

Impact of Renewable Energy Installations on Habitat Quality

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Abstract. In all the disciplines referring to environmental protection, the reference to ecosystem services (ES) is widely increasing. The growing awareness of climate change and the recognized need to secure energy production has been a driving force behind the expansion of the Renewable Energy Sources (RES) and their technologies.

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) with particular reference to the impact that coming from not-regulated wind farms installation. For this approach it's fundamental integrate the concept of ecosystem services into land management and planning decisions for control the pressures that threaten the ecosystem and their functionality, and "build" a model of governance that preserve their biodiversity and sustainability.

Keywords: Ecosystem services · Habitat quality · Renewable energy sources

1 Introduction

The Millennium Ecosystem Assessment [1] defines Ecosystem services (ES) as goods and benefits humans derive from nature, identified as provisioning (e.g. food), regulating (e.g. carbon sequestration), cultural (e.g. tourism and recreation) and supporting (e.g. nutrient cycling). Since ES have both direct and indirect effects on human well-being, it is useful for territorial planning discipline to deeply understand how land use changes affect ES provision and, above all, how to integrate the concept of ES in decision making and policies design processes. The energy transition underway in favor of the use of renewable energy sources affected the Basilicata region where the forecast of in-stalled power and energy produced for wind farm installation has been saturated since the end of 2017. The exploitation of wind natural resource to produce energy represents an essential way to tackle climate changes and to ensure energy security. Several factors have contributed to the diffusion of wind energy at local level, in particular mini wind tur-bines

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[2, 3] for self-production and self-consumption needs: increasingly efficient technology, low construction and maintenance costs of a plant, the possibility of financing and the simplification of authorization processes. However, their strong diffusion is accompanied by an absence or inadequate planning of guidelines for the proper inclusion of plants 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 inclusion in a landscape context of a wind farm, be it industrial, mini or micro wind, certainly determines a more or less significant impact on the territory and on the ecosystem services [6]. This work is aimed in spatially representing some critical issue of the relationship between RES and ES, analyzing a case study from the Basilicata region.

2 The Territorial Assessment Methodology

2.1 Study Area

The study area extends for a total area of about 304 km^2 and includes five municipalities belonging to the province of Potenza: Cancellara (680 m above s.l, 1256 residents), Pietragalla (834 m above s.l, 4025 residents), San Chirico Nuovo (745 m above s.l., 1294 residents), Tolve (568 m above s.l, 3160 residents) and Vaglio Basilicata (954 m above sea level, 1964 residents). It is characterized by a settlement system traditionally arranged on peaks with an average density of about 44 inhabitants per sq. kilometer (source ISTAT, 2018 [7]).

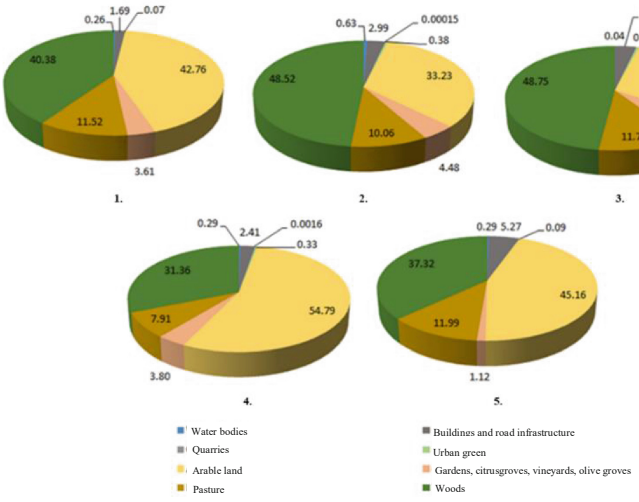

Fig. 1. Classification of land use: 1. Cancellara, 2. Pietragalla, 3. San Chirico Nuovo, 4. Tolve, 5. Vaglio Basilicata

The whole territory has a high naturalistic value and does not have areas subject to naturalistic constraints. The graphs in Fig. 1 represents the distribution of land use classes on the five municipalities.

2.2 Methodology

A spatial approach has been used for the evaluation of territorial transformations through the toolbox provided by InVEST (Integrated Valuation of ES and Tradeoffs) developed by Stanford University within the "Natural Capital Project" [8].

The "Habitat Quality" module is instead the model associated with the ecosystem service as a proxy for the assessment of the level of biodiversity and the associated risks of degradation. The concept of habitat referred to in this work is considered in a general sense as an environment suitable for the presence of different plant and animal organisms.

Inputs for InVEST models were obtained mainly by collecting soil data from GeoTopographic DataBase made available by the RSDI Basilicata geoportal in the "DGBT & CTR" section. A spatial and temporal comparison was made considering an interval of time from 2013 to 2018 to appreciate the territorial transformations following the installation of RES. The first land use map refers to 2013; in the second, related to 2018, the classes of wind aggregates were added. In the study area, wind power plants have been mapped and classified according to their power (P) in 4 typologies: micro ($P < 1$ kW), mini (1 kW $< P <$ 100 kW), medium (100 kW $< P <$ 1000 kW) and big ($P >$ 1000 kW).

Each turbine was represented by a polygon obtained by buffering with a radius proportional to their power output. The polygons thus obtained were then aggregated using the threshold distance of 250 m as a criterion to consider the loss of ecosystem functionality. Aggregates were then classified according to footprint in: small (class 1), medium (class 2) and large (class 3) aggregates. These components constitute a source of threat acting on the territory for the 2018 input map. For a detailed methodological description please refer to previous studies [6, 9–14]. The outputs generated by the model are two maps that represent the quality of the habitats and their level of degradation for a current scenario:

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;

deg_sum_out_c representative of the level of degradation of the habitat on the current landscape (Habitat Degradation - D). 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.

3 Results and Discussions

The model returns as output a spatial distribution of habitats quality and their degradation. For the Habitat Quality map, four classes have been defined from *low* to *very high* values (max value is 0.999994 in 2013). The lowest values are registered only in correspondence to the most populated centers and areas. Consistent with the values assigned in the habitat definition, the quality is higher in wooded areas and along watercourses (Fig. 2 and 4).

Following the installation of wind turbines, there is a decrease in habitat quality (max value is 0.999993 in 2018) in the areas immediately surrounding the wind turbines.

Figure 6 shows that in 2013, more than 37% of the total surface has very high quality, 10,15% has high quality, 49,68% has medium quality and just 2,52% has low quality value.

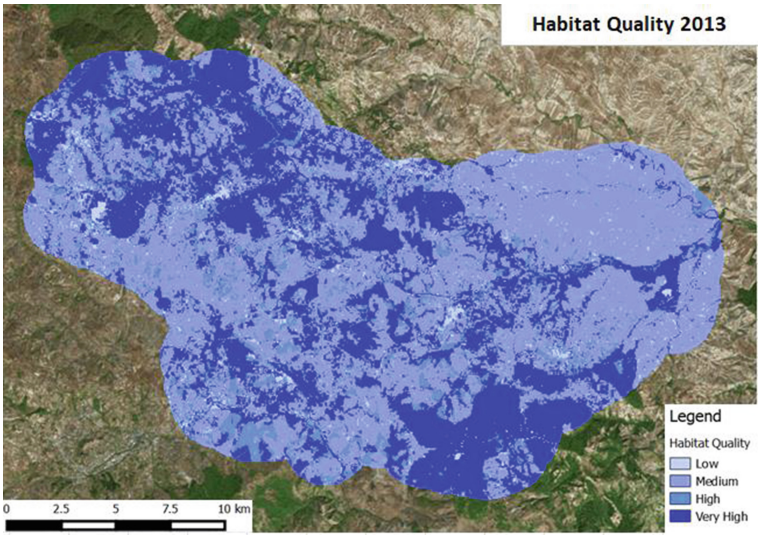

Fig. 2. Habitat quality 2013

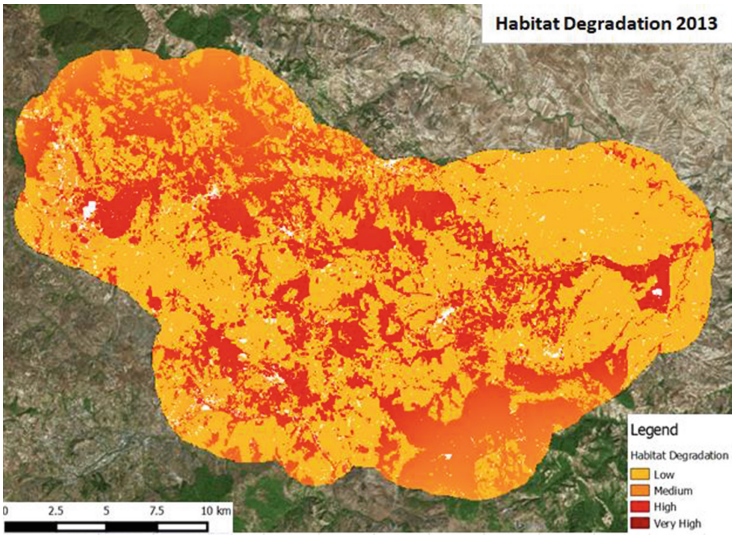

Fig. 3. Habitat degradation 2013.

Note that the areas characterized by low quality values increased by +16,23% (about 2 km^2) from 2013 to 2018.

In the Figs. 1 and 3 is shown the comparison between the habitat quality distribution histograms related to 2013 and 2018.

The decrease in habitat quality is particularly evident in the areas were from 2013 to 2018 wind turbines were installed. In particular there is a greater reduction in quality

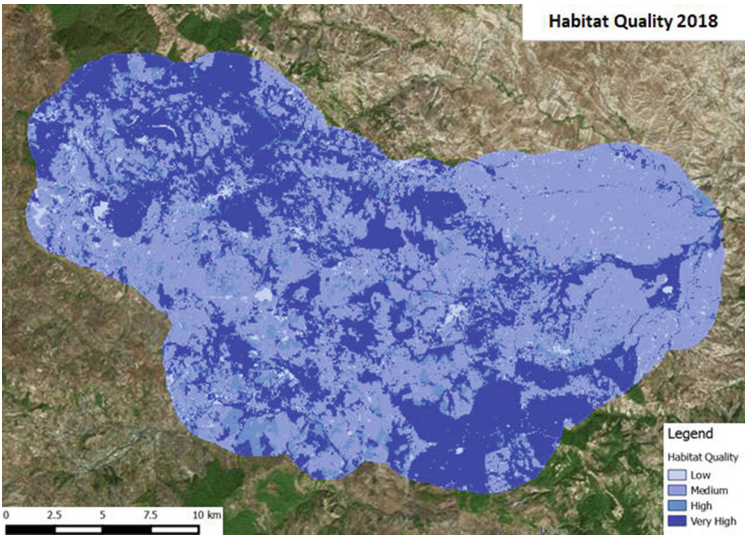

Fig. 4. Habitat quality 2018

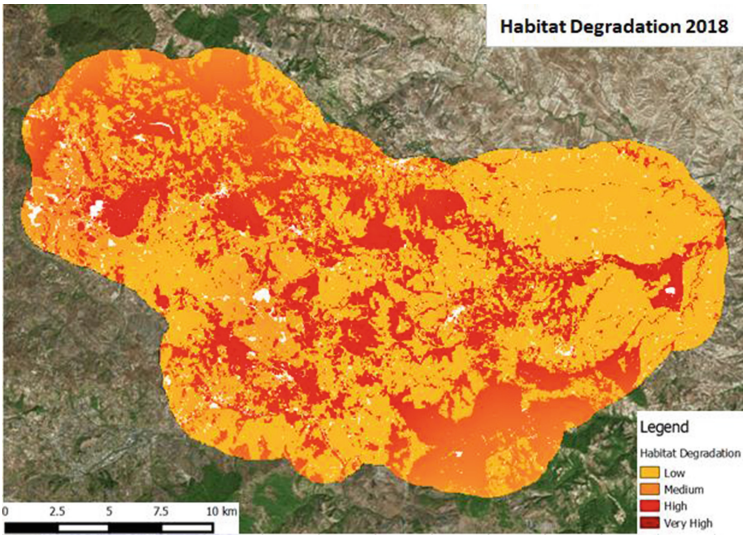

Fig. 5. Habitat degradation 2018.

for medium (−0,61%), high (−0,44%) and very high (−0,16%) classes from 2013 to 2018.

The variation in the degradation degree over the entire period was analyzed in the same way, identifying four degradation classes: low, moderate, high, very high.

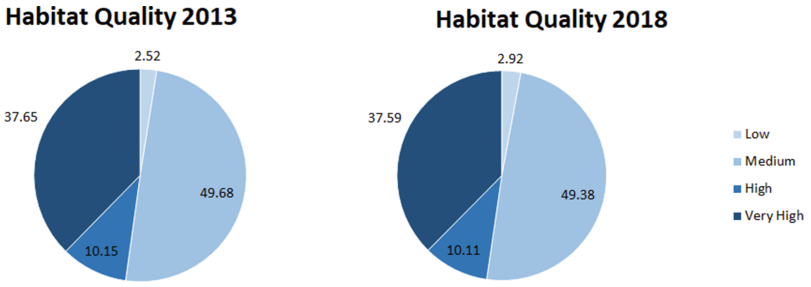

Fig. 6. Habitat quality 2013–2018.

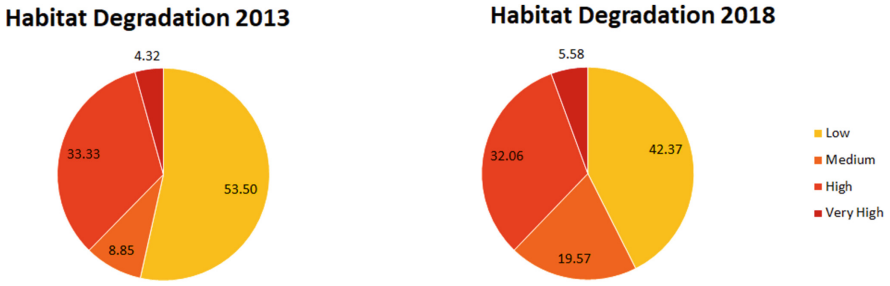

Fig. 7. Habitat degradation 2013–2018.

Figure 7 shows that in 2013, more than 4% of the total surface has *very high* degradation, 33,33% has *high* degradation, 8,85% has *medium* degradation and more than 53% has *low* degradation value.

The classification of the level of degradation is shown in the maps of the Habitat Degradation of 2013 Fig. 3 and 2018 Fig. 5. The areas characterized by medium and very high degradation values increased from 2013 to 2018. In particular there is a greater increase in degradation for medium (+54,78%) and very high (+22,63%) classes. 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 White areas represent wind energy aggregates and other threats which, have a null degradation value.

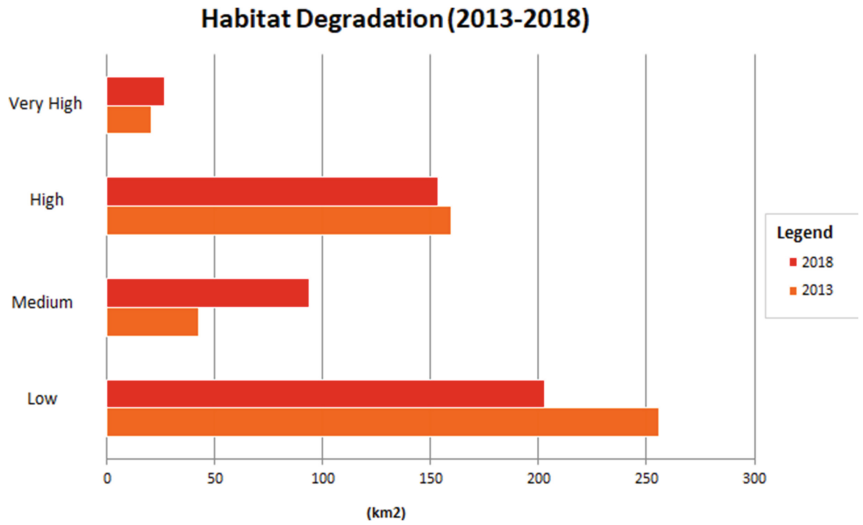

Fig. 8. Area in square kilometers for each class of degradation in the two-time phases analyzed

The graph in Fig. 8 shows the total area amount (square kilometers) included in each of the degradation classes identified in 2013 and 2018. The areas with average degradation have increased by about 50 km^2 from 2013 to 2018. Also, the area classified as very high Degradation has grown in the time interval. Additionally, the areas classified as low and high Degradation have decreased between the two temporal phases.

4 Conclusions

The increase in the number of plants for the production of energy from renewable sources in the last decade has changed the rural landscape of Basilicata in a marked way. These transformations have occurred in most cases in the absence of proper installation planning [15, 16] which has also affected real estate values [17–20]. Moreover, the lack of the Regional Landscape Plan and of sectorial rules aimed at limiting pollution by noise emissions and electromagnetic fields led to an uncontrolled increase of RES installations at local level. The proposed method can represent a concrete support for a land management process. It provides a spatial monitoring system that takes into account the quality of the habitat and its degradation status. It is suitable for the assessment of land use projects (ex-post) and allows the construction of scenarios (ex-ante) [21] for the assessment of impacts on the territory due to human transformations.

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