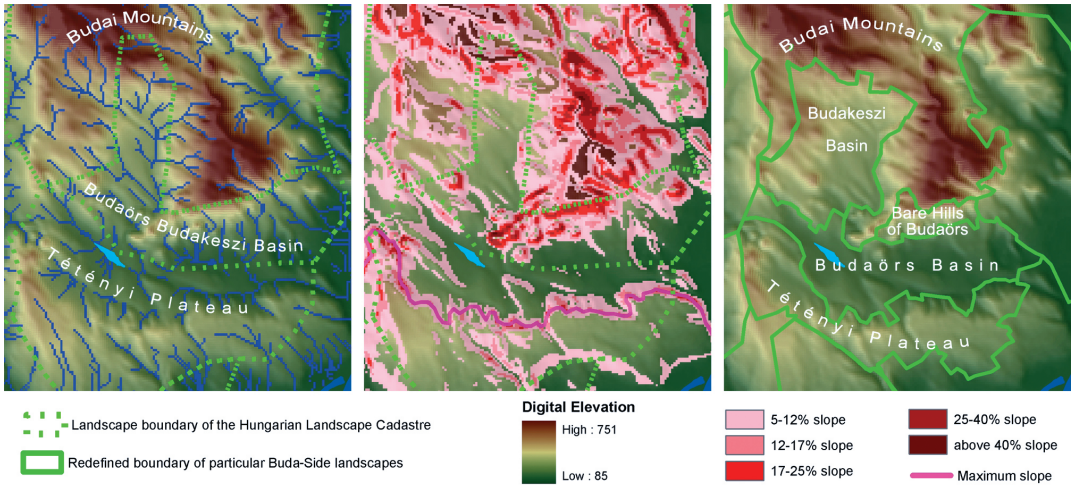


Fig. 5. Particular steps of landscape boundary redefinition with the example of maximum slope based division between a basin and a plateau

seem to be helpful tools to grab some distinct, hidden characteristics of landscapes that human mind is not able to perceive for the first glance. The automatic methods might not be able to end up providing solutions for character enhancement or in protective decisions, but they more likely can support landscape characterisation using the top-down approach.

Conclusions

Remote sensing and GIS is a good combination for various use in landscape character assessment. Remote sensing data like aerial photographs, satellite images, historical images, photographs and techniques of visual interpretation, image classification or segmentation are applications that are definitely variously usable for the characterisation step of the assessment. The current practical application for the Southern Buda-Side study area supporting rural character enhancement and protection proved that a practical goal gives the essence of characterisation and makes mapping objectives more clear.

The integrated use of manual classification based on visual interpretation of remote sensing data in the assessment was successful. It proved that the process essentially needs field work and survey, analysis of landscape development tendencies, practical knowledge and experience about the landscape, and actual information of development plans as well. Automatic image classification methods can provide useful information for landscape character assessment in the future, but implementation of landscape classification with automatic image classification needs to be tested carefully and integrated in the assessment methodology with criticism and not replacing it.

Acknowledgements: The article was made with the co-financing of TÁMOP-4-2.1.B-09/1/KMR- 2010-0005

References

ETS No. 176, Council of Europe, 2000: European Landscape Convention, European Treaty Series, Florence

Marosi S, Somogyi S. (eds) 1990: Magyarország kistájainak katasztere (Landscapes Cadastre of Hungary) MTA Földrajztudományi Kutató Intézet, Budapest 1990

Mücher, C.A., Klijn, J.A., Wascher, D.M., Schaminée, J.H.J. 2005: A new European Landscape Classification (LANMAP): A transparent, flexible and user-oriented methodology to distinguish landscapes, Ecological Indicators, Volume 10, Issue 1, 2010, pp.87-103

Pedroli, B., van Doorn, A., de Blust, G., Paracchini, M.L., Wascher D., & Bunce F., 2007: Europe's living Landscapes. Essays exploring our identity in the countryside

Publisher: KNNV Publishing (The Netherlands) in cooperation with LANDSCAPE EUROPE

Swanwick, C., 2002: Landscape Character Assessment, Guidance for England and Scottland, The Countryside Agency, Scottish Natural Heritage

Wascher, D. M. (ed.) 2005; European Landscape Character Areas – Typologies, Cartography and Indicators for the Assessment of Sustainable Landscapes, Published by LANDSCAPE EUROPE in collaboration with ELCAI project partners