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Geographical analysis and numerical quantification of visual impact for aerogenerators and photovoltaic panels using Open Source GIS

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Landscape is not only a static fact, but its quality can influence the quality of life of each citizen, since the environmental psychology [9] and the geopsycology can affect the each one's choices and preferences [3]. Photovoltaic fields and windfarm can really impact on the landscape perception.

The background of this work is represented by some optical studies about the human eye perception and the definition of the field of view (for example

[12], [2]) some studies about descriptive geometry [4] and Geographical Informative Systems competencies. In particular the computation of the right field of view for a specific distance and position between object and observer, the evaluation of distortion perceived by the human eye, while observing the object and the capability to analyze the mutual relation between object, observer and earth morphology, allows to evaluate quantitatively the real visual impact of this kind of systems on the landscape.

The visual impact of photovoltaic fields and windfarm is one of the most tricky themes in landscape quality evaluation because there is still not a specific, univocal and standardized method to quantify the impact and there are not guidelines internationally adopted for geographical "non qualitative" analyses, but only qualitative or state-specific laws (for example [10], [5], [6]).

This note shows a geographical method to evaluate quantitatively the visual impact of aerogenerators and photovoltaic panels. The software used are two Open Source GIS: GRASS GIS [7] and QGIS, and the programming language Python. In particular, a specific tool called "r.wind.sun" has been developed using the modules of GRASS GIS and the Python scripting and then the tool has been added to the GRASS GIS plugin tool box of QGIS. The adoption of QGIS was needed in order to facilitate the use of the module from the public administrators who can find the GRASS GIS graphical user interface (GUI) a little tricky. A great enhancement for the module has been the changeover, in the use of the visibility tools, from r.los (GRASS GIS version < 6.4) to r.viewsheed (GRASS GIS version 7.0), which we have sponsorized.

The rationale of the module is that the visual impact of an object is related to its occupancy of the human field of view. In order to quantify this impact, the portion of the areas belonging to the observed object, respect to the human field of view (FOV), is calculated. In this way, the visual impact is represented, in the end, by a nondimensional intervisibility index (NI-ratio). In particular, taken as fixed the dimension of the observed object and the angles (up, down, left, right) defining the human field of view, the FOV area only depends on the distance from the observer. The NI-ratio is function of the FOV area calculated for the distance existing between the observer and the object.

The placement of the aereogenerator or of the photovoltaic panel is generally known and that means that the NI-ratio can be calculated for each point in the surroundings. In order to run the module user needs a digital elevation model (DEM) and a vector point layer containing the position of the aereogenerators or of the photovoltaic panel centroids. Moreover some other specific information (aereogenerators dimensions, photovoltaic panel dimensions and inclinations) have to be provided. The output of the model is a raster layer where cell values represent the nondimensional intervisibility index value. Optionally, for the photovoltaic panels, a layer of areas eventually prone to dazzling (due to panel's surface reflection) can be generated.

The analysis is executed singularly for each element (single panel or aerogenerator), in the way that, for each one of them, a raster map of the non dimensional impact index is created. Once every panel or aerogenerator is processed, the final map is obtained by sum the impact index value for each map, on each pixel of the final map. Moreover, in estimating the area of each object, both the distance between the object and the observer and the inclination of line which links them, are considered; in the way that the object results with a certain distortion (the panel surface, which is rectangular becomes irregular, the rotor of the aerogenerator occupies, with its rotation, an ellipsoidal area), as it is really perceived by the human eye.

Since the map produced by the model are in raster format, it is understandable that the duration of each simulation is strongly related to the maximum distance chosen to evaluate visual impact. Moreover, the values obtained for the impact index are often very small. This happens because when the distance between the object and the observer grows, the human field of view increase more than the object gets small, so, the values of impact index obtained by the simulation, decrease in lognormal way with the distance between observer and object. To better understand the results of each simulation, it can be useful to reclassify the output map, with the aim to obtain a zone-map from "small" to "great" impact (**Figure 1**). Another way to better understand a resulting value (NI-ratio) is to estimate the distance from the observer at which, a little object of known dimensions (for example a paper sheet), have to be put in order to give the same occupancy of field of view (NI-ratio).

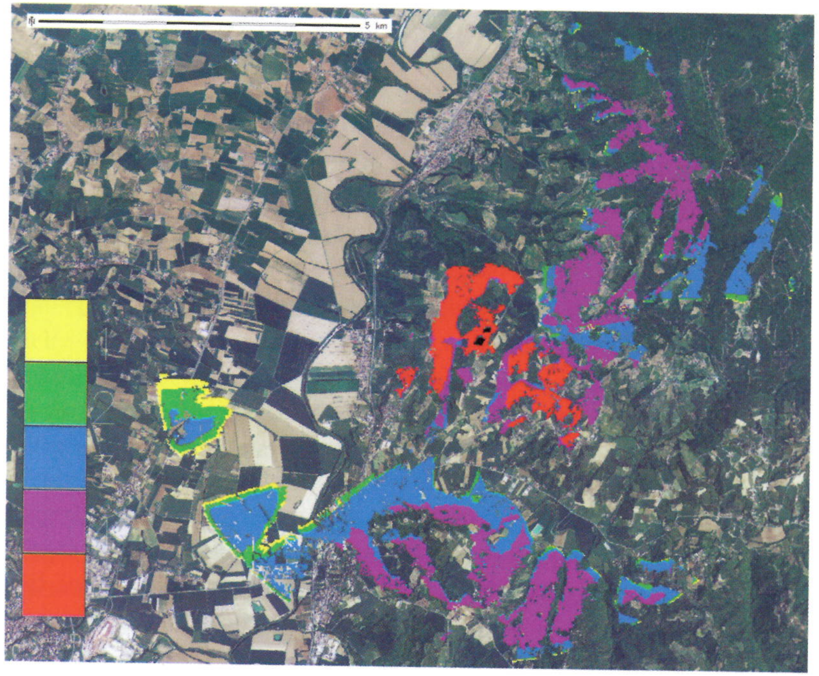

FIGURE 1

To simplify the use of this kind of tool and to keep the same scientific power, we are planning to serve this model as a Web Service using the Web Processing Service (WPS) standard from OGC [8]. With this approach the tool could be executed using a WebGIS application with a user friendly interface and with no need to install any other tool then a Web Browser. In this way it is possible for each one who wants to evaluate the impact, to use this methodology with just few clicks and, for example using a Mobile Device, to run the tool directly in place and to see the result using Augmented Reality [1]. Expecially in mobile application, to grant compatibility, is very important to develop tool wich can be executed from a Web Browser.

Since there is not a precise set of rules in this specific field, but only some similar studies involving social or agricultural factors (for example [11]), the method allows to evaluate the intervisibility in a purely objective way by providing not a judgement, but a representative number. Moreover, this method can be useful to professionals and public administration to decide the feasibility of the photovoltaic field or the windfarm.

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