VISUAL QUALITY INDICATORS FOR ASSESSING LANDSCAPE CHARACTERISTICS AND MANAGING ITS PROTECTION

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Abstract
The study of a landscape can be considered as a multidisciplinary topic that should include all its different characteristics and their relationships in space and time. The international scientific literature currently proposes several methodologies for the assessment of landscape visual quality, jointly with the analyses of natural, agricultural and human component dynamics, which are at the basis for land planning and management. In this paper, suitable landscape visual characteristics have been identified through the elaboration of some relevant indicators, able to take into account different land components and based on the concepts of six landscape visual characters, *i.e.*: coherence, disturbance, historicity, complexity, naturalness and ephemera. After a methodological framework description, an analysis in an *open-source* GIS environment has been applied. This approach is based on the integration of landscape metrics and land use data, which are the starting point for implementing these indicators. The methodology allows to analyze large land portions, for which the study area of a whole Italian region – the Basilicata Region - has been considered. The final result is represented by a series of different map-based indicators, that can be individually analyzed, or even combined, so as to formulate a general index for the landscape visual quality.

Key words: landscape protection, visual characters, landscape metrics, Geographic Information System, Map-based indicators

Introduction

Landscape transformations are constantly increasing and, especially in the last century, their frequency and intensity are irreversibly redesigning patterns and structure (Antrop, 2000) often with negative impacts on nature conservation, quality of life and recreation for people (Kienast et al., 2015). These landscape transformations frequently have common features, even in areas with different territorial characteristics (Olišarová et al., 2018, Statuto el al., 2018/b). After the European Landscape Convention of 2000, the awareness importance of monitoring, planning and regulating all landscape components has increased, with the aim to preserve and enhance the landscape heritage (Statuto and Picuno, 2017). Several investigation methods have been proposed, such as the concept of *Landscape Character Assessment* (Swanwick, 2002). In the present study we applied an innovative approach to assess landscape visual quality, with the aim to evaluate some fundamental characteristics for the management and protection of the landscape. This approach is based on different techniques that mainly consider land cover datasets and landscape metrics (Statuto et al. 2018/a), which allows to implement a replicable and modifiable methodology, based on different objectives and landscape characteristics.

Material and methods

The study area (Fig. 1), consisting of the whole Basilicata region (Southern Italy), covers a surface of 10,073 km^2. From a landscape point of view, Basilicata is characterized by different protected areas of particular interest from a naturalistic and historical-cultural point of view. Many areas require continuous monitoring and planning actions, due to the fragility of the natural heritage and the increase in tourist pressure (Cillis and Statuto, 2018). The Basilicata's landscape presents varied morphological aspects thanks to the geological differences, that determine a considerable vegetational and faunistic richness.

Fig. 1: The Basilicata Region (Italy)

The methodology is based on six visual quality landscape indicators as suggested by Ode et al. (2008): *coherence, complexity, historicity, naturalness, disturbance and ephemera,* that measure some of the key concepts proposed by Tveit et al. (2006). Each indicator has been calculated thanks to some specific tools (Martín et al., 2018) and related plugins with in a Geographical Information System (QGIS 3.4). The information needed to calculate these indicators refer to land use cover of 1960 (Land Use map of Italy), Basilicata region official dataset (2013), Land Copernicus dataset (land cover 2018) and Digital Elevation Model (DEM). These indicators have been evaluated as (Statuto et al. 2018/a):

- *Coherence:* it is related with landscape fragmentation. It has been calculated with "Effective Mesh Size" landscape metrics, based on land cover 2018;
- *Complexity*: it has been calculated as a landscape diversity index, using the Shannon's Diversity Index;
- *Historicity*: the degree of landscape historical continuity has been calculated in the period 1960-2018 for each area with land cover continuity and expressed in percentage;
- *Naturalness*: It describes the perceived closeness to a natural state. Starting from the use of the 2018, the naturalness has been calculated with the Hemeroby index (Walz and Stein, 2014) and inverting the values to be able to compare the indicator with others ;
- *Disturbance*: the presence of disturbing elements has been calculated as the percentage of anthropized area, obtained from the official Basilicata Region dataset;
- *Ephemera:* It refers to landscape modifications during the year, related to season succession or weather change. Recovering detailed information on Basilicata Nature Map, the percentage of vegetation that changes with the season (orchards, vineyards, pastures, arable lands, forests and meadows) has been assessed.

The first two indicators - *i.e.*: complexity and coherence - have been calculated, considering the whole study area, by Fragstats 4.2.1 software, applying a moving window approach. Historicity, naturalness, disturbance and ephemera have been expressed in a regular 1 km^2 square-mesh grid. The value of each indicator has been normalized within a scale ranging from 0 (lower value) to 1 (higher value), to make them mutually comparable and usable for further processing.

Results and Discussion

In figure 2, the map-based values of the six indicators are reported.

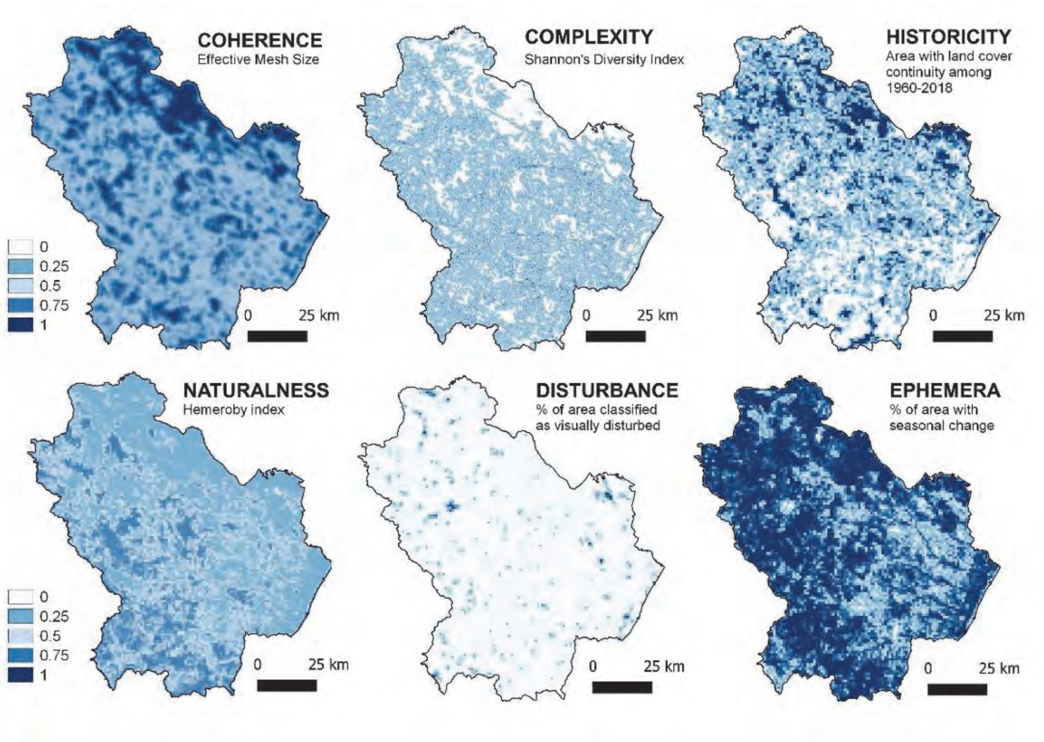

Fig. 2: Map-based values of the six indicators.

In the first step of calculation, the Index for Landscape Character Assessment (ILCA) has been obtained from the algebraic sum of the values calculated for each one of the six above-mentioned indicators, except for *Disturbance,* which has been subtracted to the total, since it determines a reduction of the landscape quality. Giving equal importance to each indicator for landscape purposes, the same weight has been assigned. Then, the Index of Visual Landscape Character Assessment (IVLCA) has been calculated with reference to an observation point, which has been extrapolated as the centroid of each 1 km^2 square grid. Finally, on the basis of a 5-m resolution Digital Elevation Model (DEM), a viewshed analysis (Čučković, 2016) has been carried out, allowing the realization of a binary cumulative raster map, that represents the visible (value=1) and not-visible (value=0) areas by each observation point (Fig. 3).

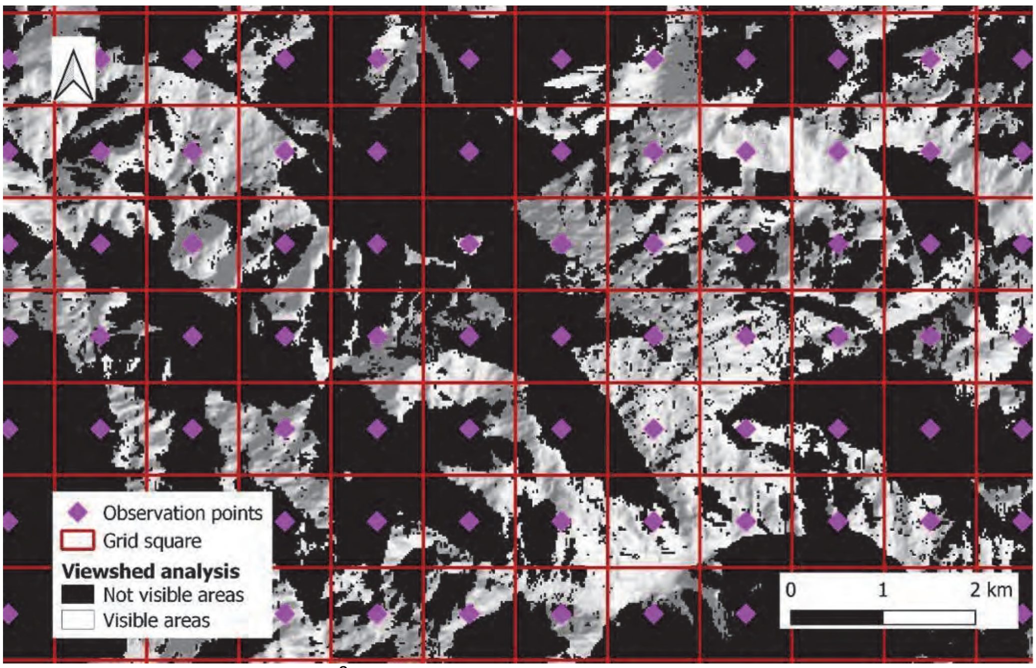

Fig. 3: Viewshed analysis: 1 km^2 square-grid, observation points, visible and non-visible areas

In a second step, the ILCA index has been then multiplied by the viewshed analysis raster value, resulting in the IVLCA map (Fig. 4 - right), in which the landscape quality is shown for visible areas only, since non-visible areas have zero value. The maximum value recorded of IVLCA is equal to 3.94 (on a theoretical maximum of 5.

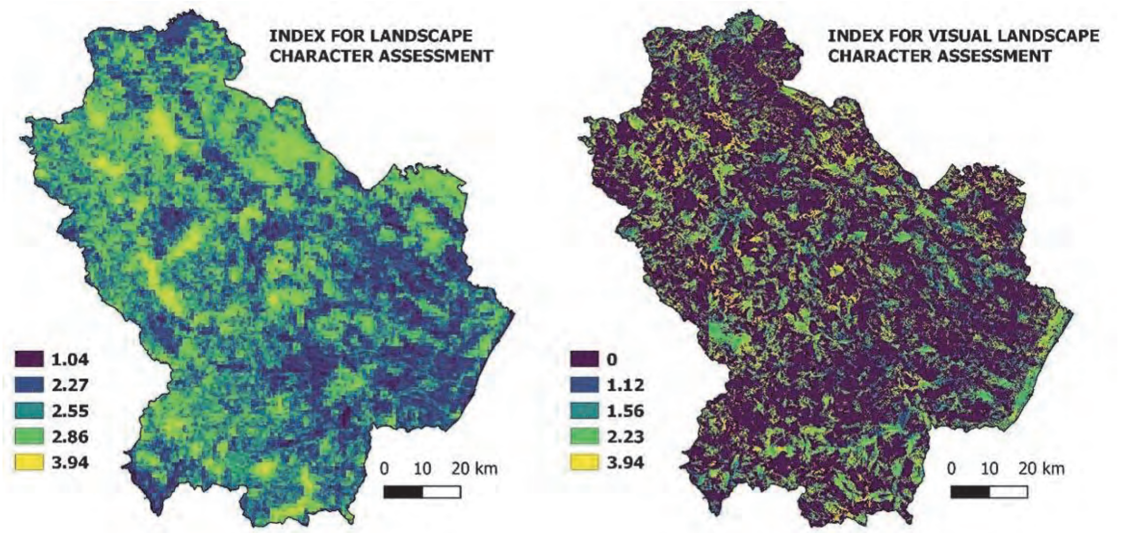

Fig. 4: ILCA (left) and IVLCA (right) maps

Finally, a more detailed statistical analysis was carried out considering the ILCA *classes*. 73.7% of the territory has indeed a value in the interval 2~3, while 16.6% in the interval 3~4. However, if we consider the IVLCA, it emerges that 67.2% of the territory is not visible from observation points, so the most representative class is still that with a value between 2~3, even if it covers a much lower land percentage (24.4%), due to a limited visibility. The same happens for the class 3~4, where the coverage percentage is greatly reduced (5.2%). The final result is that wide areas of the territory, even if characterized by an intrinsically high value of visual quality, are anyway roughly appreciable from an aesthetic point of view.

Conclusions

The methodology which has been implemented allows the evaluation of the indicators which have been considered, individually or as a whole. For example, the elaboration of the *Disturbance* indicator shows how low is the anthropic pressure on this study area and therefore, with the exclusion of some core zones, it has a limited influence on the decrease of the final index. In this case study, only some key indicators have been selected but, for a more detailed analysis, others characteristics may be considered. In addition, based on the different needs of the public decision maker, each indicator can be assigned by a different weight, depending on the specific objectives of analysis. This methodology, implemented into a GIS and processing land use and land cover data, constitutes an useful tool for planning activities, in the perspective of rural landscape protection and valorisation.

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Souhrn
V této studii byla navržena metodika pro vypracování indexu vizuálního hodnocení charakteru krajiny. Prvním krokem byl výpočet šesti specifických ukazatelů: soudržnosti, složitosti, historicity, přirozenosti, rušení a efeméry. V prostředí GIS byly vypočteny všechny jednotlivé mapové ukazatele, pak se spojily vizuálně. Nakonec byl první obecný index zkombinován s analýzou pohledu, aby se vypracoval konečný index pro hodnocení charakteru vizuální kvality.

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