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TOURIST ASPECTS OF ASSESSING LANDSCAPE CHANGE

Réka Kata BODNÁR*
University of Debrecen, Faculty of Science and Technology, Department of Landscape Protection and Environmental Geography, H-4032 Debrecen, Egyetem tér 1. Hungary, e-mail: fyp444@gmail.com

Abstract: Main aim of this paper is to reduce the subjectivity of assessing landscapes by studies of exact, however, rarely used methods. In this way, we also would like to call attention to landscape destruction. The first example shows that 3D digital elevation models (DEM) created by geoinformatic methods can reveal visually the grade of landscape alteration. The other method is based on the well known GIS softwares with the difference that a horizontal image is the starting base. The principle and technical background of photo analysis is the same, only the point of view is different corresponding to the demands of the end users (e.g. tourism). Practical advantage of these methods occurs not only in tourism but in landscape historical, landscape aesthetic analyses, landscape planning and land-use or in seasonal habitat studies of vegetation.

Key words: GIS, 3 dimensional digital elevation model, landscape changing, landscape reconstruction, landscape indicators, landscape aesthetics, landscape marketing, Balaton Uplands

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SETTING THE PROBLEM

Several authors have stated during touristic geographical studies that landscape or to be more precise "*healthy*" landscape view has an ever more decisive role for tourists in choosing their destination area (Kerényi, 1995, 2003; Csemez, 1996, Konkoly-Gyúró, 2003, 2008; Csorba and Bodnár, 2007; Bodnár, 2008). This is in close correlation with that more-and-more people wish to go out in Nature to enjoy the beautiful harmonic landscape in our stressful life in our rapid world (Csíkszentmihályi, 1998; Michalkó, 2005, 2010).

But what landscape can be regarded as healthy and how was its state changed in the last decades? How can we decide that a landscape is more valuable and thus is worthier to be preserved and presented to visitors than the other, etc? Questions like these were raised by landscape researchers long ago. Numerous methods and ideas have been worked out to determine the indicators and parameters for the specific characteristics of a landscape and their changes in time, etc. (Mezősi, 1985; Lóczy, 2002; Kerényi, 2003, 2007; Csorba, 2003, 2008, Mezősi and Fejes, 2004).

The question of originality of a landscape – due to their continuously changing character – can be defined very difficultly including examinations that can be described hardly by quantitative methods or parameters. A certain scientific "incomprehensibility"

* Corresponding author

is always especially true for landscape aesthetic studies. Every scientist faces with the problem of subjectivity-exactness when focuses on aesthetics.

This is why it is natural to try to analyse the landscape from as many aspects as possible by a wide range of methods of different scientific fields in order to approach reality as a synthesis of the results. In this paper landscape view is modelled by geoinformatic research methods and results of the two studies are assessed from the aspect of touristic applicability.

In the case of the first group of investigations, our primary aim was to present the landscape alteration of the Tapolca Basin – as the result of the decades long basalt mining – by geoinformatic methods. The landscape reconstruction performed during this work may prove to be suitable to draw attention to the significant landscape altering effect of the "wounds" in the landscape as the results of basalt mining. Such problem-orientation may have exponential effects on drawing attention to the problem in the case of tourists visiting the area as they can directly observe in situ the negative effects of landscape destruction.

Special sense is experienced in a landscape having such unique view as the Tapolca Basin (Futó, 2003) and its buttes rising over the plains as guard towers. Unique beauty of this landscape alone motivates visitors, however, if scientific information is also presented to them, their attention to the values of our landscape heritage and to the importance of landscape (view) protection can be raised much more effectively.

As a result of the numerous studies regarding landscape analysis, most effective procedures are well-known by a wide range of researchers together with the difficulties of applying landscape analysing methods (Kerényi and Csorba, 1993; Bárány-Kevei and Botos, 2001; Drexler et al. 2003; Csorba et al. 2004). A common characteristic of these works is the point of view of research as in most cases scientists see the landscape to be studied from above as the mapper, considering for example natural vegetation or land-use, land cover (see: CORINE).

Furthermore the problem of the vertical and horizontal research aspects is faced frequently during studying the relationship between landscape and tourism (figure 1). In other words, maps may not be the best investigation perspectives in every case as although visitors use maps they view the landscape in situ in horizontal – like greeting cards and not maps – aspect in its own reality and landscapes impress visitors in this horizontal aspect (view points, scenic routes) as well (figure 2).

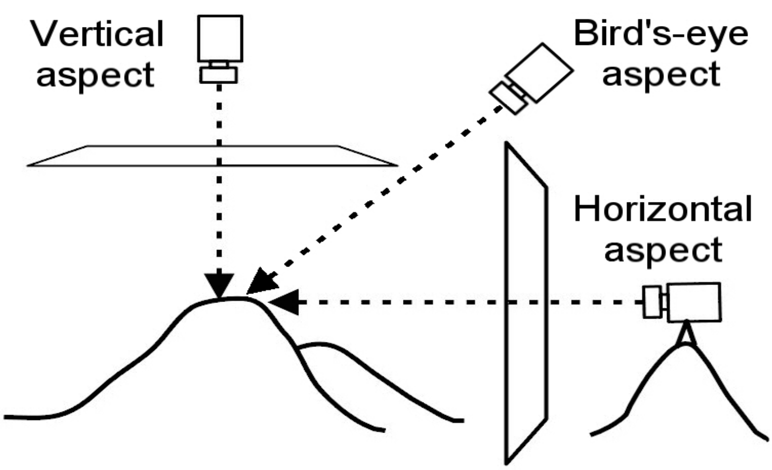

Figure 1. Problem of vertical and horizontal aspects in landscape research
(Drawing: Molnár, L. Sz.)

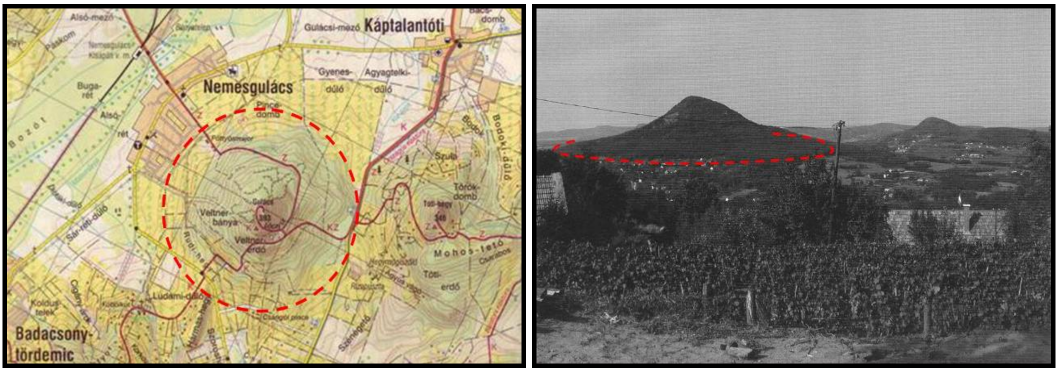

Figure 2. Same and still different: the Gulács on the tourist map with the scale of 1: 40 000 and in a traditional photo. Note: The dashed red line indicates the same area from different points of view. (Source: Cartographia Ltd. 2005; Molnár, L. 2007)

Based on the above the question is raised, how it is possible to analyse landscapes attracting visitors from touristic aspect but with scientific quality. Second group of investigations try to answer this.

LANDSCAPE VIEW RECONSTRUCTIONS IN THE TAPOLCA BASIN

In this chapter we present examples for the visualization of the extent of landscape alteration by 3D digital elevation models prepared by geoinformatic methods. The base of the analysis, the so called *"original landscape"* (to which the comparison is made) prepared by these methods may prove valuable for local governments and other authorities when they prepare or overview their landscape plans in order to make the landscape similar to the original conditions for example in the course of reconstruction works.

The studied Tapolca Basin received its unique relief conditions and landscape view from its special geological development, i.e. its buttes. Most significant geological changes in the area of the Balaton Uplands were brought about in the Pannonian period. From several explosion centres first tuff and clasts were deposited then basalt flooded the loose sedimentary rocks covering the surface at that time (Martonné, 2007).

Probably the two most beautiful examples of the appearance of basalts are the abandoned quarries of the Hegyestű and the Haláp Hill elevating on the northern border of the Tapolca Basin small landscape. The most important difference between the two explosion centres is that the Hegyestű is a "*vertical section*" of the basalt vent while the Haláp exposes a rather "*horizontal*" series that can be traced down to the bottom thanks to mining (Borsy et al., 1986).

In the Haláp Hill traces of smaller quarries can be dated back to Roman ages, however, particular data on basalt mining are found from as late as the early 20th century. Produced and cut basalt stone blocks were used primarily for road covering. In this time period numerous roads in Budapest were built of basalt mined here (Reichert, 1929).

Production became most intense and thus landscape deterioration most dramatic in the middle third of the 20th century (Jugovics, 1955). In the 1960's and 1970's basalt quarries were closed one after the other in the surrounding hills (e.g. Badacsony, Gulács), however, the basalt of the Haláp – due to its excellent quality – rocks were transported to the building works of the airport terminal Ferihegy II in the 1980s as well (Klespitz, 2007, Kónya, 2007). Even this kind of information can prove to be interesting for interested visitors if for example in "*Did you know that…*" style illustrated by photos the famous buildings and roads that were built of the Haláp basalt are presented (Kónya and Bodnár, 2008).

One of the most striking consequences of basalt mining is that a significant part of the Haláp is practically vanished by today (figure 4). The amount of the excavated material (0.14 km^3) estimated on the basis of relief models exceeds half of the amount of stones used for building the pyramid of Cheops (0.25 km^3).

This strong landscape degradation resulted in a landscape conflict unsolved even today thus the task of landscape planning is urgent. This of course does not mean that the original landscape would be returned and the former landscape part would operate again as the excavated material of the quarry cannot be replaced (Csorba, 2006). And this is not necessary as the exposed geological features, strata and structures have a significant scientific-educational role functioning as an open geological textbook. It can be also stated that they increase the reputation of the landscape increasing its value (Csorba, 2006).

A method reconstructing the basalt butte of the Haláp

The image of the degraded landscape of the Haláp gave the idea for the research presented below. The base is presented by a series of contour maps prepared at different times because the image is determined primarily by the relief reconstructed by the contours and because the 3D elevation models produced by the ArcMap software based on maps prepared at different times become comparable (figures 3 and 4).

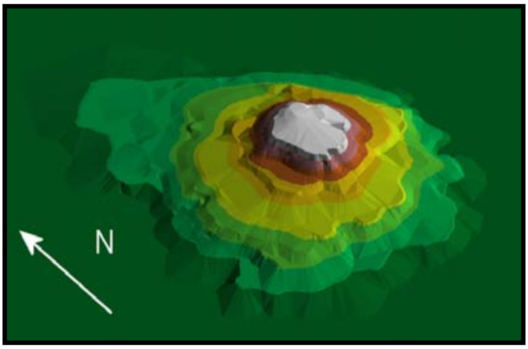

Figure 3. 3D DEM of the Haláp prepared on the basis of the Third Military Survey (1880-1881)
(Drawing: Molnár, L. Sz.)

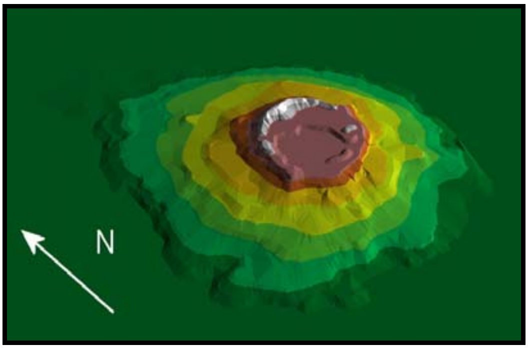

Figure 4. 3D DEM of the Haláp prepared on the basis of the 1:10000 topographic maps (1962-68)
(Drawing: Molnár, L. Sz.)

The applied raster maps were fitted into a common projection system (EOV) thus their orientation and scale characteristics are the same. The DEM reflecting earlier times (figure 3) is based on the map sections of the Third Military Survey (MS III henceforward) on the Tapolca Basin with the scale of 1:28,800 (Arcanum Ltd. 2007). Levelling base of MS III was the middle water level of the Adriatic Sea (173.8385 metres lower than the Levelling Base Point at Nadap). 10 m contour lines are shown on the maps, however, at places – where sloping is small – half (5 m) and quarter (2.5 m) contours are also shown.

The DEM showing the current state (figure 4) is based on the 1:10,000 scale topographic map sections for the same area (Cartographia Vállalat 1974). Their levelling base was the middle water level of the Baltic Sea (173.1638 metres lower than the Levelling Base Point at Nadap). We will come back to the problem of different base points later. Their vertical resolution is 1 m, however, corresponding to the sloping conditions half (0.5 m) and quarter (2.5 m) contours are also shown (Stegena, 1983).

The above explain the problem that the vertical resolution of the two map series is different – 10 m and 1 m. In order to achieve better view comparison similar – or almost similar – representation characteristics were applied, however, considering only view and not quantity. In this way the following solution was applied.

Contour lines of maps containing less contour and data – MS III – were not possible to densify in the course of digitizing. Adding a new contour line in between to known ones so that it would run according to the relief is not possible as we were not able to determine the route of extra contour lines in relation to the relief.

As a result the data of the 1:10,000 maps had to be reduced so that only the 10 m contour lines were regarded (or where gentle slopes required the 5 m and 2.5 m ones as well). This method produced a secondary result besides similar representation characters as less data in the case of the 1:10,000 maps made their digitizing faster.

The following conclusions were draw considering the differences of the mapping elevation base levels mentioned before. It is a fact that the elevation base points were different and thus the similarity of the DEMs may not be complete as contour lines do not run at the same places overlapping each other but with a small difference. However, they have to be orientated parallel to each other as they are situated in the same plane of reference (almost horizontal) independent from the elevation base levels.

Comparison of the levelling base points reveals that the difference stays below the common vertical resolution (10 m) of the maps. Difference between the Adriatic and the Baltic base levels is less than 10 % of the vertical resolution, 0.6747 m (the Baltic level is higher). In this investigation only relative elevation values are important as the relative elevation values of the maps on the same relief element group (Tapolca Basin) cannot differ. Thus contour lines were digitized according to this. Based on the vectorized contour lines digital elevation models were generated from both vector sets creating TIN (Triangular Irregular Network) models.

In the "*raw*" DEMs (containing only contour lines) every "*disturbing*" element (e.g. vegetation, land-use) was neglected in order to depict the landscape deteriorating effect of mining as impressively as possible. Relief forms and their change were in the focus of representation. 3D models in figures 3 and 4 were prepared from similar coordinates, similar height with similar direction and view angles.

Reconstructing the landscape of the Tapolca Basin prior to draining

Of course not only the change in relief can be studied by the method presented above. For example, in the case of the Balaton the reconstruction of the different water level states – e.g. according to the abrasion platforms 120 and 130 m a.s.l. of our research area by digital elevation models could be interesting and representative (figures 5 and 6). This depicts and makes the state of the Balaton area prior to the drainings and the process of landscape transformation more understandable for visitors without deeper geographical knowledge.

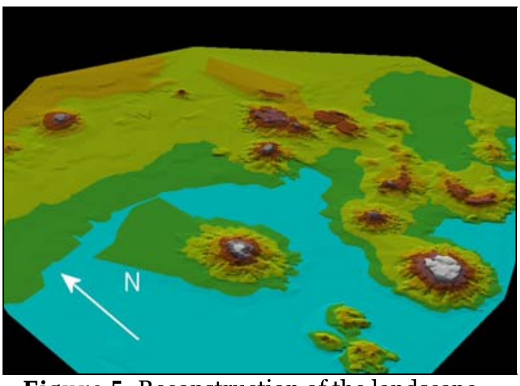

Figure 5. Reconstruction of the landscape prior to the water regulations based on the 120 m elevated shores
(Drawing: Molnár, L. Sz.)

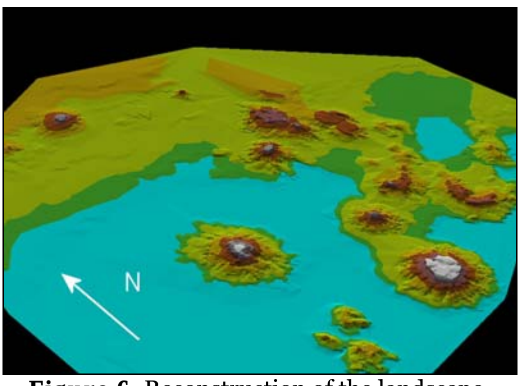

Figure 6. Reconstruction of the landscape prior to the water regulations based on the 130 m elevated shores
(Drawing: Molnár, L. Sz.)

For example it can be seen in figure 6 that considering water level at 130 m the Szent György hill and the tuff cones of the Szigliget hills elevate from the water of the Balaton like islands while the Badacsony forms a peninsula resembling today's Tihany peninsula. The landscape reconstruction also clears that most of the Tapolca Basin was under water when water levels reached 120 m and 130 m in this way the draining works and their landscape transforming effects can be understood easier by the visitors.

The method not only enables the representation and comparison of former and current landscape conditions but models forecasting future conditions based on the appropriate surface processes and trends and they can be compared to the present conditions as well. Furthermore, raw DEMs are also suitable for analysing and depicting other surface conditions (e.g. vegetation cover, land-use) in relation to relief.

Utilization of results in tourism

The landscape view reconstruction made by the above method enables to view a former state of the landscape, i.e. we can take a journey back in time. This new perspective may make the landscape more attractive for visitors by highlighting the destination. Presentation of the landscape images as the results of the study may take place for example in the visitor centre of the Balaton Uplands National Park Directorate in the form of an interactive exhibition.

Such an innovative exhibition that is not widespread in Hungary has additional not insignificant functions apart from contributing to the substantial relaxation of visitors by new and memorable adventures. Developing environmental consciousness is one of the major challenges nowadays and it is an essential interest of today's society. Increasing knowledge of our environment – including an image of the landscape 100 years ago – contributes to the development of the so called landscape empathy that may increase the aptitude and responsibility for the health of their environment and thus the landscape.

Nevertheless increasing knowledge of the history of the landscape together with the preserving of the traditional land-use, landscape structure and the unique and valuable landscape view concur absolutely with the targets set by the Balaton Uplands National Park Directorate as well. Using the landscape view images in tourism is not insignificant at all in a popular destination like this but developing landscape empathy we can contribute to the effective increasing of environmental consciousness of the entire society.

HORIZONTAL ASPECTS OF LANDSCAPE ANALYSIS

In the second group of our investigation the applied computer evaluation method – considering its operation principle – is based on GIS softwares widely used among geographers like the CORINE land cover database, for example, with the difference that in our case the starting base is not a satellite image or an orthophoto but a traditional photo or a horizontal image about the given landscape. The principles of photo analysis are the same only the viewpoint is different according to the requirements of the different end users (i.e. tourism).

Operation of traditional GIS softwares (e.g. ArcView, **T**errain **A**nalysis **S**ystem, IDRISI) is based on vector and raster analysis (Detrekői and Szabó, 1995; Kertész, 1997; Lóki, 1998) that – as in the case of every analysing software – has its problematic fields. One of them is the definition of so called learning area (Detrekői and Szabó, 1995; Kertész, 1997; Lóki, 1998) where human factor as competence and experience, skill in this process plays a significant role.

Applied method

In the course of our research the TAS software was applied as it is clearly suitable for performing the required tasks and it is available for free. The three phases of the analysis are presented in the following with the help of figures 7-9.

Figure 7. Original photo of the author,
i.e. first phase of the method

Figure 8. The image following dissection into RGB channels,
removal of channel Blue and recolouring
(Drawing: Molnár, L. Sz.)

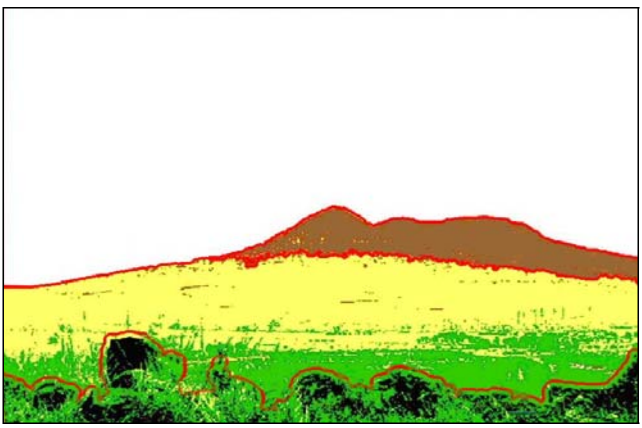

Figure 9. Groupped pixels and the definition of the foreground,
middle ground and background
(Drawing: Molnár, L. Sz.)

In the course of photo analysis as a first step the original image (figure 7) is dissected into RGB channels. The obtained so called false colour images show the intensity of the colour range (Red, Green, Blue) of the image regarded as the starting state. In most cases the photos record objects and view elements located in different distances that can be considered as objects situated in different depths. This is reflected in the "*haziness*", "*opacity*" of more distant parts caused by the larger distances. In order to avoid this, channel Blue is removed from the original image (arithmetic operation) and it is recoloured by the contrast palette (figure 8).

Pixels of the obtained image are classified into groups of small number of elements (4-12 pieces) making the content of the image strongly simplified, however, it will still retain its original ratios becoming in this way comparable and interpretable (figure 9).

Figure 9 holds extra information regarding the "*foreground - middle ground - background*". As the three parts of the two dimensional image express dimensionality are highlighted by the simplified and grouped pixels significant subjectivity is experienced (i.e. decisions made by the analyser) in the course of such image dissections and analyses. This can be significantly reduced by this computer method as spatial boundaries are always drawn according to the same rules assuming that the same pixel characteristics are applied when grouping them.

Applicability and major fields of usage

The procedure can be applied for traditional black-and-white photos / brown prints and digital photos as well and also for scanned (originally paper based) or digitally recorded images when the images to be compared were taken from the same (or at least fairly similar) viewpoints.

Applicability of the method is limited by the quality of the data. As a simplified principle we can state that the image of higher resolution has to be simplified to the least detailed one in order to make them comparable. Weather conditions (saturation, direction of sunlight, cloud cover, etc.) at the time of taking the photos may influence the quality of the photos, however, most of these effects can be eliminated by appropriate filters.

Considering all, fields of application are wide ranging. Most interesting among them, regarding tourism, are the landscape historical researches – where studies focus on the change of landscape through time (Karancsi, 2004, 2006; Karancsi and Kiss, 2006) as the history of a given tourist destination can be cognized best via the changing process of the given landscape. According to these studies both the grade and direction of the change can be determined by analysing the ratio of the landscape forming elements.

Figure 10. Change in built-up areas at the spa and wellness hotel in Egerszalók
(Source: http://commons.wikimedia.org)

The *"before-after-and-why"* type computer comparison image analyses can give the degree of change in percentage as well that increases the exactness of the strongly subjective landscape aesthetic studies by determining parameters. Figures 10-12 present the method via a particular example. Based on this, in the case of Egerszalók famous for its calcareous tuff hill and called as the “*Hungarian Pamukkale*” the analysis of the original landscape and the visual plan of the new hotel by the above method would (have) enable(d) us to calculate the increase of built-up area and the grade and direction of change in the landscape prior to the investment.

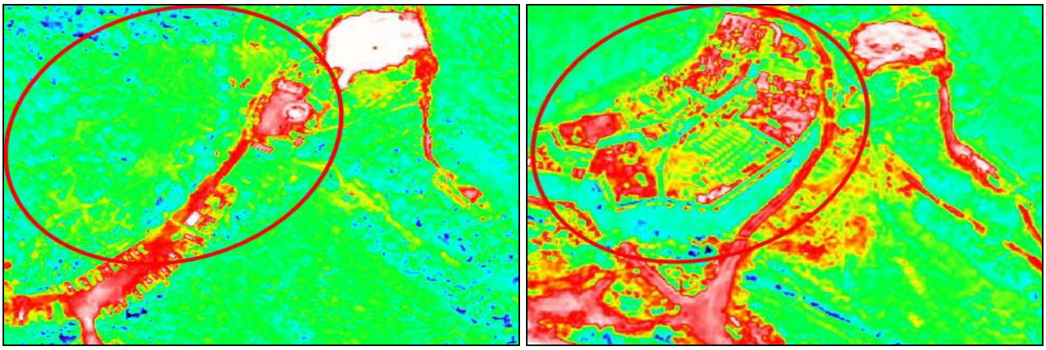

Figure 11. Middle state during photo analysis: false colour image following dissection into RGB channels without channel Blue
(Drawing: Molnár, L. Sz.)

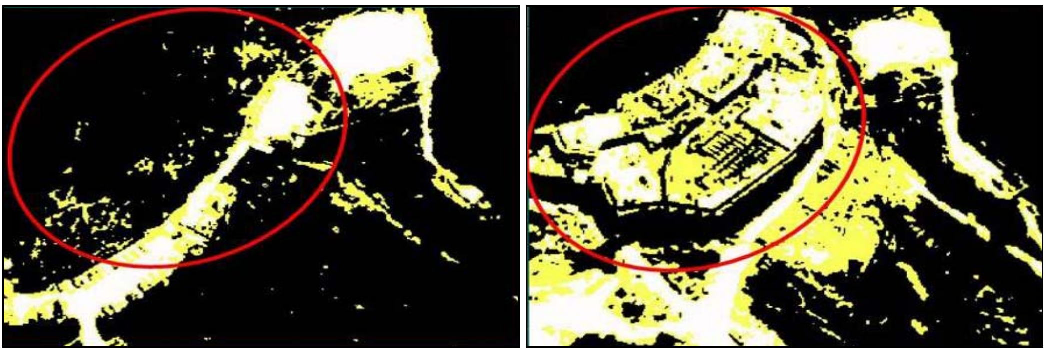

Figure 12. With pixels grouped into categories drastic landscape (view) change can be determined in percentage as well
(Drawing: Molnár, L. Sz.)

Based on the data of Table 1 our calculation determined that the thermal hotel in Egerszalók caused a decrease in the area of the intact vegetation until then by 24.59 %. In total the difference between the two analysed images was 49.18 % following the building of the hotel, i.e. almost 50 % of the study area was affected by changes of some kind.

Table 1. Grade of change in the studied groups based on their area ratio

Prior to investment	**Following investment**	**Change**
Intact vegetation: 81.81 %	Intact vegetation: 57.22 %	-24.59 %
Disturbed vegetation: 9.10 %	Disturbed vegetation: 25.34 %	16.24 %
Built-up area: 9.09 %	Built-up area: 17.44 %	8.35 %

To the question what belongs to the study groups (as “*intact vegetation”, disturbed vegetation’,* “*built-in area*”) in figure 12 the following answer can be given. The original almost intact vegetation is marked by black colour the decrease of which was greatest as the building process was performed. Yellow colour indicates vegetation disturbed prior to our investigation, its area increased during the building process. White colour indicates vegetation free, built-up areas.

The parameters obtained in this way can be very useful for landscape planners and for decision makers as well because with the help of visual plans it can be decided in the phase of obtaining permits whether the planned investment meets the benchmarks of the building plans or not. Considering a particular tourist case, for example, how much the planned hotel – seeing from a given distance – will hide of the viewing angle or the landscape when it is constructed and whether it threats the landscape too much or not. Maybe if building in a given landscape was regulated (and the regulations enforced) landscape destructing investments like the one in Egerszalók could be avoided in the future.

Practical use of the method is taken not only in the fields mentioned above but, for example, in the study of the seasonal change aspects of vegetation as well as this procedure is much cheaper than, for example, to take aerial photos / satellite images in every season or to buy numerous aerial photos of the area. Other possibility is to study the tendencies in the changing of agricultural land-use and the series of possibilities is long.

Finally we would like to emphasize the difference the dissecting into RGB channels with the help of the false colours can make in a photo depicting a tourist destination (figures 13 and 14) attracting the eye and making visitors to think. The images show two UNESCO World Heritage Sites in different representation aiming primarily to attract attention with the help of the technical equipment available today.

Novelty of these images and their unusual colours suitable to attract the attention of those watching them focusing their attention and thoughts on the places depicted in the images. Calling attention like that can bring new and fashionable colours, literally, to the marketing of tourist destinations that we fully recommend to travel agencies for example (Bodnár and Molnár, 2010).

Figure 13. The Belém tower on the shores of Tajo river (Source: whc.unesco.org)

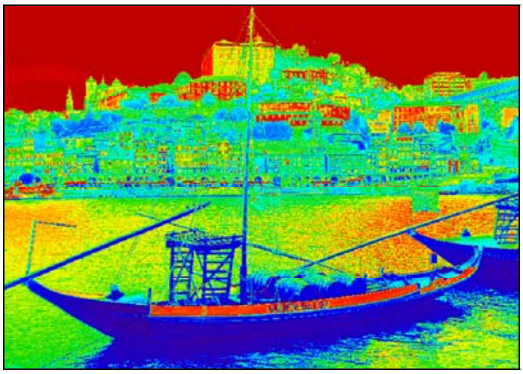

Figure 14. Vista of Porto, false colour version (Source: whc.unesco.org)

CONCLUSIONS

General aim of the presented studies was that contributing to the reduction of landscape subjectivity with analyses using geoinformatic methods from a new perspective, we call attention to landscape change and in certain cases landscape deterioration by methods that can be regarded as exact but rarely used for this kind of purposes. Main aim of the procedure presented in chapter 1 was to depict the landscape transformation as the result of decades long basalt mining at the basalt butte of the Haláp in the northern margin of the Tapolca Basin, Balaton Uplands. This investigation could be suitable to draw attention to the landscape transforming effect of (basalt) mining in a wider context as well. Such problem orientation may affect tourists visiting the area more effectively as visitors can face the consequences and negative effects of landscape deterioration in situ experiencing the sentimental side of the problem.

In a popular destination like the Balaton Uplands the touristic application of landscape images obtained via the presented procedures is not insignificant in order to contribute to the effective increase of the environmental consciousness of our entire society by developing landscape empathy. Simultaneously, landscape view and landscape character protection become emphasized increasingly in landscape research.

According to the results presented in chapter 2 any side view image or photo can be analysed by the traditional GIS softwares just like a map or any other vertical view data source (e.g. aerial photo or satellite image). The presented method is based on the well known GIS softwares with the difference that in our case the starting base is not a satellite image or an orthophoto but a traditional photo or a horizontal image about the given landscape. The principles of photo analysis are the same only the viewpoint is different according to the requirements of the different end users (i.e. tourism).

Practical advantage of these methods occurs not only in tourism but in landscape historical, landscape aesthetic analyses, landscape planning and land-use or in seasonal habitat studies of vegetation.

Furthermore, tourism marketing can also take advantage of the false colour photo technology that was a partial result of the research with the help of which the interest and attention of visitors can be focused on the destination to be advertised.

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