VISUAL QUALITY ASSESSMENT IN A GIS ENVIRONMENT AS A DECISION SUPPORT SYSTEM FOR LANDSCAPE PLANNING

Giuseppe Cillis., Dina Statuto, Pietro Picuno
School of Agricultural, Forest, Food and Environmental Sciences, University of Basilicata, 85100, Potenza, Italy

Abstract
An important aspect to be considered in the study of a landscape is how people perceive it. Assessing the landscape visual quality has a fundamental importance, and it is one of the parameters to be taken into account for planning issues. Moreover, it has an additional significance, because in many cases there is a relationship between visual and ecological landscape indicators.
In this paper, nine landscape visual characters (coherence, disturbance, historicity, complexity, naturalness, visual scale, stewardship, imageability and ephemera) have been taken into account to elaborate map-based indicators. Considering the scale and the complexity of the assessment, these indicators have been combined into a GIS environment, so as to create an overall visual quality index. The methodology has been applied to a case study in Southern Italy, whose landscape is extremely diversified, with many critical issues in terms of protection and enhancement. The GIS revealed as a powerful tool for an accurate and replicable analysis, because it allowed to combine different indicators based on land cover data and landscape qualitative and quantitative parameters. The obtained indicators revealed very useful for a stand-alone evaluation, as well as an information base which could profitably be included in a Decision Support System (DSS) for landscape planning.

Key words: Landscape protection, visual characters, Map-based indicators, Geographic Information System, Decision Support System

Introduction

Landscape transformations, in the last century, are constantly increasing in frequency and intensity, with irreversible reshaping of land patterns and relevant structure (Antrop, 2000; Statuto et al., 2017), as well as with negative impacts on nature conservation, quality of life and recreation for people (Kienast et al., 2015). These landscape transformations have often common features, even in areas with different territorial characteristics (Picuno et al., 2019). After the European Landscape Convention of 2000, the awareness importance of monitoring, planning and regulating all landscape components was increased, and several investigation methods have been proposed, such as the concept of *Landscape Character Assessment*. In the present study, the methodology proposed in a previous work (Statuto et al., 2019) has been extended and improved, including all the nine key concepts reported in Tveit et al. (2006): coherence, complexity, historicity, naturalness, disturbance, ephemera, visual scale, imageability and stewardship. In a GIS environment, all these individual map-based indicators have been calculated and then combined together. This approach has been based on different techniques that mainly consider land cover datasets and landscape metrics (Statuto et al. 2018), which allow to implement a replicable and modifiable methodology. Moreover, they provide data that can be used within a Decision Support System (DSS). For a preliminary application within a DSS, the need for a planner to assess the landscape character in the visible area from old sheep-tracks - currently used in Basilicata region for slow tourism and hiking (Cillis and Statuto, 2018) - has been considered.

Material and methods

The study area (Fig. 1) covers a surface of 10,073 km^2, consisting of the whole territory of the Basilicata region (Southern Italy). Basilicata is characterized, from a landscape point of view, by different protected areas of particular naturalistic and historical-cultural interest, presenting varied morphological aspects thanks to some geological differences. This determines an important vegetational and faunistic richness. Due to the fragility of the natural heritage and the increase in tourist pressure (Cillis and Statuto, 2018), many areas require continuous monitoring and planning actions.

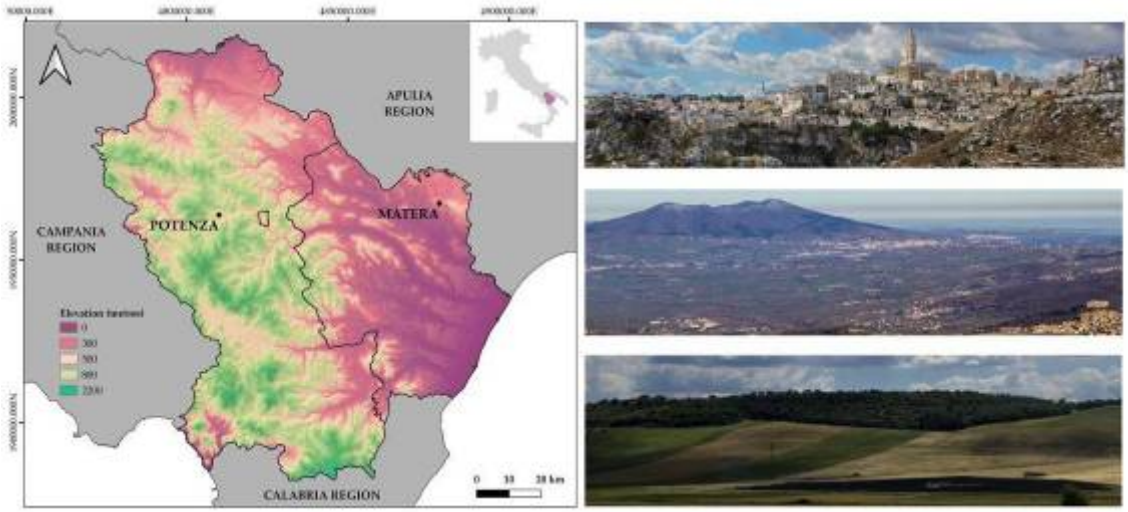

Fig. 1: Basilicata Region and high value landscapes: Murgia Materana (top), Mount Vulture (middle) and a typical hilly agroforestry landscape (bottom).

For the analysis of the landscape visual characters, the following six indicators suggested by Ode et al. (2008): *coherence, complexity, historicity, naturalness, disturbance, ephemera* - already considered in Statuto et al. (2019) - have been integrated with the following three indicators:

- *Visual scale*: focused on the size of open space in the landscape. It is calculated through the percentage viewshed analysis;
- *Imageability*: it reflects the ability of a landscape to create a strong visual image in the observer, thereby making it distinguishable. It's calculated through the density of viewpoints. These have been extrapolated by OpenStreetMap (panoramic points), selecting points linked to geographical important areas and panoramic landmarks included in the Basilicata region dataset;
- *Stewardship*: Nassauer (1995) described it as the level of land farming, and calculated it by the level of abandonment of agricultural land.

These nine indicators have been calculated thanks to some specific tools and related plugins in the QGIS 3.10 software. The relevant information has been retrieved in: land use cover of 1960 (Land Use map of Italy); Basilicata region official dataset (2013); Land Copernicus dataset (land cover 2018); Digital Elevation Model (DEM).

All the indicators have been calculated in a regular 1 km^2 square grid. All different values of each indicator have been normalized with a value ranging from 0 (lower value) to 1 (higher value) to make them comparable and usable for further processing (Fig. 2).

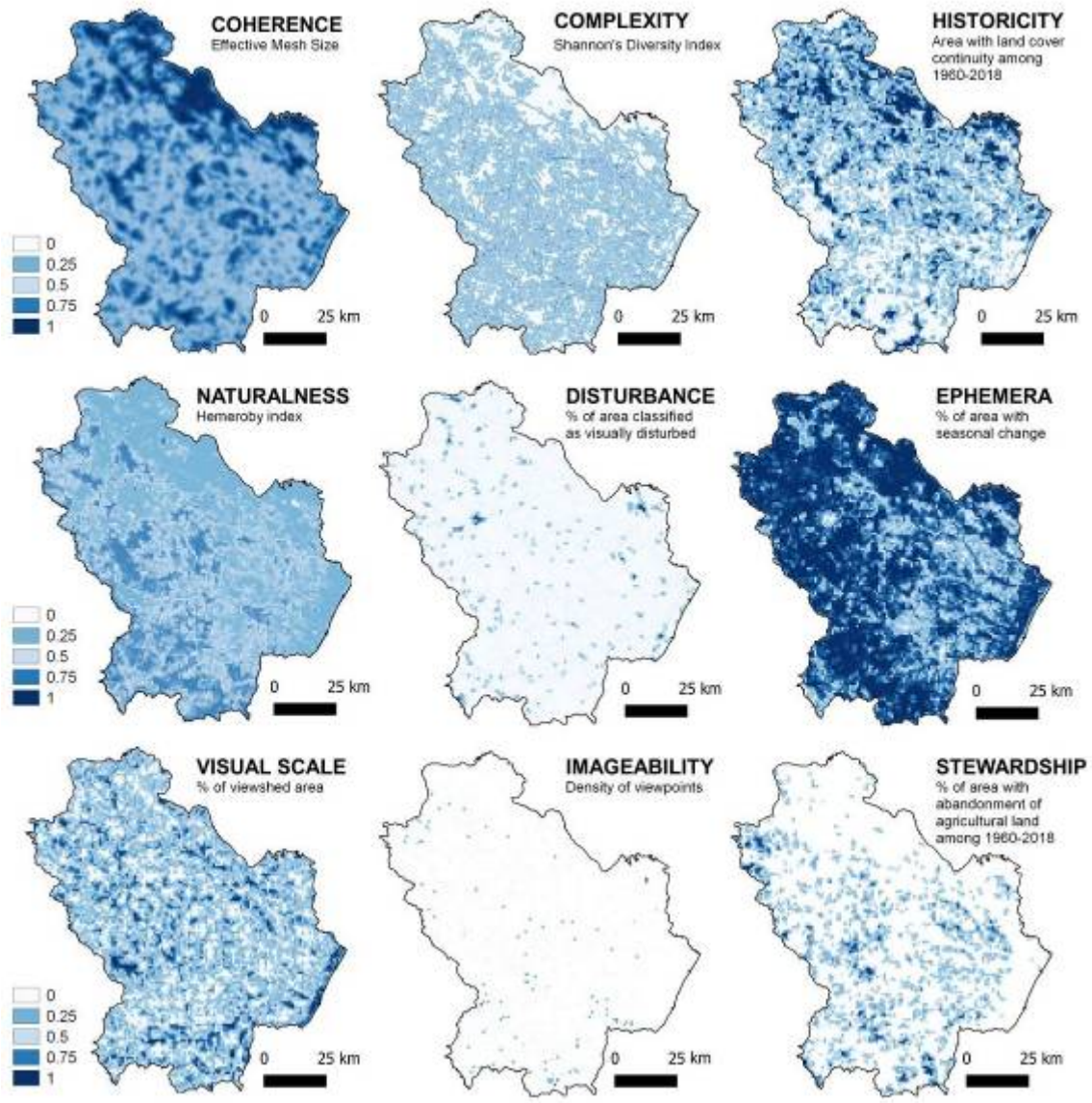

Fig. 2: Map of calculated indicators.

Hence, the Index for Landscape Character Assessment (ILCA) was obtained from the algebraic sum of the raster of indicators, except for *Disturbance* and *Stewardship*, whose values were subtracted, considering that they determine a reduction of the landscape quality (Fig. 3). For a first general assessment, the same weight was assigned, considering an equal importance of each indicator on landscape quality.

In a second phase, the dataset of the old sheep tracks with historical and landscape value of the Basilicata Region was used. The vertices of these polylines (n. 3986 vertices) were extracted, considering them as hypothetical observation points. These points were used as the basis for a viewshed analysis (Statuto and Picuno, 2017; Cillis et al., 2020) in a 5m resolution DEM. The preliminary binary cumulative raster that has been elaborated refers to the observation points. It has enabled the calculation of a raster, expressing the percentage of cell visible from these points.

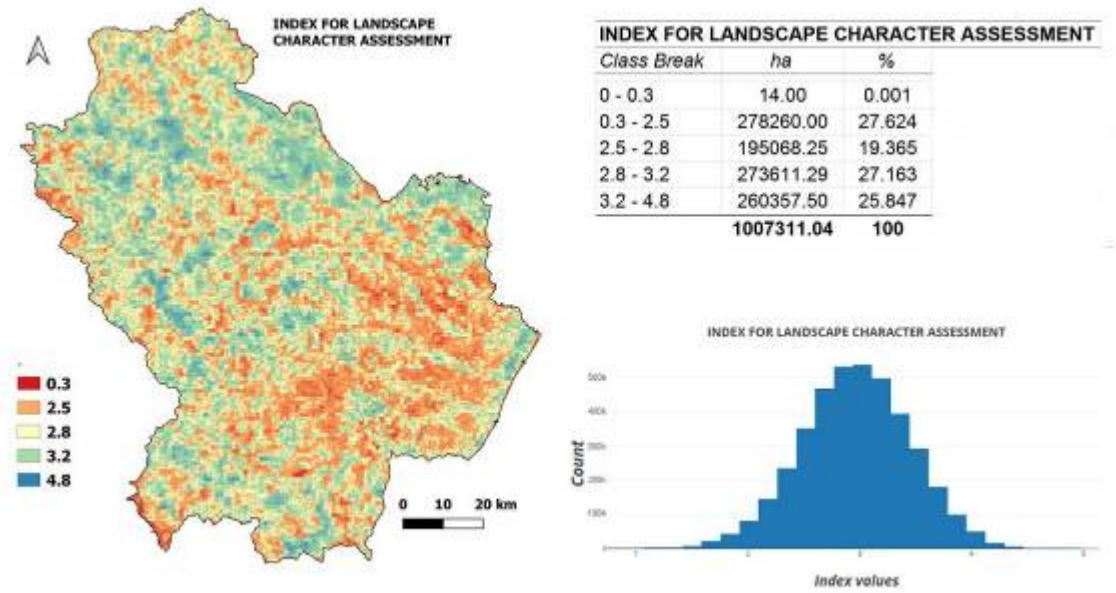

Fig. 3: Map of ILCA. On the right, the areas and percentages with respect to class breaks of index (top) and the distribution of values (bottom).

The last step was the multiplication between the ILCA of the area (Fig. 4a) and the viewshed analysis raster (Fig. 4b). The product is a map (Fig. 4 c), corrected and weighed considering the areas with the greatest visual influence.

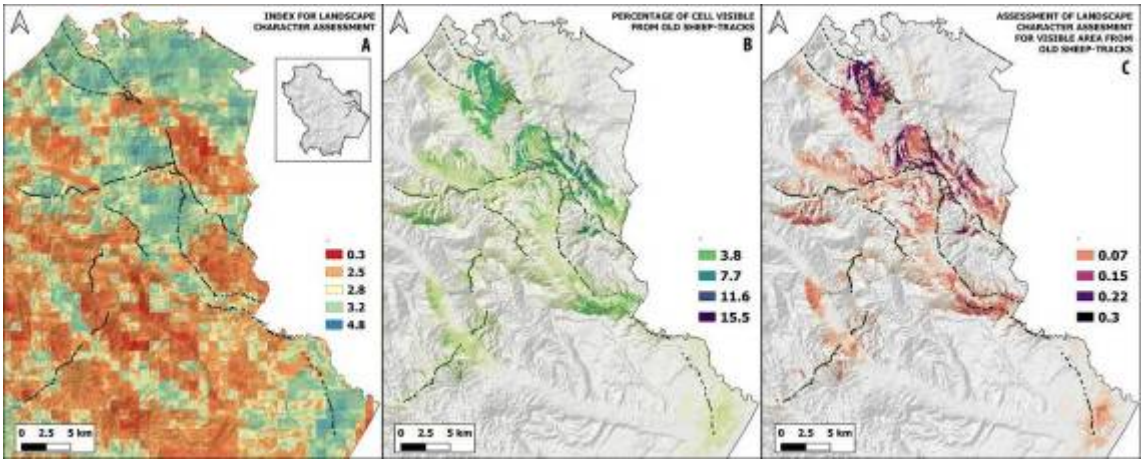

Fig. 4: (a) ILCA map; (b) percentage of cell visible from old sheep-tracks; (c) final assessment of the area with old sheep-tracks.

Results and Discussion

This methodology allowed the evaluation of the presented indicators, individually or as a whole. Evaluating ILCA it is possible to see that most of the area presents values around the average, and that the eastern part of the Basilicata region has lower values due to a greater presence of human and agricultural activities. A more accurate assessment of the ILCA may be obtained if different datasets used to build indicators are improved and defined in better detail. For example, *Disturbance* - which takes into account the negative impact of urban areas - can be corrected by excluding those urban areas with a high panoramic skyline view, a factor which increases the visual quality. This is possible thanks to the use of new geographical tools, their interoperability and the use of integrating different types of data. Thus, the quality of the landscape may be assessed by combining both qualitative and quantitative techniques. For a more detailed analysis, based on the different needs of the public decision maker, a different weight related to the specific objectives of analysis can be assigned to each indicator, so that data can be implemented into a Decision Support System (DSS), a tool that may enable to identify areas that most need attention, in order to conserve, restore or enhance the visual quality of the landscape.

Conclusions

The use of this approach to assess landscape quality has proved very useful to evaluate some fundamental characteristics for the management and protection of the landscape. The possibility to obtain some evaluation parameters from the use of land datasets, allows to apply a cartographic approach, an objective assessment of the landscape that can be successfully carried out. Moreover, thanks to the GIS technologies and new tools able to process land use and land cover data, it is possible to guarantee a good applicability and reliability. A general approach that can be applied to different visual scales, by considering particular viewpoints or panoramic roads spread on the territory, can be intended as a useful tool in terms of planning opportunities, in the perspective of the protection and valorisation of the landscape.

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Souhrn

V této studii byla navržena metodika zpracování indikátorů pro zhodnocení vizuálního charakteru krajiny. V GIS prostředí byly vypočteny jednotlivé mapové indikátory a pak spojeny na viditelném měřítku. První hlavní index byl zkombinován s analýzou obrazu a vznnikl index vizuální kvality charakteru. Přístup byl založen na různých technikách, které pracují hlavně s daty krajinného pokryvu a krajinných metrik a které umožňují zahrnout opakující se a modifikovanou metodiku založenou na různých cílech a krajinných charakteristikách. Současná studie, provedená v regionu Basilicata (Jižní Itálie), může být vzhledem ke své aplikovatelnosti využita na různých místech a může být kdekoli replikována.

Contact:
Dr. Giuseppe Cillis
E-mail: giuseppe.cillis@unibas.it