A Digital Approach to Understanding the Complex Italian Landscape: From Viewshed to Visual Intrusion

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Abstract

Landscape capacity generally refers to the degree to which a landscape area is able to absorb change without significant effects on its character and perception. The aim of this study is to examine the changes caused by the construction of settlements and infrastructures by checking which patterns of landscape are affected and by what amount, through means of image analysis techniques integrated with GIS software. This type of landscape analysis allows us to create an objective image compounded by its basic elements, numerically identifying the colour ranges and geometries that constitute its structure, using the azimuth view (orthophoto) and views from the road as observation points as well as numerically comparing those values with all of the attributes that characterize a part of a territory (cultural, rarity, historical, scenic value, sound, etc.). In this way we can assess the level of impact caused by the construction of a settlement or an infrastructure by evaluating the degree of change introduced and comparing the pre-work to the post-work situation. This will give decision makers the possibility to:

- have a more objective idea of a territory not influenced by cultural background and personal attributes;
- assess with a methodology independent from any context;
- rationalize the perceptual experience of the present day landscape;
- univocally define the parameters that identify a territory; and
- have a map of the territory's vulnerability (the analysis regards its characters and visual aspects).

1 Introduction

The methodology here presented is the result of several professional experiences on Environmental Impact Assessment and it has been originally created in order to reply to the authority's observation about the landscape impact of a large PV park in the south of Italy.The study, who's respondent has been from the beginning the local authority, has been improved and investigated as an independent research of the authors.

Every local transformation process contributes to the modification of the landscape, either by consolidating or by weakening the relationship between the elements that compose it

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and determine visual perception of it. For the purposes of the present study, our analysis has focused on: texture, change in the form of patches, and colour characteristics. The analysis tool gives as output a series of models that identifies the type of landscape, the "value" we obtained with the analysis, will be used for the calibration of the anthropic element that will be inserted in the landscape analysis. If the order geometric / colour of the item will be similar to that of the surrounding environment, the visual impact of the project will be lower, with less interference in the visual context.

The case studies presented involve new infrastructure projects (PV Park) in areas which are extremely complex due to the morphological characteristics and the delicate nature of the environmental, historical and architectural elements in Central Italy.

2 Methodology

The proposed methodology and the logical sequence of data analysis and maps are utilized to achieve a deeper understanding of a landscaped area. The study seeks to analyze the territory from its perceptual point of view and, with the aim of a multi-criteria analysis, to evaluate the features and the intangible values of historical and cultural elements embedded in the territory which determine its rarity, scenic and aesthetic value.

The aim is to rationalize the perceptual experience of landscape and to develop a more objective method of evaluating landscapes. Using Image Analysis techniques (Fast Fourier Transform and RGB Analysis) and GIS software it is possible to assess the extent of the impact on the landscape in terms of changes in colour and patterns and to carry out a more objective evaluation.

For this particular study, the visible aspect and perception of landscape is related to the following features: shape, colour and main structures of the territory in relation to the point of observation which is influenced by its absolute and relative position. The variables here selected are those suggested by the national and international authority (FEILDEN & JOKILEHTO 1998; SCAZZOSI 1999; FATTORI & MANCINELLI 2010) and attributes related to panoramic viewpoints and time of exposure have been selected by the authors.

The study is articulated in 5 points.

1. Definition of the current landscape structure: assessment of the natural and anthropic data for the territory and identification of the visual basin.

In this first phase, all the elements which define the territory are taken into consideration: morphological structure, watershed, use of the soil, cadastral organization, aggregate and isolated residential developments, local road networks and elements of historical, cultural and environmental value (fig. 1). In order to explore the perceptual vision of a hypothetical observer and its vulnerability, we have also identified the access roads and classified them in relation of their scenic value, speed of travel, and type of usage. The result is a Territory Sensibility Map. This map (fig. 1) illustrates the landscape character before the construction of the proposed infrastructure.

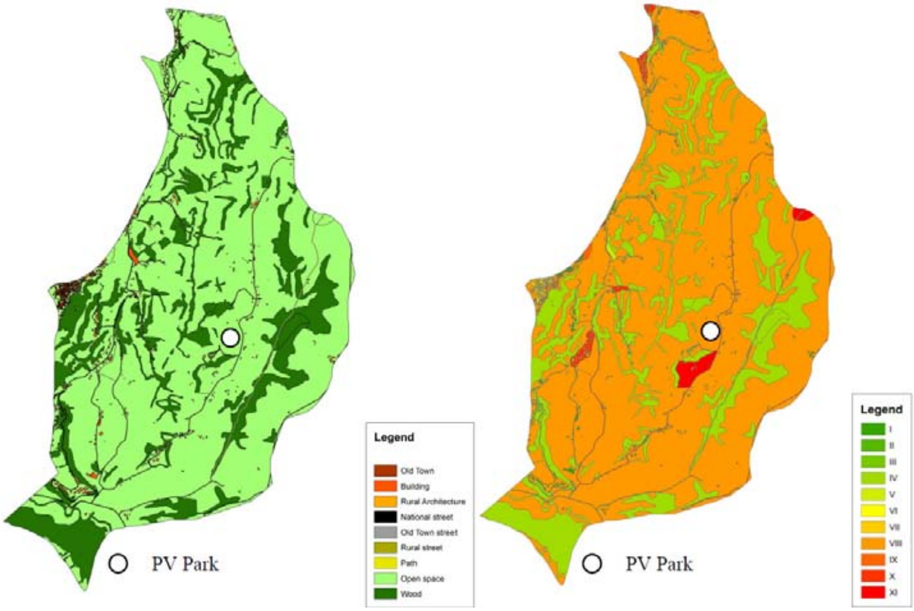

Fig. 1: Left: territory characterization classification of landscape Territorial Unit. Right: Territory Sensibility Map – each category has a value (an intrinsic value) based on the weighted sum of its representativeness, its rarity, its scenic view and its aesthetical significance. Red levels refer to higher sensibility, the green one to the lower.

2. The second step concerns 2 analysis corresponding to 2 maps:

   - A Viewshed Analysis that allows us to identify the degree of visibility with consideration of the visual barriers and the topography of the area (fig. 2).
   - A study of the visual attenuation depending on the distance from the object and the position of the observer. The Viewshed Analysis used in this methodology simulates the real vision of the human eye, instead, the Viewshed maps produced with the most common tools for Viewshed Analysis take into account only the geometric relationships between observer and target. The algorithm generally used gives information on a vision capability purely geometrical; in this case, a function that reduces the visual acuity function of the distance was added while the real vision is proportional to the chromatic contrast of an object with the background.

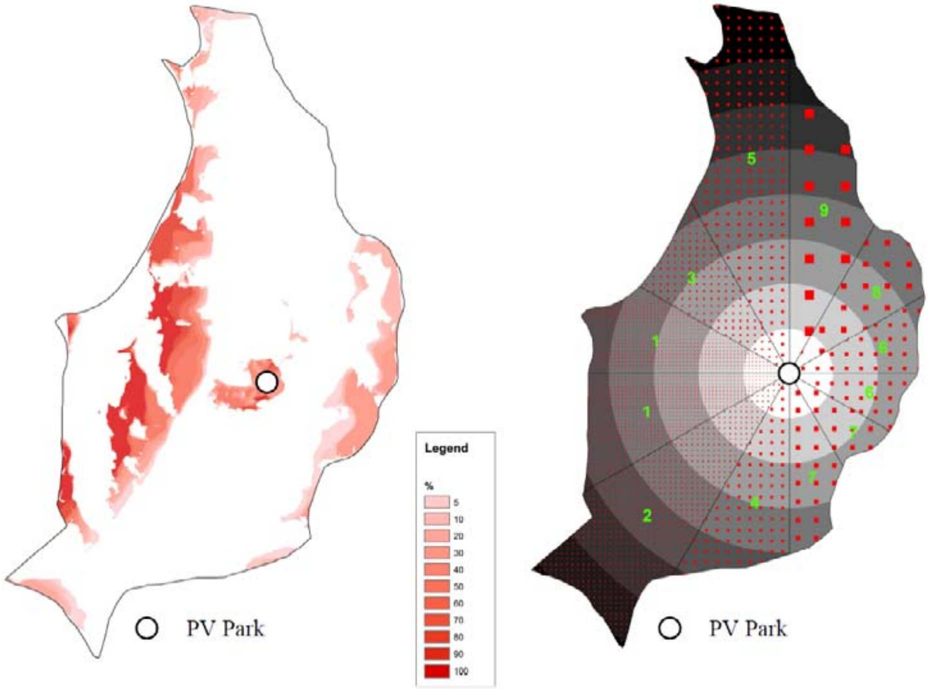

Fig. 2: Left: Viewshed Analysis. Right: Map of Attenuation function of Viewshed function. The boundaries of the grey zone define the influenced area of visual intrusion due to a PV park. Circles are placed at a distance of 500 meters one from the other and the degree of density of the squared hatch is related to the different degree of visibility from a given position of the observer. The denser the hatch is, the higher the visibility of the PV park. The implant is located in the centre of the white circle; the appreciation of the PV park varies from different positions and from different distances.

3. The third point of the methodology regards a study of Visual Sensitivity based mainly on a deeper explanation of Territory Sensibility Map. This step is essential in order to detect the levels of visual sensitivity of the area with respect to the observation time of exposure, the panoramic value and significance of the items considered (an intrinsic value is attributed to each element based on the weighted sum of the following values: representativeness, rarity, scenic/aesthetic value).
4. The fourth point is about the analysis of Visual Intrusion (fig. 3). This map overlaps all the analysis and maps drawn before and gives us the possibility to define the most sensitive areas both from a perceptual and cultural point of view. It allows us to detect the territory's most sensitive viewpoints from which we can assess the change in terms of colour and pattern of the landscape by applying image analysis procedures.

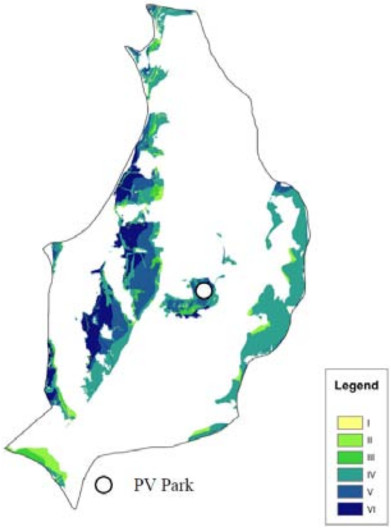

Fig. 3:
Map of the Visual Intrusion of the infrastructure in a defined influenced area with defined sensible viewpoints. The map describes with a range of colour the areas that will be more affected, in perceptual terms, by the construction of an infrastructure, with consideration of the visual barriers, the topography of the area and of the characteristic items that identify it and with respect to the time of exposure, rarity, cultural and historic signifycance and scenic and panoramic value. Category I represent the smallest impact while the blue color (category VI) define the most sensible areas.

5. Image Analysis tools applied to selected view points (fig. 4). The last part of our methodology concerns a landscape assessment by means of Image analysis techniques conducted by The Fourier Transform and the RGB Analysis. These techniques allow us to give a more objective evaluation of landscape changes. The tool enables us to obtain objective information about the scene in order to understand how, and to what extent, the perceptual image of the landscape has been changed after the construction of an infrastructure in terms of geometry and colour.

Fig. 4a: Example from a selected view point: The territory in this tract of land is organized as a mosaic of landscape primarily related to land use, with an irregular pattern and sinuous shapes where woodlands and vegetation are related to water sources and tightly interconnected to each other. The area is characterized by a remarkable visual depth. Urban regulatory plan define this part of territory as agricultural area. The project of a PV park is considered compatible. The photo shows how the PV arrays introduce a geometrical pattern uncorrelated with the landscape organization in this part of Italy. This is clearly demonstrated by the image analysis conducted with Fast Fourier transform below.

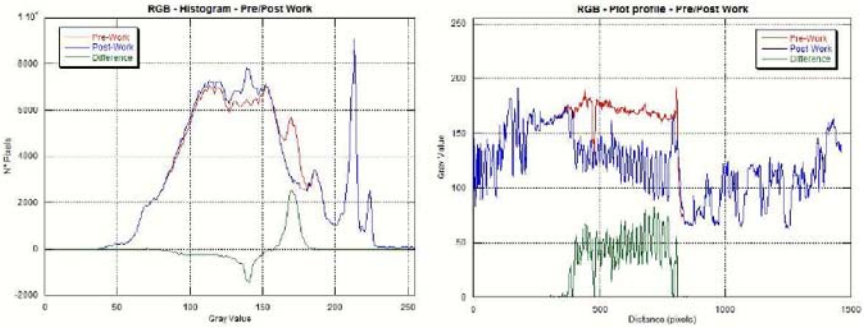

Fig. 4b: Histogram and Plot profile for Pre-Work situation and Post-Work situation. Diagrams point out the variation in terms of colour due to the insertion of the PV park. Red line: pre work situation, blue post work situation, green difference between the values. The trend shows the decline of green values and the rise of blue colour (due to the panels) after the insertion of the PV park.

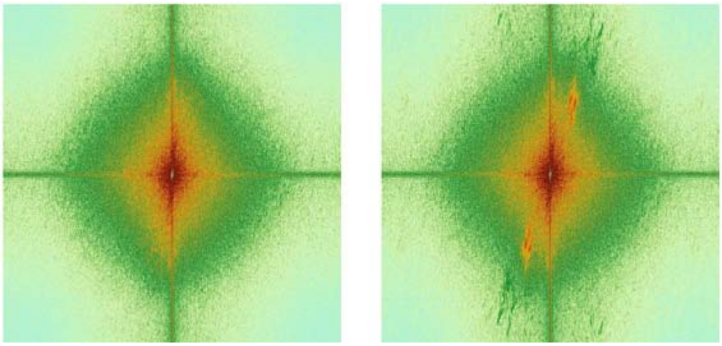

Fig. 4c: Left: Fast Fourier Transform applied to the Pre-Work Situation shows a uniform distribution of the frequency domain. Right: Fast Fourier Transform applied to Post-Work Situation point out the contribution of the PV arrays in the frequency domain.

3 Conclusions

Landscape visual evaluation has been frequently criticized due to lack of standardization of the data and methodology. The methodology here presented instead provides the framework for a more objective evaluation of landscape and a more accurate assessment of the extent of the visual impact, in terms of shape and colour and can be used in any different settings of landscape without depending on cultural background and personal attributes.

Working from the assumption that a landscape is a delicate and complex organism, not something that can be considered as simply a space available for any sort of project, the case studies and proposed methods of analysis show that an awareness and analysis of color and geometric characteristics of a territory are essential factors in minimizing the visual impacts of any structure we want to design.

We highlight that the methodology has been tested in several PV park's Environmental Impact Assessment. The variables selected are those considered most relevant and suggested by the authorities responsible for landscape conservation, but of course, in a wider interdisciplinary study other variables could be considered.

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