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RES and Habitat Quality: Ecosystem Services Evidence Based Analysis in Basilicata Area

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Abstract. In the field of environmental protection, the reference to ecosystem services (ES) - the benefits that human beings derive, directly or indirectly, from ecosystem functions- is increasingly widespread. The objectives of the new energy strategy try to combine two public interests: Renewable Energy Sources (RES) and the landscape and its cultural, environmental and naturalistic values. However, RES has a spatial impact on the landscape and consequently on ES. This paper analyzes some critical aspects of their spatial mutual relationship considering an area of the Basilicata region including 5 municipalities (Cancellara, Pietragalla, San Chirico Nuovo, Tolve and Vaglio Basilicata) assessing changes in Habitat Quality coming from not-regulated wind farms installation. This represents an approach for the correct planning of renewable technologies, the management of the land use and its ecological, cultural and economic functions, in order to preserve biodiversity and sustainability.

Keywords: Ecosystem services · Habitat quality · Renewable energy sources

1 Introduction

The Millennium Ecosystem Assessment [1] defines ecosystem services (ES) as the benefits that come from ecosystems. They represent both the goods (food, water, raw materials, building materials), and the set of functions that contribute to carrying out specific process: absorption of pollutants, protection from erosion and floods, regulation of surface water flow and drought, maintaining water quality, disease control, soil formation, etc.

ES have a direct and indirect utility for man therefore it is essential, in the context of territorial management and planning policies, to integrate the concept of ES and evaluate the effects that the different land use choices have on them [2]. The energy transition underway in favor of the use of renewable energy sources affected the Basilicata region. The Regional Environmental Energy Plan, approved in 2010, set certain targets for 2020

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in terms of installable power and energy produced in relation to the various types of renewable energy source.

Wind energy represents an effective intervention category to face the threat of climate change and to guarantee energy security. The strong diffusion of the wind source and, in particular, of the mini-wind turbines [3] (born above all for the needs of self-production and self-consumption and whose expansion is justified both by the provision of economic incentives and by increasingly simplified authorization paths), is often accompanied by an absence or inadequate programming of guidelines for the correct insertion of the implants in the territory [4, 5]. Since the landscape is considered as the result of interactions over the centuries between natural and anthropic activities, it is recognized that the spread of plants for low-carbon energy production could have a considerable impact on ecosystems services. As regards wind farms, their installation and use represent an important form of landscape transformation, influencing the environment at different spatial and temporal scales developed out of an effective spatial planning system able to allow territorial administration to manage such territorial transformation [6].

This work analyzes some critical issues of the spatial relationship between RES and ES, with particular reference to the impact that the installation of wind farms has in the study area considered.

1.1 The Territorial Assessment Methodology and Main Results

Habitat quality is a relevant component of ES approach. It is suitable to be considered in order to produce spatial assessment and territorial classification according to spatial explicit models implemented in the toolbox provided by InVEST (Integrated Valuation of ES and Tradeoffs) developed by Stanford University within the "Natural Capital Project" [7].

The "Habitat Quality" module allows to compute an index of overall biodiversity which falls into the category of support services or as a regulation service. The concept of habitat referred to in this work is not linked to the presence of a specific species but, in a wider sense, to the comprehensive value of the environment related to the presence of plant and organisms. The study area examined has a total area of approximately 304 km^2 and includes the following municipalities in the province of Potenza: Cancellara, Pietragalla, San Chirico Nuovo, Tolve and Vaglio Basilicata.

InVEST models use as input land use and cover map maps we derived GeoTopographic DataBase made available by the RSDI Basilicata geoportal in the "DGBT & CTR" section. Two dates had been chosen to prepare the input layers representing the transition from the initial stage on land use (2013) and the current one characterized by the effect of RES installation (2018). The first relates to 2013 and includes relevant layers describing land uses, while the second, relating to 2018, have also been added the wind aggregate classes. In the study area wind farms installation had been mapped [3, 4] and classified according to their power: ranging from 20 kW to 1000 kW ore greater (Table 1).

Table 1. Classification of wind turbine by power.

Typology	Power (kW)
Micro wind turbines	P < 1
Mini wind turbines	1 < P < 100
Medium wind turbines	100 < P < 1000
Big wind turbines	P > 1000

A buffer with a radius proportional to the installed power has been created around each point element. These polygons were aggregated using the threshold distance of 250 m as a criterion in order to consider the loss of ecosystem functionality even in the areas comprising several wind turbines. The aggregates thus obtained were then classified on the basis of the footprint in the territory into: small (class 1), medium (class 2) and large size (class 3) aggregates. Such components report the transition from original land uses (2013) to the actual one corresponding to an anthropic land uses ore in other word a habitat quality source of degradation. We refer to previous studies for detailed methodological description [8–12]. The outputs of the model consist in two maps generated in output for a current scenario are:

(i) **quality_out_c** which indicates the relative level of habitat quality on the current landscape (Habitat Quality - Q). A higher number indicates a better habitat quality. Areas that are not habitats obtain a quality score of 0. This quality value is determined by means of Eq. 1, is devoid of units and does not refer to any particular measure of biodiversity;

$$Q_{xj} = H_j\left(1 - \frac{D_{xj}^z}{D_{xj}^z + k^z}\right) \tag{1}$$

where parameter z is 2.5. *Qxj* is equal to 0 if *Hj* is also null, increases as a function of *Hj* and decreases as a function of *Dxj* reaching a maximum value of 1.

(ii) **deg_sum_out_c** representative of the level of degradation of the habitat on the current landscape (Habitat Degradation - D) whose value, for each cell, is calculated by means of Eq. 2. A high score in one cell of the grid indicates that the degradation of the habitat in the considered cell is high compared to the others.

$$D_{xj} = \sum_{r=1}^{R}\sum_{j=1}^{Y_r}\left(\frac{w_r}{\sum_{r=1}^{R} w_r}\right) r_y i_{rxy} \beta_x S_{jr} \tag{2}$$

where y and Yr indicate the cell and the set of grid cells respectively on the raster map of the r-threat. If the sensitivity Sjr = 0 then Dxj is not a function of the r-th threat and therefore will be: Dxj = 0.

The model returns a spatial distribution of the quality of the habitats which, in relation to the study area, varies between moderate and high, assuming the lowest values only in correspondence with the inhabited centers and the most populated areas. Consistent with the values assigned in the definition of the habitats, the quality is higher in the wooded areas and along the waterways. Following the installation of the wind turbines, there is a decrease in the quality of the habitats in the areas immediately surrounding the wind turbines.

Figures 1 and 3 compare the habitat quality for 2013 and 2018 and were obtained by converting the frequency of the pixels belonging to a certain class into the corre-

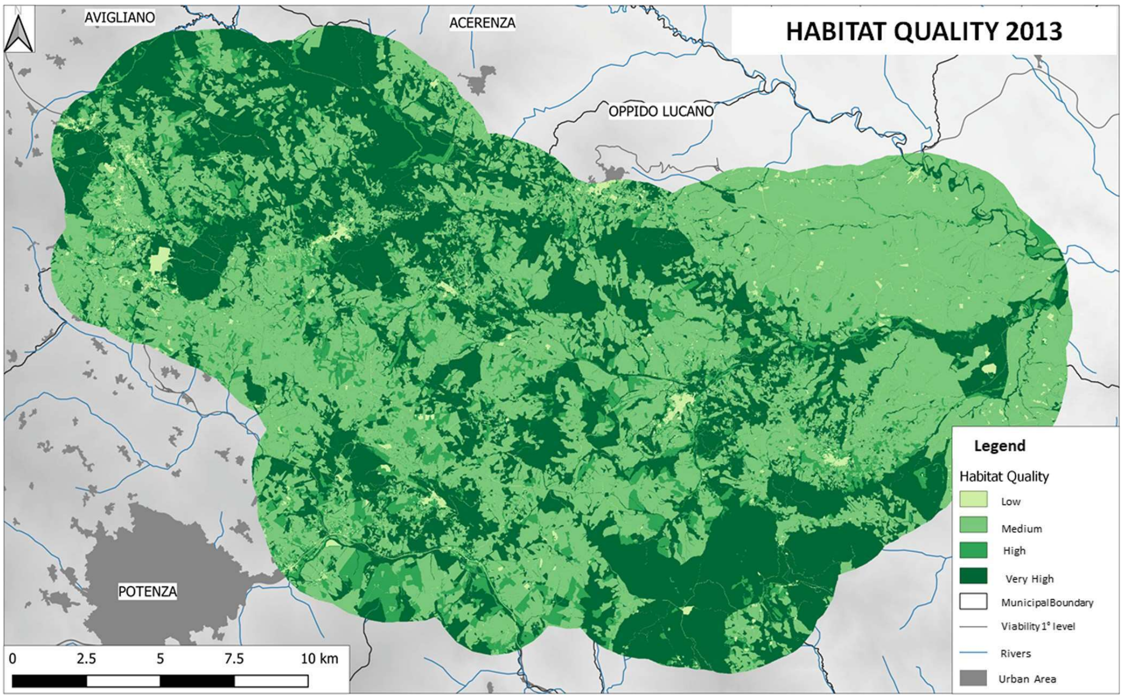

Fig. 1. Habitat quality 2013.

sponding soil surface, expressed in hectares. Note that the areas characterized by "low" quality values increased from 2013 to 2018.

The reduction in quality occurs in the areas that from 2013 to 2018 change their intended use of the land and are classified as "Wind turbine use".

The degradation level of the output maps of 2013 and 2018 was analyzed in a similar way. Four degradation classes: low, moderate, high, very high, have been identified.

The classification of the level of degradation is shown in the maps of the Habitat Degradation of 2013 Fig. 2 and 2018 Fig. 4. The areas characterized by "medium" and "very high" degradation values increased from 2013 to 2018. The alteration occurs mainly near areas that from 2013 to 2018 change their intended use of the land and are classified as "Wind turbine use" in the map of land use and coverage 2018. An increase in degradation is visible especially where there is a greater density of class 2 and 3 wind aggregates, therefore those of larger size and power.

The graph in Fig. 5 shows the amount of surface area in square kilometers for each degradation class identified in 2013 and 2018. The areas with medium degradation

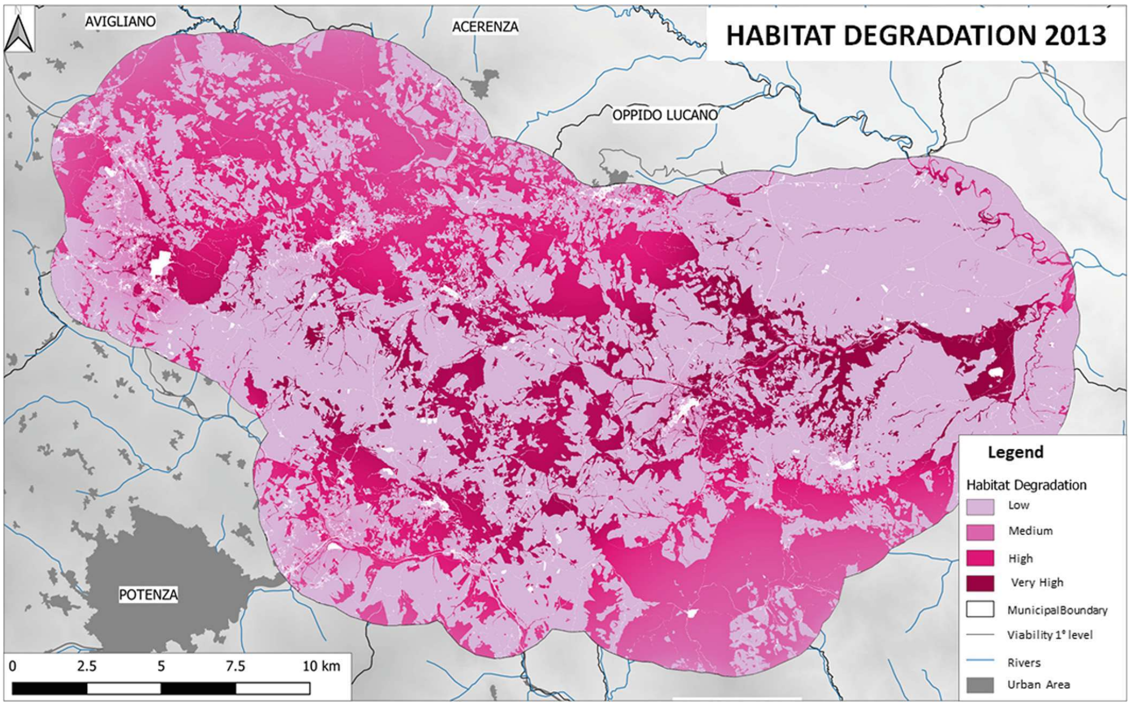

Fig. 2. Habitat degradation 2013.

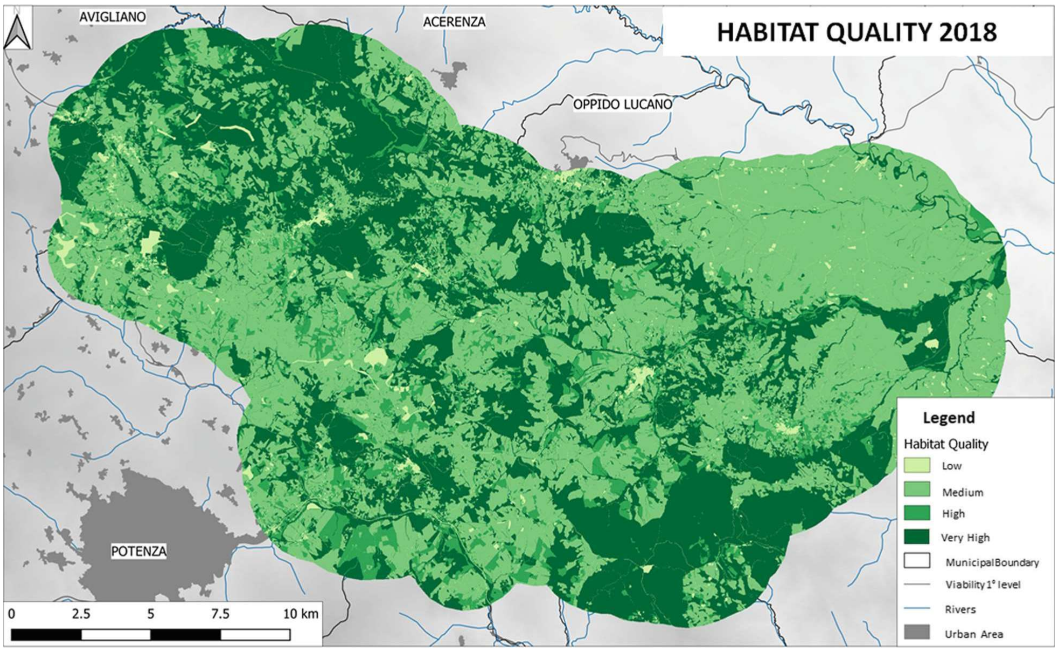

Fig. 3. Habitat quality 2018

increased for about 50 km^2 between the two temporal phases. Also, the area classified as Very high degradation increased over time. Complementarily the areas classified as Low and High degradation decreased over time.

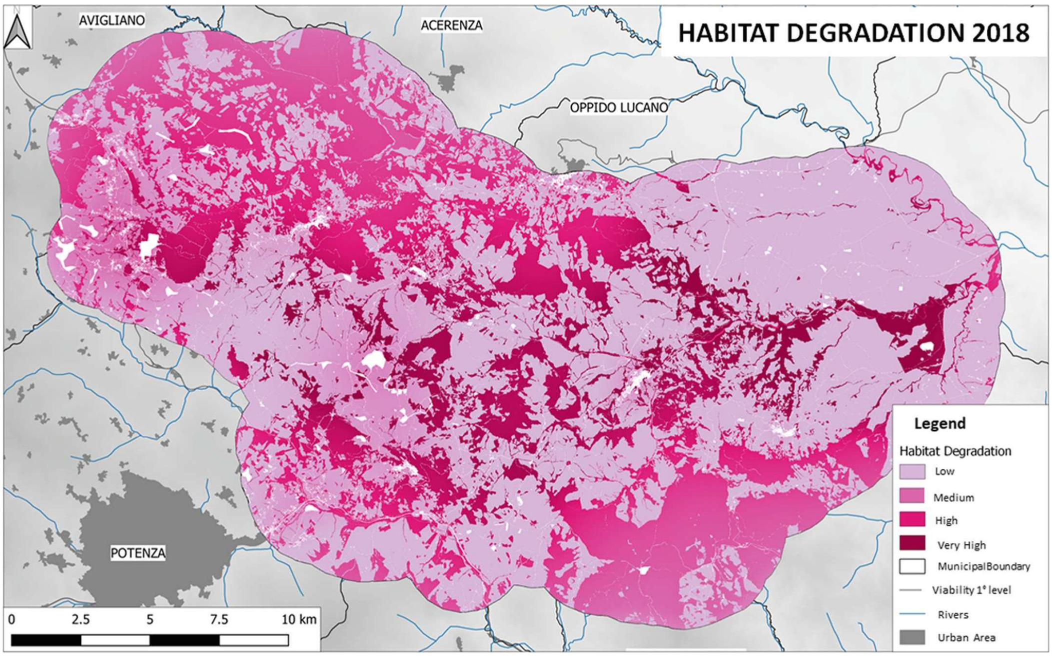

Fig. 4. Habitat degradation 2018.

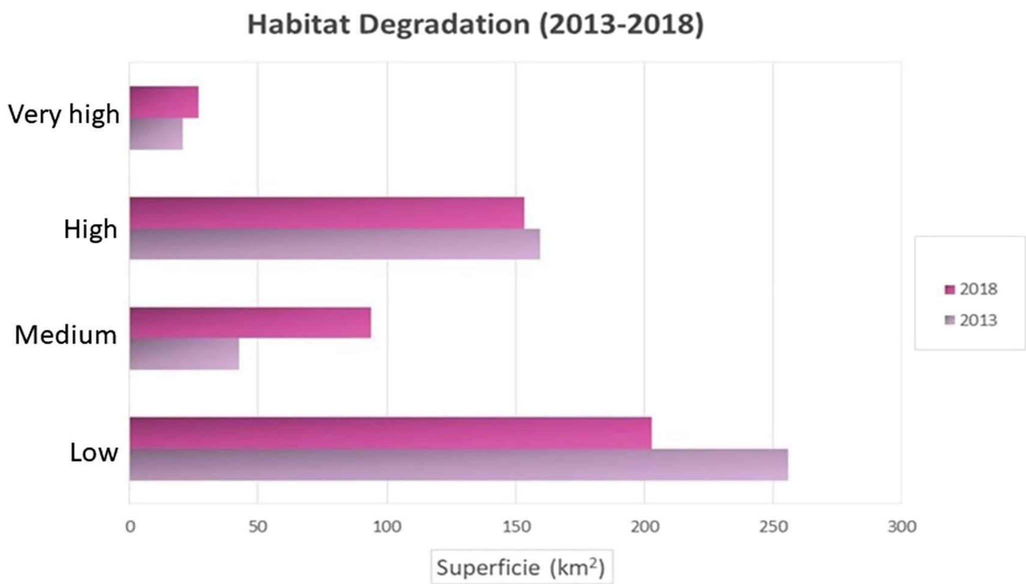

Fig. 5. Area in km^2 for each class of degradation in the two time phases analyzed

2 Conclusion

During the last decade, the rural landscape of the Basilicata region has changed significantly due to the continuous increase in the number of installations for the production of energy from renewable sources (see also [13–15]. These transformations, endorsed by an aura of "sustainability" justified by the global need to combat climate change, occurred in the absence of an adequate regulatory framework [16–18] affecting also real estate values [19–23]. The lack of the Regional Landscape Plan and sectoral rules aimed at limiting pollution from noise emissions and electromagnetic fields [24] have led to an uncontrolled increase in RES installations. The proposed method can represent a concrete support for a territorial management processes delivering a spatial monitoring system of a relevant territorial value (habitat quality) suitable for transformation projects assessment (ex-post) and scenario building (ex-ante) [25].

Further research aims at implementing an integrated monitoring system spatially explicit in order to reinforce the impacts assessment capacity of public authorities entitled of planning competences.

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