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Estimating the tourist carrying capacity for protected areas. A case study for Natura 2000 sites from North-Western Romania

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Abstract

The estimation of the tourist support capacity for three Natura 2000 sites located in North-Westerm Romania and the appropriate use of a quantitative methodology adapted to the current working techniques are the main objectives of this scientific approach. In this respect, parameters were determined for obtaining the physical carrying capacity, then the resulting value was modified by the coefficients related to the correction factors. They also consider CAV_NDVI, a factor reflecting the abundance of vegetation and the value of the NDVI spectral index at pixel level, used to quantify the state of vegetation health, as a measure of the ecological status of the sites. The obtained results highlight the sensitivity of the algorithms used for the correction factors and the possibilities of converting these results into elements with practical possibilities for the sustainable sites management.

Keywords: *Tourism Carrying Capacity - TCC, Physical Carrying Capacity - PCC, Real Carrying Capacity -RCC, Linear Spectral Unmixing - LSU, Normalized Difference Vegetation Index - NDVI*

Rezumat. Estimarea capacității turistice de suport pentru situri Natura 2000. Studiu de caz din NV României

Estimarea capacității turistice de suport pentru trei situri Natura 2000 din NV României și utilizarea adecvată a unei metodologii cantitative adaptată tehnicilor de lucru actuale reprezintă obiectivele principale ale acestui demers științific. În acest sens, s-au determinat parametri pentru obținerea capacității fizice de suport, după care valoarea rezultată a fost modificată prin coeficienții aferenți factorilor de corecție. În cadrul lor a fost introdus și CAV_NDVI, factor ce reflectă abundența vegetației și valoarea indicelui spectral NDVI la nivel de pixel, prin care cuantificăm starea de sănătate a vegetației, ca măsură a stării ecologice a siturilor. Rezultatele obținute indică senzitivitatea algoritmilor utilizați la coeficienții factorilor de corecție și posibilitățile de conversie ale acestor rezultate în elemente cu valențe practice pentru gestionarea sustenabilă a siturilor.

Cuvinte-cheie: *capacitate turistică de suport - TCC, capacitate de suport fizică - PCC, capacitate de suport reală - RCC; analiză spectrală liniară - LSU, indicele normalizat de diferențiere a vegetației -NDVI*

Introduction

The statements that render in many ways the idea that the global development of tourism with its dual valences of economic activity and social act asserts an even greater strain on the terrestrial or maritime protected natural areas, represent already introductory patterns found in a lot of papers, studies, articles and special reports (Coccossis et al., 2002, Salerno et al., 2013, Weber et al., 2017).

Actually, these statements with postulate value express a reality noticed since the '30s, but especially after WW2, when the first worrying signs related to the rapid growth of outdoor recreation tourism and the degradation of the natural elements of the environment appeared (Butler, 1996, Whittaker et al., 2011).

Naturally, as the dichotomous aspect of this reality exacerbates, in the sense of raising the economic benefits for the stakeholders on the one hand, and declining the quality of the environmental factors in the protected areas on the other hand, we have conceived working techniques and methods to help us evaluate the qualitative and quantitative limits regarding the degree of tourist capacity supported by an area, without being irreversibly affected in a negative way.

Thus, beginning with the '60s, the concept of carrying capacity debated rigorously by Wagar, în 1964 (Lime and Stankey, 1971; Manning, 2002) has been coined and implemented in the management of tourist activities within national parks worldwide.

From land protected natural areas (Cifuentes, 1992, Amador et al., 1996, Cifuentes et al., 1999, Somarriba-Chang et al., 2006, Segrado et al., 2008, Viñals et al., 2014, Queiroz et al., 2014), to coastline areas with seaside tourism (Zacarias et al., 2011, Jurado et al., 2012, Jurado et al., 2013) and up to underwater trails in maritime protected areas (Ríos-Jara et al., 2013, Cupul-Magaña and Rodríguez-Troncoso, 2017), all of them have been the subject of a number of laborious studies targeting the estimation of tourist carrying capacity.

We have made this brief presentation to point out the present scientific framework, clearly dialectic, but extremely fertile in terms of knowledge, of this segment of tourist carrying capacity worldwide. In Romania, where according to governmental data (Romanian Government, 2019) the natural protected areas (including Natura 2000 sites) cover 23% of its total area, the concept of tourist carrying capacity entered quite late in the academic literature with more theoretical approaches (Dumbrăveanu, 2004, Erdeli and Gheorghilaș, 2006), and as regards its effective implementation in projects, even much later, after 2010, these being rather few. For example, between 2012 and 2014, there was the project called Evaluating the carrying capacity for visitor management in protected areas. Case study: Danube Delta Biosphere Reserve, as part of ”DANUBEPARKS STEP 2.0 - Anchoring the Danube River Network of Protected Areas as Platform for Preservation of Danube Natural Heritage” project, and currently an application called ”Monitoring system of the ecological carrying capacity” on the site of the National Institute for Research and Development in Tourism (http://smcse.incdt.ro/index.pl/home_ro) is being implemented as a result of a project run by the aforementioned institute.

The main objectives of this study are:

- estimating the physical and real tourist support capacity for the Natura 2000 Sites: Cefa, Valea Roșie and Ferice Plai;
- adapting a classical quantitative methodology to current working techniques;
- identifying correction factors that also meet the needs of the protected areas to maintain
- them in a dynamic environmental balance;
- modeling these factors so that they can be integrated into the standard methodology;
- their partial validation on the three analyzed areas.

Study Area

This research paper focuses on 3 Natura 2000 sites (Sites of Community Importance - SCI): Cefa, Ferice Plai and Valea Roșie (Fig. 1).

Cefa (code ROSCI0025) is located in the Lower Crişurilor Plain from north-west Romania, in the Bihor County, is by far the largest protected area, with 5224 ha (http://natura2000.eea.europa.eu), while Valea Roșie Natura 2000 site (ROSCI0267) is the smallest, with only 786.7 ha (http://natura2000.eea.europa.eu) within the Western Hills, while the Ferice Plai have (code ROSCI0084) 1993 ha.

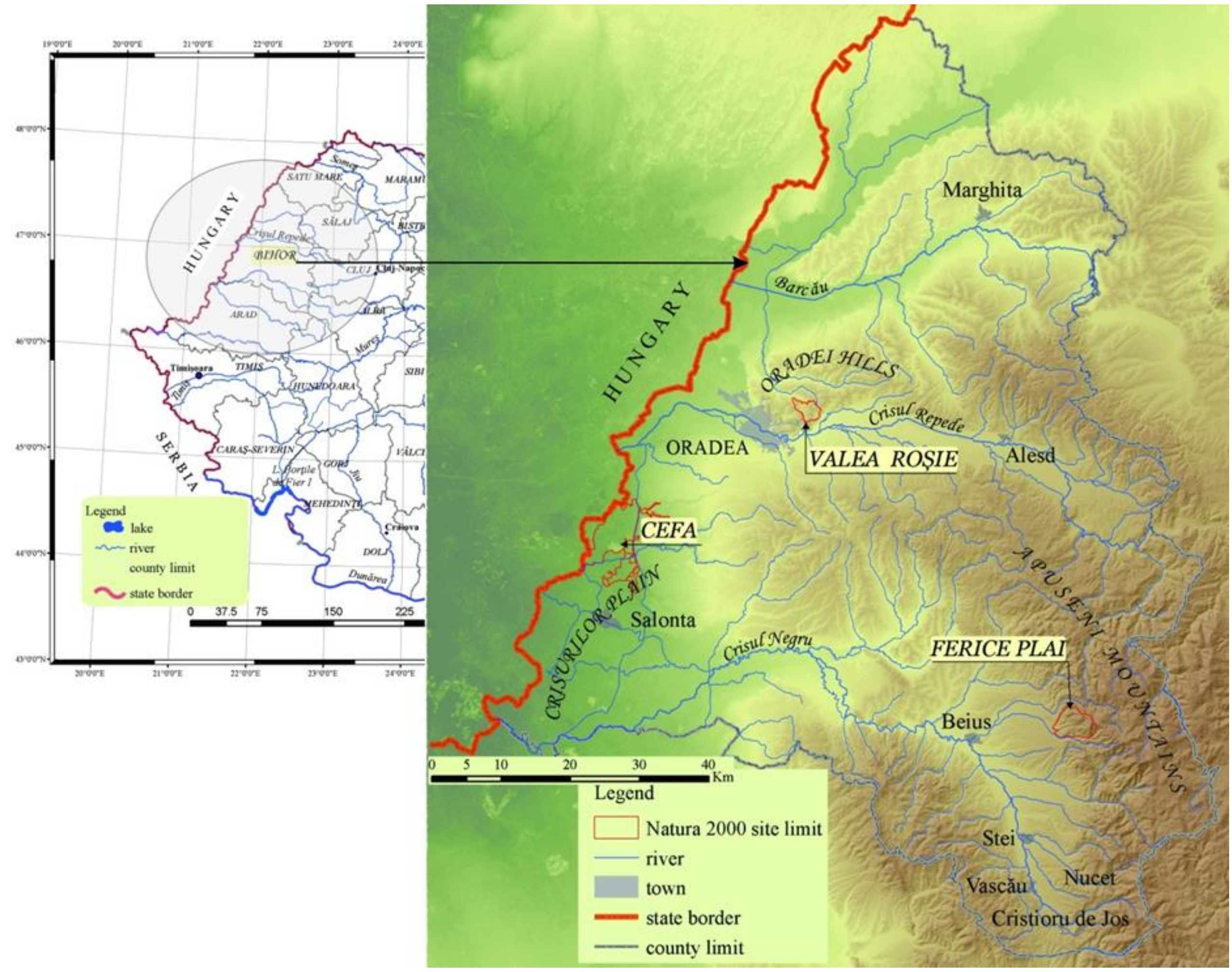

Fig. 1: Study area location

Methods

The working methodology of this present study is based on standard working techniques to quantitatively estimate the tourism carrying capacity (TCC) in protected areas, and satellite data processing techniques.

Most of the papers in the academic literature that deal with this problem (Segrado et al., 2008; Zacarias et al., 2011; Lagmoj et al., 2013; Queiroz et al., 2014; Viñals et al., 2014) mention and/or use Cifuentens' methodology (1992), internalized and adopted by Ceballos-Lascuráin (1996). Nevertheless, we must state that, as early as 1986, Boullón (quoted by Shackley, 1996; Viñals et al., 2014) publishes a calculation formula for carrying capacity similar to the one of Cifuentes, except that it is not expressed on the three levels (physical, real, effective) become classical in the tourism research.

Hence, after Boullón (1986), the carrying capacity is expressed in the following manner:

$$CC = \frac{area\ used\ by\ tourists}{average\ individual\ standard} \times R_f$$

R_f - rotation coefficient

$$R_f = \frac{No.of\ daily\ hours\ area\ is\ open\ for\ tourists}{Average\ duration\ of\ visits}$$

Our modus operandi is based on Cifuentes' methodology (1992, 1996), with the suggested proper changes, that will be presented throughout the paper.

As we stated above, it demands an approach on three levels of accuracy and complexity regarding the indicator in discussion, with adaptations of the limiting factors taken into consideration (elements that reduce the carrying capacity), according to the local specific aspects of the analysed sites.

From our point of view, the reporting criteria for such an undertaking must also be determined from the start:

- type/form of tourism for which we carry out the estimation;
- essential elements with tourist value in area for the type of tourism taken into consideration.

We state all these because, in many of the protected nature sites, the landscape endmember variety is incredibly large, but, in general, for a particular type of tourism, only a few sets of component are relevant.

For the Natura 2000 sites considered in this study (Cefa, Valea Roșie, Ferice Plai), we selected two endmembers, vegetation and water, that we consider essential for the type of targeted tourist activity, namely hiking. Clearly, this does not mean that the rest of the tourist resources are completely ignored within the study area.

Physical Carrying Capacity (PCC)

It refers to the maximum number of tourists that can be on the area of the nature site, where the public access is allowed, in a determined time frame.

$$PCC = \frac{A}{A_u} \times R_f$$

A - available area for public use;
A_u - area available per user;
R_f - rotation factor (number of visits/day).

Real Carrying Capacity (RCC)

It is obtained by modifying the value obtained for PCC, based on some indices calculated for the so-called correction factors (correction factor, cf1, cf2 etc.):

$$RCC = PCC \times (cf_1 \times cf_2 \times cf_3 \times \ldots cf_3)$$

The correction factors come off from the specific environmental, biophysical, social attributes of the sites, with local adaptations for each territory and type of tourism taken in consideration, in the sense that for their expression those natural and/or social elements are considered that limit the tourist activity.

For example, Amador et al. (1996) use as correction factors: erodibility, accessibility, precipitations, sunshine duration, floods, temporary closing of the site, while Figueras et al. (2011) use: social factor, precipitations, sunshine, wind, and Somarriba-Chang et al. (2006) take Cifuentes correction factors, eliminating sunshine duration and rains.

Their mathematical expression is the following:

$$C_{fx} = 1 - \frac{Ml_x}{Mt_x}$$

C_f - correction factor for variable x;
Ml_x - limiting magnitude of variable x;
Mt_x - total magnitude of variable x.

Effective Carrying Capacity (ECC)

The value of the RCC is corrected by a coefficient defined by a factor that takes into account the available managerial capacity, infrastructure related to the tourist facilities (trails, equipment), the qualified staff provided to the tourists, the financial investments, the regulations of the legal entities in the studied areas. There is no such infrastructure for the three Natura 2000 sites, not even legal regulations (management plans) are not finalized, so that the actual support capacity is equivalent to the real carrying capacity.

Results and Discussion

Physical Carrying Capacity (PCC)

The estimation of PCC implies, as can be seen from the corresponding formula, to obtain the values for A (available area for public use), Au (area available per user) and RF (rotation factor).

Naturally, A (area for tourist activities) can be easily obtained from the management documentations of Natura 2000 sites, and if there are no restrictions, it can be determined based on the distribution of the tourist resources taken in consideration, according to the tourist activity that we are interested in.

In Romania, however, there are situations where the management plans of the sites are on the anvil, therefore getting some official data of this kind is impossible. This is also the case of two out of the three protected areas that we previously presented (excepting Cefa, for which the existing documentation mentions a functional internal zonation, but which is not restrictive for hiking, as form of tourism).

Under these conditions, we determined the value of A based on the distribution of the two categories of components that we selected, with attributes of tourist resource (vegetation, water).

The effective way of extracting (A – ha) the area available for tourists in this study is based on a multispectral image processing technique, Linear Spectral Unmixing, by which the abundance, at pixel level, of the material geographic elements from an area is obtained. The term abundance must be understood as the participatory percentage share of an endmember on a predetermined area (for example, a value of 0,7 for the forest element indicates that 70% from the surface of a cell/pixel is occupied by this element). Other details concerning the Linear Spectral Unmixing will be offered throughout the presentation of the methodology for Real Carrying Capacity.

To validate the results, we used common techniques of vectorizing the ways of land use on orthophotoplans (1:5000, 2012), corrected on high resolution multispectral images (Pleiades, 2014, 160 cm resolution for Blue, Green, Red and NIR, respectively 40 cm for panchromatic, https://spacedata.copernicus.eu) and verified in field.

In fact, real problems concerning A appear in the case of Cefa site, because of the heterogeneousness of the land cover (Fig. 2).

And this is the reason why we also used LSU (the main reason for using LSU reside in the correction factors applied for RCC) for highlighting the compact areas occupied by water and forest vegetation (Fig. 3). Of the 5224 ha of Cefa site, according to the site's documentation and GIS data (http://www.mmediu.ro.articol/date-gis),the touristic value (estimated by summing up the rasters that express the abundance of vegetation and water) has 1027 ha, of which the area that can be used by tourists (A, resulted from the exclusion of the areas occupied by water) is of 232,35 ha (Fig. 3).

In Valea Roșie and Ferice Plai, the share of forest areas exceeds 90% (92.41% for Ferice Plai, 94.42% for Valea Roșie, according to the evaluation reports of the anthropic impact for the two sites in the year of 2016), thus their areas can be tantamout to the values of A.

Au (area available per user) is most often understood as the area used by a tourist (a group of tourists can also be taken into consideration, but then we must intervene with the distance between the groups as correction factor) so that he feels comfortable, which also implies the requirement of not intersecting with other persons or groups. In Cifuentes' methodology from 1992, it is expressed as a report (V/a), that has the value of 1, in the sense that it is considered that a tourist needs 1 m2 to move freely, value adopted by other studies too.

Ultimately, the value of Au depends on the type of tourist activity which we refer to. For example, Lagmoj et al. (2013) consider that, for an ecotourism recreation activity of 4 hours in a forest that has 19247 m2, a person needs 10 m2, while Queiroz et al. (2014) use the value of 1 m2 for estimating the carrying capacity in I-le Azore, at level of tourist routes.

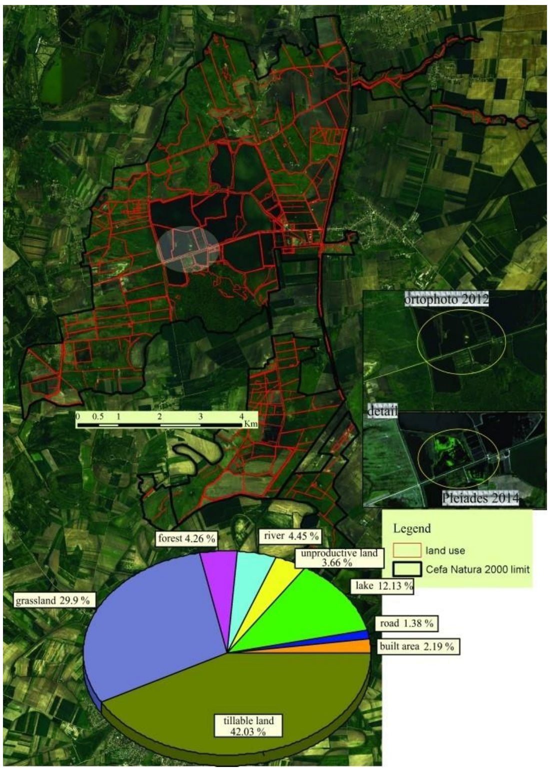

Fig. 2: Cefa Natura 2000 site. Land use (data sources: Ortophoto 2012, Pleiades 2014)

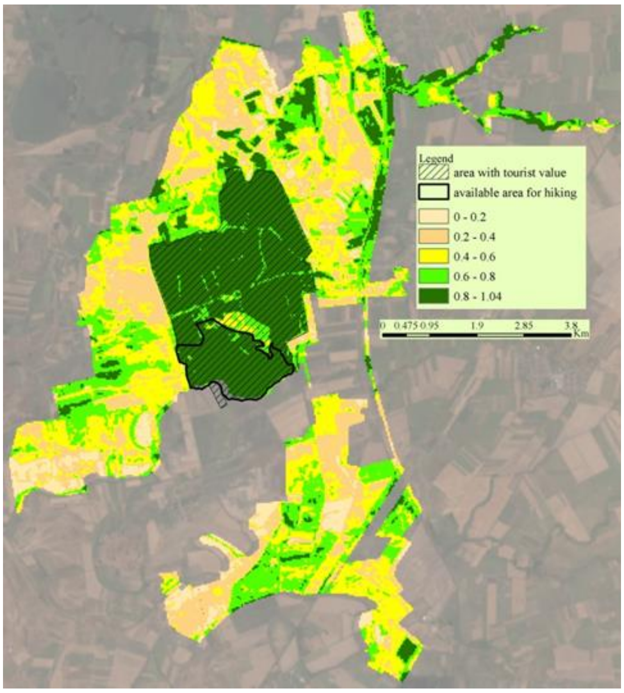

Fig. 3: Cefa Natura 2000 site. Sum for vegetation and water fraction images (background data source: Landsat 8 OLI 2014)

In Romania, the norm of space for walks in forests without visiting infrastructure, according to the National Tourism Research and Development Institute is 0.01 ha/person, that is also the space that a person needs for fishing or a walking in the park (http://smcse.incdt.ro/index.pl/ctsm_ro), a situation we cannot agree with, even considering the simple premise that hiking involves the movement of a person on a particular route. That is why we consider that a minimum value of 0.09 ha (900 m2, 30 * 30 m) is acceptable, in order to respect the principle of non-interference with other people.

R_f (rotation factor) is expressed as a report between the period of time when the site or tourist objective is open for public and the average duration of hiking:

$$R_f = \frac{open\ period}{average\ time\ of\ hiking}$$

Because in the case of the three protected areas there are not visiting hours established by the administration, the value of open period was obtained by averaging the monthly values of the daylight duration during a year, in the west of Romania (Table 1), based on the data from the ”Admiral Vasile Urseanu” Astronomical Observatory.

For this study, the average duration of a hiking is considered to be 4 h, after consultation with the persons from the administration of sites (custodians).

The results for Physical Carrying Capacity (Table 2) for the three sites surveyed indicate, as expected, higher values in the Valea Roşie and Ferice Plai sites, even if their total area is smaller than the Cefa site, because the area available to the public is important, which we have interpreted as an area of touristic value.

Although they appear to have high values (at Ferice Plai and the Valea Roșie), they actually indicate a maximum situation, which is the base for the actual estimation of the number of tourists, that can be supported by those areas, so that these sites are not affected by irreversible changes in the quality of the environmental factors.

Table 1: Average daylight duration in the west of Romania

J	F	M	A	M	J	J	A	S	O	N	D	Year
8,5	10,4	11,3	13,5	14,8	15,81	15,32	14,2	12	11,12	9,4	8,44	12,1

(Data source: http://www.astro-urseanu.ro)

Table 2: Physical Carrying Capacity

Site name	Total area (ha)	A - Available area for public use (ha)	A_u - Area available per user (ha)	R_F - Rotation Factor	PCC (visits/day)
Cefa	5268	232,45	0,09	3,025	7809
Valea Roșie	819	819	0,09	3,025	27527
Ferice Plai	1997	1997	0,09	3,025	67121

We mention that in the scenarios that take into account that 1 m2 (Au), from Cifuentes' initial methodology, the figures for the PCC are much higher, therefore even hypothetically these being unacceptable.

Real Carrying Capacity (RCC)

The correction factors used to obtain RCC are:

- vegetation abundance at pixel level;
- NDVI (Normalized Difference Vegetation Index);
- average number of days with frost;
- number of days with rains ≥0,1 mm;
- accessibility.

We consider necessary some explanations with value of argument for using the first two factors, which, in fact, are indices derived from the processing of satellite date in software packages for remote sensing.

By inserting them in a methodology of this kind, we wanted to quantify the qualitative environmental (health) state of the protected nature areas and thus to correct the value of TCC not only by indices that appeal to the tourist's need of comfort, but also by factors that take note of the possibilities of ecological carrying for sites. Parenthetically, this does not mean that TCC becomes a „Physico-ecological carrying capacity" (Zacarias et al., 2011), it remains a way (mean) of expressing the carrying capacity for a certain type of tourist activity, but indexed (corrected) by indices with ecological value.

As a matter of fact, in the academic community it is also known the much debated problem of unidirectional quantitative approach of TCC, stressing more the tourist's needs and less or not at all the needs of the protected areas, with suggestions of new methodologies, of which some with a descriptive character, but such debates do not make the object of this study.

Regarding the methodology of obtaining the first two factors of correction (vegetation abundance – VA and NDVI), we mention that these will be combined, at the end resulting an index that expresses the health state of the vegetation in a certain period of time.

In this regard, we used Landsat 8 OLI/TIRS multispectral satellite scenes of medium resolution from the year of 2014 (for NDVI, scenes from the months of March, June and August; and for LSU, scenes from the month of June), taken from https://earthexplorer.usgs.gov/ and applied standard operations of pre-processing in ENVI 5.3, respectively radiometric calibration and atmospheric correction, pointing out that for Landsat 8 OLI, according to the recommendation from Yale University, Center for Earth Observation (), it is possible to go directly to conversion from DN (digital number) into reflectance (ToA – Top of Atmosphere Reflectance). For atmospheric correction (a necessary operation to go from ToA to Surface Reflectance), we used Dark Subtraction and Fast Line-of-sight Atmospheric Analysis of Spectral Hypercubes – FLAASH methods, comparatively. If the FLAASH module is used, a rescaling of the resulted raster will be necessary, because by this work flow implemented in ENVI, the final data are multiplied with the value of 1000 (Envi HELP), and the data stored in the reflectance raster must be between 0 and 1.

Linear Spectral Unmixing (LSU), as reflectance processing technique for highlighting vegetation abundance/pixel, is based on the principle that each pixel from an image consists of the spectral signature of several endmembers, and each pixel contributes individually to its configuration, thus being perceived separately by the remote sensing sensors (Adams et al., 1995).

The essential aspect of this undertaking, of which the quality of the final result depends, has to do with identifying and determining the spectral endmembers taken into consideration, with value of endmember (de Asis et al., 2007; Meusburger et al., 2010). The notion of endmember must be understood as a material endmember (area or type of land cover) that has a unique spectral signature.

The ground rule is that the number of endmembers to be smaller than the number of spectral bands of the spectral image that was used (ENVI EX User`s Guide).

We used five endmembers: water, vegetation, bare soil, built-up areas and roads. The spectral endmember (Fig. 4) was extracted directly from the calibrated satellite image (reflectance), previously being selected the pixels considered to be pure as regards composition, using Pixel Purity Index (PPI) from ENVI, followed by a close pixel evaluation, for which we used orthophoplans and spectral images of high resolution.

The data stored in the multispectral product that resulted must be comprised between the values of 0 and 1, having the significance that we already mentioned.

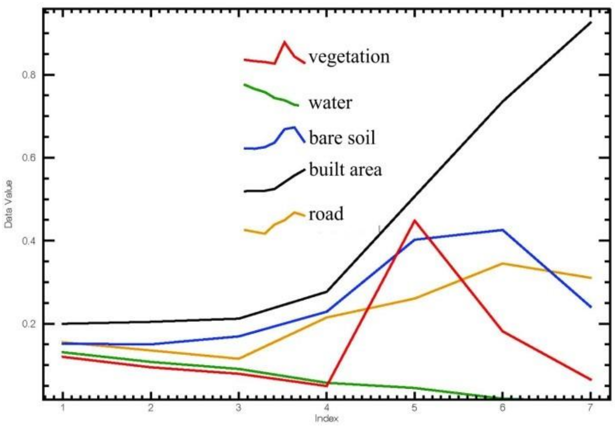

Fig. 4: Spectra for endmembers

4NDVI (Normalized Difference Vegetation Index) falls into the category of spectral indices that

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express the vegetation vigour and consistency, being known that the green plants (with chlorophyll) absorb radiation from the red domain and reflect radiation from the near infrared domain (Bannari et al., 1995).

Conceived by Rouse et al. (1973), it is one of the indices with the largest applicability in research, from evaluating and monitoring the ecological state of different vegetal associations (Pettorelli et al., 2011) to estimating the C factor from the universal equation of soil erosion (Van der Knijff et al., 2000; Lin et al., 2002), probably because of its simplicity too, as algorithmic way and processing technique.

$$NDVI = \frac{NIR - RED}{NIR + RED} = \frac{B_5 - B_4}{B_5 + B_4} \ (for\ Landsat\ 8\ OLI)$$

Its values are comprised between +1 and −1, and their interpretation is simple: the closer the values are to 1, the higher the vegetation vigour is, and its health state is better. On the contrary, low values indicate a precarious state of vegetal cover. Figures very close to 0 show that there is no vegetation, while the negative ones point to the presence of water. If temporal series of multispectral images are used (we used only three scenes), the results can be then averaged, which we did.

Evidently, interpreting values implies determining some thresholds for class delimitation, which means a good knowledge of the field, as well as a result checking based on some samples of high resolution satellite or aerial images.

The combination of the two factors expressed spatially and alphanumerically, by a simple operation of multiplication (VA * NDVI) in the Raster Calculator of ArcGIS, after they were previously exported in grid format from ENVI, permitted a correction as regards PCC with an index resulted from the real situation of the ground of the three sites (Fig. 5, 6, 7).

For the actual calculation of this index, that we shall name it CAV_NDVI, the rationale of the steps is the following:

- the operation of classifying/reclassifying data is executed, undertaking that involves determining values – threshold, according to the endmember reality of each site;
- for determining MI the class with the lowest values is taken into consideration, because this threshold expresses spatially and numerically the territory of site where vegetation has a weak consistency;
- the class with negative values and tantamount to 0 is not taken into consideration, because it identifies with water areas.

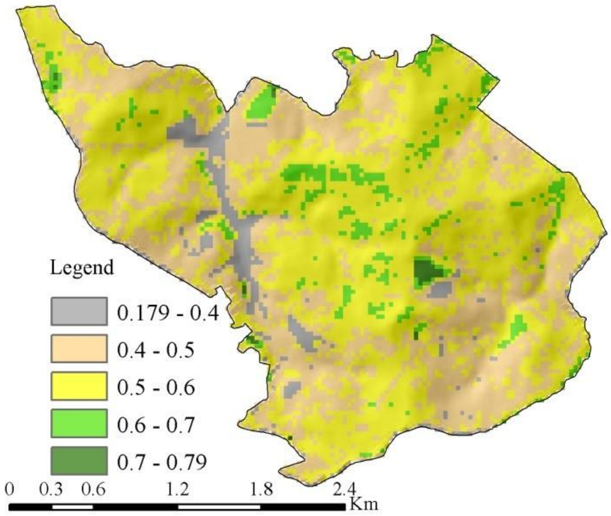

Fig. 5: *VA*NDVI* for Valea Roșie site

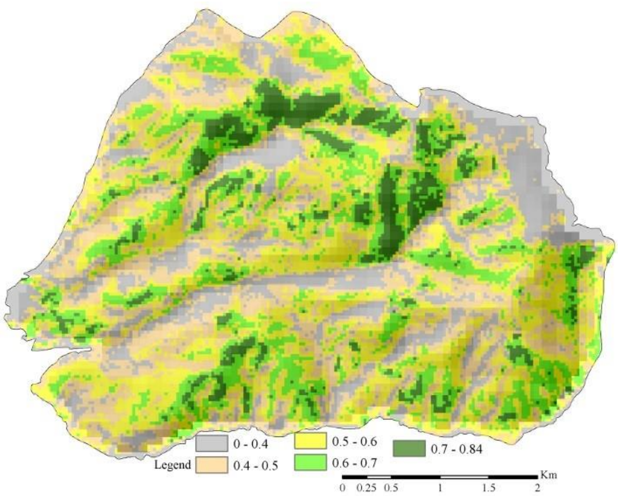

Fig. 6: *VA*NDVI* for Ferice Plai site

Forward, the way of obtaining CAV_NDVI integrates in the operational flow of standard methodology, i.e. we extracted the surface of the inferior class (e.g., for Cefa the class is [0,01 - 0,2]), relates to the surface of the site, and the resulted value is used for obtaining the correction index (Table 3):

$$C_{AV\_NDVI} = 1 - \frac{S_i}{S_t}$$

Si – surface of the class with inferior values;
St – total surface of the site;

Table 3: C_{AV_NDVI} values

Site Name	S_i (ha)	S_t (ha)	C_{AV_NDVI}
Cefa	3304	5268	0,37
Valea Roșie	37,68	819	0,95
Ferice Plai	371,79	1997	0,81

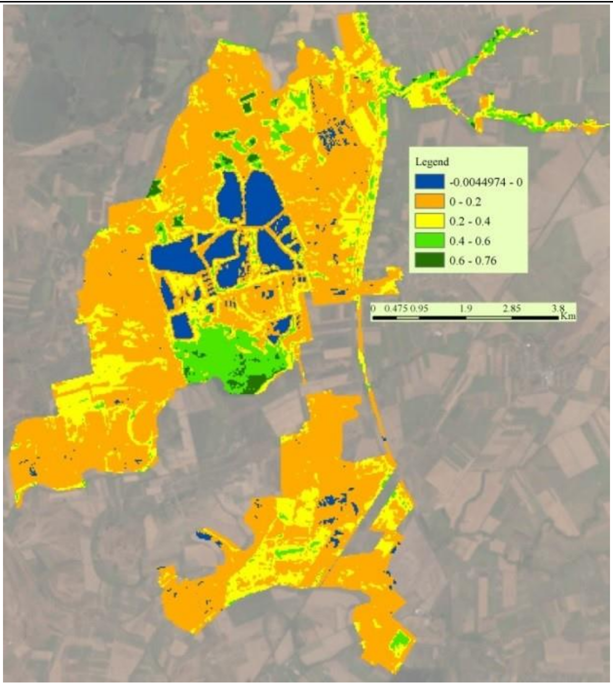

Fig. 7: *VA*NDVI* for Cefa site

The average number of frozen days in a year (the meteorological parameter expressing the average number of days with the minimum temperature ≤ 0° C) was chosen as a correction factor, starting from an elementary logic, that such days do not provide a positive motivational framework for the potential tourists. Its value was calculated based on data from the nearby weather stations, because throughout the sites there are no measurements recorded. Thus, for Cefa and Valea Roșie there were used the data from the Meteorological Station Oradea, processed by Dumiter (2007), and for Ferice Plai, the data from the Meteorological Station Ştei, mediated with the ones from Stâna de Vale (even if Stâna de Vale is an extreme case of evolution for many meteo-climatic parameters from Romania, it is very close to the eastern limit of the site - 3 km), processed by Gaceu (2005).

For Cefa and Valea Roșie the value of this factor is 0.73 (the average number of days with frost per year is 95.3) and for Ferice Plai of 0.62 (the average number of days with frost per year is 138, 15).

The average number of days with rains ≥0.1 mm, as a factor limiting tourist activity, has the same data source and logic of using the values as in the previous case, so we do not go into further details.

For Cefa and Valea Roşie, the meteorological parameter value is 131.4 days / year (Dumiter, 2007), and the value of the correction coefficient is 0.64.

For Ferice Plai, the average number of days with rain ≥0.1 mm is 166.65, the value of the correction coefficient being 0.54.

Accessibility is perceived in such studies as a way of assessing natural (physical-geographic) conditions inside protected areas that make travel difficult, considering the access of tourists. For Valea Roşie and Ferice Plai, the slope is the morphometric parameter that best quantifies the tourists' travel possibilities. It is not advisable to combine this parameter with hypsometry, because even if the mathematical slope is defined as the value of the angle made by the slope of the profile, with the horizontal of the place, geomorphologically it expresses how the altitude changes according to the distance, therefore by this parameter we synthesize the terrestrial elevation. At the Cefa site, the water and marsh areas restrict the movement of tourists.

The slope (Fig. 8, 9) was obtained by processing digital elevation models with a resolution of 15m, resulting from the interpolation of the digitized level curves on topographic maps, 1: 25,000 scale and 5m equidistance, and for aquatic and marshy areas, we used the water abundances raster, the documentation from the "Action Plan for taking into the administration the Cefa Natural Park with ROSCI0025 Cefa, ROSCI0387 Salonta, ROSPA0097 Cefa Fishing - Rădvani Forest and the Natural Reserve 2194 Colony of Birds from the Rădvani Forest, located in the North West Region of Romania" and the vector data taken from orthophotomaps (2012) corrected for 2014.

From the slope grids the highest values (25-39° - Ferice Plai, 17-21° - Valea Roșie) are considered as restrictive for hiking, and their surfaces were used to obtain the correction factor (Table 4).

Table 4: Ferice Plai, Valea Roșie. Accessibility

Site name	Slope class (°)	Area for slope class (ha)	Total site area (ha)	Correction Factor
Ferice Plai	25 - 39°	376,83	1997	0.81
Valea Roșie	17 - 21°	3,03	819	0.99

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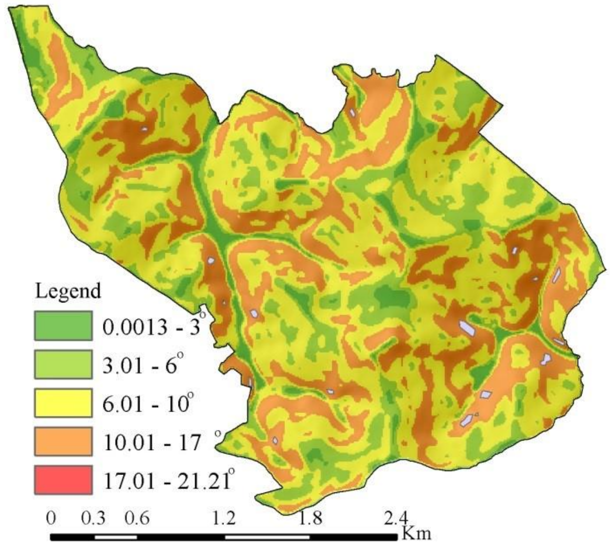

Fig. 8: Slope for Valea Roșie site

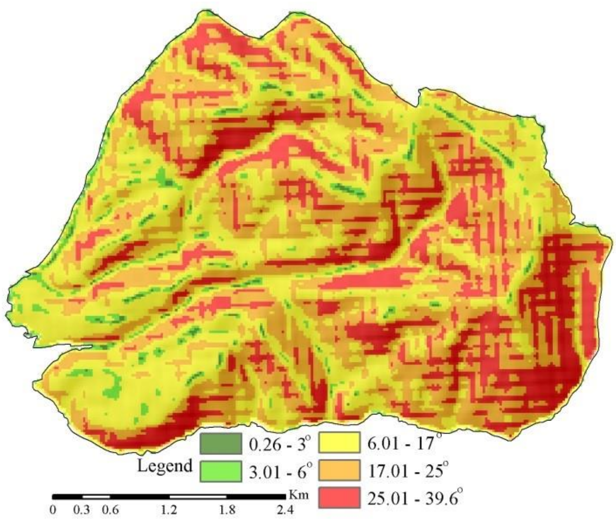

Fig. 9: Slope for Ferice Plai site

The values obtained for the aquatic areas of the three data sources range from 620 ha (LSU derived raster), 633.69 ha (GIS data), 689.46 according to the mentioned documentation. Any of them use only minor changes of the value of the correction factor (by 0.01, from one data source to another), but we will refer to the values considered official.

The result is a correction factor induced by aquatic and marshy areas of 0.87.

The coefficients of correction factors radically change the theoretical estimates of PCC and lead to Real Carrying Capacity (RCC) values, closer to the geo-environmental potential of sites (Table 5).

What draws the attention, even to a simple primary data evaluation is the value approximation of the results from the two sites (Ferice Plai and Valea Roșie) relatively homogeneous in terms of land cover (forest vegetation over 90%), but with very large differences in the area available for public use, e.g. 819 ha for Valea Roșie and 1997 ha for Ferice Plai.

In fact, the study of two sites, having a close structure of the vegetation formations, was made to understand whether and how significant, the differences caused by the correction factors that have more physical valences, not social (in this study), meaning that there is no room for re-interpretation or manipulation of the coefficients.

Clearly, the two figures for RCC (12095 visits / day, 14 744 visits / day) indicate the sensitivity of this indicator to the variables correctly taken into account, even if the coefficient variation value is quite small.

In the case of the Cefa site, which is also the most exposed to anthropogenic pressures due to tourist activities (based on a higher attractiveness), the reduced value of RCC is conditioned not only by A (available area for public use) but by the value of CAV_NDVI) as well.

If there were quantifiable attributes related to the management capability, even minimal (for the purposes of legal regulations embodied in approved management plans), the RCC values would diminish (probably significant for the Ferice Plai and Valea Roșie), thus receiving valences of ECC, therefore the research results would become a working tool in managing these protected areas.

Table 5: Real Carrying Capacity

Site name	C_{AV_NDVI}	Average number of days with frost /year	Average rainfall days ≥0,1 mm/year	Accessibility	RCC (visits/day)
Cefa	0,37	0,73	0,64	0,87	1174
Valea Roșie	0,95	0,73	0,64	0,99	12095
Ferice Plai	0,81	0,62	0,54	0,81	14744

Conclusion

Starting from the objectives of this analytical approach, we can make some statements with conclusion value.

Thus, with all the criticisms brought in the literature, Cifuentes' methodology remains a scientific inquiry, but also a viable working tool in the protected area management, if used correctly and integrated in coherent management flows.

Our (numerical) results should be understood as maximum values of the number of tourists that could be supported by these sites, considering hiking as a type of tourism. They have practical valences, if they are taken over by decision-makers and interpreted as starting elements in developing projects that relate to the infrastructure specific to the mentioned type of tourism.

Through the design mode, the CAV_NDVI correction factor, derived by means of remote sensing, has a flexible behavior and a sufficiently high sensitivity to induce quantitative changes in the tourist support capacity, consistent with the environmental status of the sites. Of all the correction factors we use, CAV_NDVI is the factor with the highest rate of change in the short periods of time, at the contemporary time scale, as demonstrated by studies that have dealt with NDVI changes on time series of satellite scenes.

CAV_NDVI can also be a tool to monitor the ecological status of sites, as ultimately, the quality of the environmental factors is best reflected in the behavior of vegetation.

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