



# Are wind turbines integrated into landscape? an analysis of its social perception in a spanish mediterranean area

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## Abstract

**Context** Renewable energy sources development has introduced wind farms as a regular landscape element. However, as human-made elements, wind farms influence on landscape's scenic beauty differently according to the socio-demographic characteristics of the beholder.

**Objectives** In this regard, the study analyses the population's visual perception of wind farms into Mediterranean landscapes with reference to three social variables: gender, age and education level.

**Method** People's preferences were assessed through two on-line surveys with several landscape photographs, with and without wind turbines. Subsequently, the score of each photograph was statistically analyzed regarding the landscapes showed and the respondents' socio-demographic variables.

**Results** The results demonstrate how vegetation had a positive effect in landscape' scenic beauty, especially forest, as well as people do not perceive negatively wind turbines presence. In fact, their implementation in deteriorated or low scored landscapes improves its scenic beauty. Lastly, despite the fact that gender, age and education do not influence on

people's perception, there is a trend between these factors and wind turbines influence on landscape.

**Conclusions** In addition to reinforce the vegetation positive effects on landscape' scenic beauty, wind turbines have become a new landscape element that, in general, do not have a negative impact on its scenic beauty but, according to age, different consideration appeared.

**Keywords** Wind farm · Landscape · Visual perception · Scenic beauty · Socio-demographic characteristics

## Introduction

Evolution of renewable energies sources

Over the last decades, European policies related to renewable energy sources (hereinafter RES) have increased considerably (Frolova y Pérez, 2008; Frolova 2010; Scaramuzzino et al. 2019), especially from 1970's to 1980's, when research and technological development became the main paradigms in RES policies (Blok 2006; Szarka 2007; Szarka et al. 2012). In this regard, Klessmann et al. (2011) differentiates three policy periods: (i) 1990's, market deployment, (ii) 1997, RES deployment and, (iii) 2010, RES market share increase. Currently, RES management is conducted by the Renewable Energy Directive 2018/2001/EU (commonly known as RED

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II), successor to the Directive 2009/28/CE (named RED I), the first European policy that reinforced RES importance by setting mandatory minimum targets (Klessmann et al. 2011; Warren et al. 2012). In fact, two of the RED II overall targets are that at least 32% and 14% share of gross final consumption and used in transport should come from RES by 2030, respectively. However, according to De Jager et al. (2011), this energy transformation involves a very expensive process (EUR 60–70 billion average annual investment) that demands different financing mechanisms (see Regulation 2020/1294/EU).

On the other hand, although RED II established European and national ambitious targets, because RES energy share increased by 36% in the European Union (EU-27) between 2012 and 2021 (Eurostat 2022), it could be achieved. Nevertheless, each European country has recorded a different RES development (Eurostat 2022) related to both economic resources assigned and their legal consideration (Scaramuzzino et al. 2019). Among all the RES implemented (hydro power, sunlight or biomass), wind energy (hereinafter WE) has promoted from the fifth to the second installed capacity in just ten years (Wind Europe, 2021). In truth, WE is the first RES produced in the EU-27 and covered 15% of Europe electricity demand in 2021 (Wind Europe, 2021), i.e., near to 90 megatons of oil equivalent (Eurostat 2022). Additionally, as with RES development, it has not been equally implemented (Wind Europe, 2021), because while 64% of all WE capacity is spread across five countries (Germany, Spain, the UK, France and Sweden), in other ones it is lower than 1.5% (e.g. Austria, Greece, Finland or Norway).

Within the Spanish territory, the legal framework developed has promoted RES (e.g., Frolova 2010; Espejo Marín y García Marín, 2012; Frolova et al. 2014), especially photovoltaic energy and WE, which recorded, respectively, the highest installation and production growth for the last year (Espejo Marín and García Marín, 2010; REE 2021). In this regard, WE is the preferred option for planners and national governments (Dai et al. 2015), in fact, in the Iberian Peninsula (REE 2021) WE has the highest installed capacity (more than 27 GW) and covered most of the electricity demand (23.9%). Though these data, WE production is below the targets established by the National Integrated Energy and Climate Plan 2021–2030 (MTERD, 2020), but near to 28 GW

should have been installed in 2020, amount that will increase to more than 40 GW and 50 GW in 2025 and 2030, respectively. Finally, in addition to this policy support, the Spanish territory has a very high WE potential related to: (i) the excellent wind resources (Espejo Marín and García Marín, 2010) and (ii) the high technological level achieved (Molina et al. 2011).

#### Renewables energies sources into landscape: perception and legal assessment

Although landscape often expresses mismatches between national targets and local realities, it plays a special role in WE planning (European Commission 2020; Frolova et al. 2015) and, therefore, at national and international energy future (Warren et al. 2012; Frolova et al. 2014; Baraja and Herrero 2015). Anyhow, landscape issues have been, and still being, a salient concern in wind power development (Warren et al. 2012; Frolova et al. 2015) due to the physical and economic changes (Meyer 2007; Möller 2010) of its industrialization (Szarka 2007). In fact, there was a significant opposition and organized resistance in various parts of the EU (Strachan et al. 2010), the UK (Strachan and Lal 2004), France (Enevoldsen and Sovacool 2016), Denmark or Germany (Frolova et al. 2015). In this respect, while several authors connected this opposition to landscape values (Devine-Wright 2009; Wolsink 2007; Ellis and Ferraro 2016), Pasqualetti (2011) suggested that it is more related to the construction of local identities.

On the other hand, accepting RES it is not the same as accepting the installation of their structures in the landscape, in fact, WE acceptance changes according to the project stage (Wilson and Dyke 2016), but declines with construction and rises afterwards (Gipe 1995; Devine-Wright 2005; Wolsink 2007). In this regard, wind turbines or wind farms placement is related to several shortcomings (Pasqualetti 2011), especially if they will be located on our surrounding area (Tsoutsos et al. 2009; Swofford and Slattery 2010). This phenomenon was defined by Gipe (1995) as “Not In My Back Yard” syndrome (NIMBYism) and has been used both to describe and to explain local opposition to energy developments (Devine-Wright 2009). Nevertheless, NIMBYism and its subtypes (Enevoldsen and Sovacool 2016) have been heavily criticized by WE researchers due to its

inaccuracy and conceptual weakness (Devine-Wright 2005, 2009; Wolsink 2007; Aitken 2010; Swofford and Slattery 2010). Indeed, an “inverse NIMBYism” was defined to support why closer residents to wind turbines could have a more positive perception than further residents (Devine-Wright 2005), support that is related to economic benefits (Devine-Wright 2005; Baxter et al. 2013) and the cost of alternatives for inhabitants (Álvarez-Farizo and Hanley 2002). In order to balance these antagonistic attitudes, the European Commission (2020) published a new guidance document where highlights that it is essential to examine each plan or project on a case-by-case basis in order to ensure they have been properly carried out.

From a legislative point of view, the European Landscape Convention (ELC) (Council of Europe 2000) represents the current landscape management framework at European level. According to the ELC, landscape is “an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors”. This definition relegated its traditional pictorial sense (Oles and Hammarlund 2011) by introducing a more democratic and participative approach (Gulinck et al. 2001; Sevenant and Antrop 2009), perspective that emphasizes and reinforces the general public’s perception for assessing landscape, i.e. a subjective (Lothian 1999) and psychophysical paradigm (Svobodova et al. 2012). Consequently, WE landscape issues have to be evaluated by people, mainly considering that it is a foundation of their identity (Pasqualetti 2011). In this regard, different studies assessed social attitudes to WE in European countries such as Czech Republic (Molnarova et al. 2012), Greece (Kaldellis 2006; Tsoutsos et al. 2009), England (Bishop and Miller 2007), Spain (Álvarez-Farizo and Hanley 2002), France (Enevoldsen and Sovacool 2016) or Deutschland (Vries et al. 2012), but also in other world regions as Australia (Lothian 2008; 2006), USA (Swofford and Slattery 2010) or Canada (Baxter et al. 2013).

#### Wind farms: visual effects on landscape and its socio-demographic relationships

Since the EU encourages WE development (European Commission 2020; Scaramuzzino et al. 2019) through a socially and environmentally sustainable legislative framework (Oles and Hammarlund 2011),

several countries have undergone an intense landscape transformation (Frolova et al. 2015; Wilson and Dike, 2016). In this regard, while WE is generally supported by the European Union citizenship (Ellis and Ferraro 2016) and has a lot of environmental advantages (Pasqualetti 2011; European Commission 2020), above all, lower environmental impact than traditional energy sources (RED II), its presence negatively influences on social acceptance (see Ellis and Ferraro 2016). In this respect, WE main issues could be summarized in: environmental, visual and socio-economic (Enevoldsen and Sovacool 2016). Among all, its main drawback lies into visual aesthetic annoyance (e.g., Bishop y Miller, 2007; Molina, 2011; Tsoutsos et al. 2009; Dai et al. 2015), which implies a landscape’s visual quality detriment (e.g. Bishop and Miller 2007; Pedersen and Larsman 2008; Molnarova et al. 2012).

In addition to wind farms negative environmental issues (Dai et al. 2015), especially on landscape visual quality, there are several WE features to be considered that are related to intrinsic (e.g. distance from the viewer, Bishop and Miller 2007; Lothian 2008; Swofford and Slattery 2010; number of wind turbines, Kaldellis 2006; or color, Lothian 2008; Tsoutsos et al. 2009; Molnarova et al. 2012), extrinsic (e.g. atmospheric effects, Bishop and Miller 2007) and location factors (e.g. visual exposure, Pedersen and Larsman 2008 or distance, Swofford and Slattery 2010). In this regard, the works of Molnarova et al. (2012) and Dai et al. (2015) made an extensive review about the main studies related to wind farm perception according to different variables, methodologies and their primary environmental issues.

In light of the above, there is another perceptual landscape parameter widely studied that should be contemplated: scenic beauty (Aoki 1999). According to Daniel (2001), scenic beauty is a landscape quality resulting from biophysical characteristics and human observer interaction that, theoretically, is marred by visual clutter (Vries et al. 2012). Thus, in spite of the fact that commonly man-made elements (Arriaza et al. 2004; Wu et al. 2006) have negative effects on natural landscapes’ scenic beauty (such as wind farms, e.g., Tsoutsos et al. 2009; Vries et al. 2012), in deteriorated areas these elements are able to enhance it (Lothian 2008). Moreover, although several papers have demonstrated general landscape perception trends (e.g. Strumse 1996; Kaltenborn and Bjerke

2002; Arriaza et al. 2004; Svobodova et al. 2012; it should be considered that people's wind farm perception on landscape is related to several socio-demographic characteristics and attitudes (e.g. Gipe 1995; Bishop and Miller 2007; Tsoutsos et al. 2009; Molnarova et al. 2012).

On this point, although there is not an accepted approach about public's visual perception for wind turbines (Molnarova et al. 2012; Maehr et al. 2015) due to several shortcomings (e.g., publication date, biased surveys or analysis of results) related to most of the literature (Aitken 2010), different works have assessed different socio-demographic characteristics in regard to wind farms landscape's perception. Among all the characteristics studied, there are some as such birthplace (Lothian 2008), income (Álvarez-Farizo and Hanley 2002), family status (Ladenburg 2009), interest level/attitude to renewable energies issues, (Bishop and Miller 2007; Molnarova et al. 2012), environmental perspective (Hobman and Ashworth 2013), residence place (Bishop and Miller 2007; Tsoutsos et al. 2009; Baxter et al. 2013) or familiarity with the area (Lothian 2008). Nevertheless, according to Aoki (1999), people's landscape preferences are related to three main factors widely studied: age (Lothian 2008; Tsoutsos et al. 2009; Bishop and Miller 2007; Molnarova et al. 2012), gender (Lothian 2008; Pedersen and Larsman 2008; Tsoutsos et al. 2009; Molnarova et al. 2012), and education level (Lothian 2008; Molnarova et al. 2012; Svobodova et al. 2012; Hobman and Ashworth 2013).

## Objectives

In order to understand better the public's perception and response to the visual impacts of wind turbines on the landscape, the main goals of the study are: (i) to analyze the influence of wind turbines on Mediterranean landscapes scenic beauty, (ii) to evaluate differences in landscape perception according to respondent's socio-demographic characteristics (age, gender and education level), and (iii) to assess differences in these perceptions and the wind turbine visual impacts on landscape. To solve these regards, this study uses a framework based on the scores of two on-line visual preference surveys with several photographs of a typical Mediterranean area, with and without wind turbines, and its further statistical analysis.

## Methodology

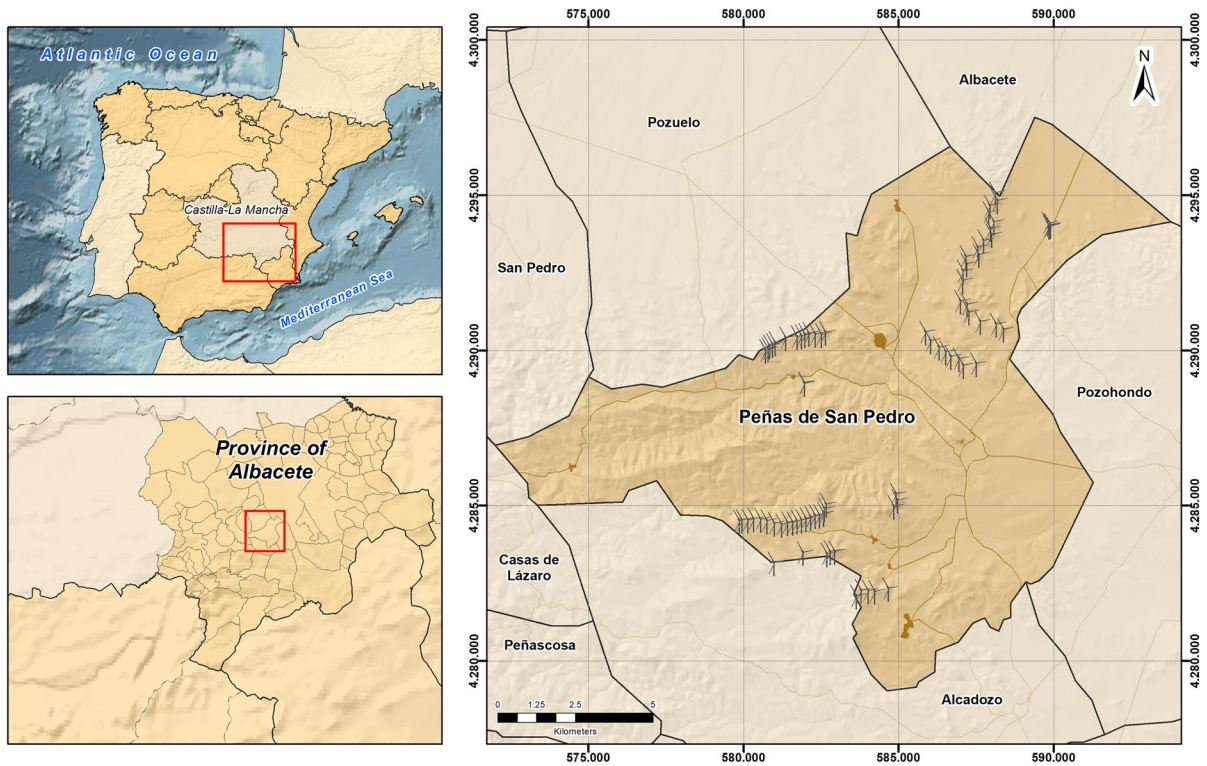
### Study area

Peñas de San Pedro (158.7 km<sup>2</sup>) is one of the 87 municipalities of the Province of Albacete, in the autonomous community of Castilla-La Mancha (Spain). The municipality is located in the southeast Central Mountains (Fig. 1), a Mediterranean area composed of urban, peri-urban, rural and natural landscapes (in regard to the ELC landscape classification). However, the area can be reduced to: (i) typical Mediterranean evergreen forest landscapes, bordering the population centers where trees (e.g., *Pinus halepensis* or *Quercus coccifera*) and labiates (e.g., *Thymus vulgaris*, *Rosmarinus officinalis* or *Stipa tenacissima*) are the most common species, and (ii) man-made landscapes, result of agricultural activities, mainly, rainfed crops such as cereal, almond and olive trees.

From a socio-economic point of view, the municipality has recorded a decrease in the number of inhabitants since the late 1960s, when an intense rural exodus started to other placements due to working conditions. Currently, the municipality has 1410 inhabitants (less than half of the 1960s), with a population density of 8 people/km<sup>2</sup> (the province average is 17.5 people/km<sup>2</sup>, INE 2021). With one of the top fifteen per capita income indices in the province, the economy of its inhabitants lies fundamentally in rainfed agriculture and animal production (INE 2021).

On the other hand, although Peñas de San Pedro is the municipality with the highest number of wind power installed (211.4 MW) and the second one with the highest number of wind turbines (178) placed in the Province of Albacete (Asociación Empresarial Eólica 2021), it only represents a 0.75 and 15.35% at national and autonomic level, respectively. Overall, there are 6 wind farms located in the surrounding area of the main roads and forest path (Fig. 1), farms which wind turbines number vary from 12 (Capiruzza I ampliation wind farm) to 75 (Molar del Molinar wind farm). Moreover, the most usual wind turbines have a 47 m diameter rotor and 50 m height (Asociación Empresarial Eólica 2021).





**Fig. 1** Location of study area and wind farms distribution

## Landscape images

Photographs were taken along different routes from Peñas de San Pedro to others minor population centers at the end of August 2018. These routes were chosen according to: (i) busiest roads (Wu et al. 2006) and (ii) highest number of visible wind turbines. Additionally, a digital camera Olympus Vg-130 at an approximate height of 1.70 m was utilized (from an adult's average view).

Regarding different factors such as distance (Bishop and Miller 2007; Lothian 2008), number of turbines (Kaldellis 2006; Tsoutsos et al. 2009; Molnarova et al. 2012), atmospheric effects (Bishop and Miller 2007) or color (Lothian 2008), five representative photos were selected among all. In general, the photographs represent the two main landscapes present in the study area and where wind farms are located: forest (photos 1 and 5) and agricultural (photos 2, 3 and 4). Finally, although in several situations manipulating photographs is mandatory in order to shown them is a survey (Barroso et al. 2012), it

should be emphasized that any digital manipulation was carried out, with the exception of deleting wind turbines from the selected photos (Fig. 2) by the GNU Image Manipulation Program (GIMP 2020).

## Questionnaire

Although on-site surveys allow to assess more observers' senses than photograph-based surveys (Natori and Chenoweth 2008), photo-based surveys are a valid methodology (Lindhjem and Navrud 2011; Barroso et al. 2012) as well as the most commonly employed for the aesthetic evaluation of wind turbines into landscape. (e.g., Lothian 2008; Tsoutsos et al. 2009; Molnarova et al. 2012; Hobman and Ashworth 2013; Maehr et al. 2015).

In this respect, two on-line surveys were conducted out. In both of them, the participants had to assess in a Likert-scale (Strumse 1996; Tahvanainen et al. 2001; Molnarova et al. 2012) and no time limit on evaluating (Tveit 2009) the scenic beauty of each photograph – with or without wind turbines – according to their

**Fig. 2** Examples of photographs showed in the survey to evaluate landscape's scenic beauty and wind turbines influence on it



preferences (Tsoutsos et al. 2009). Although in scientific literature the most common scale seems to be composed by 5-point evaluation system (e.g. Bishop and Miller 2007; Molnarova et al. 2012; Baxter et al. 2013; Maehr et al. 2015), various scales could be found, such as 1 to 10 (Álvarez-Farizo and Hanley 2002; Lothian 2008; Tsoutsos et al. 2009), 1 to 5 (Strumse 1996; Cañas et al. 2009; Tveit 2009) or 0 to 10 (Sevenant and Antrop 2009; 2010). Nonetheless, considering Crask and Fox (1987) and Jaccard and Wan (1996) recommendation, as well as other works (Kaltenborn and Berje, 2002; Svobodova et al. 2012), in this study each photograph was scored on a 7-point scale from 1 (dislike) to 7 (very much).

Finally, even though both surveys were anonymous, participants had to indicate the three

socio-demographic characteristics which most influence on personal preferences: age, education level and gender (Aoki 1999). On this matter, while according to Svobodova et al. (2012) education level was divided into two categories (non-university studies and university degree), in regard to Martín Ruiz (2005), age was done into five (< 20; 20–29; 30–49; 50–59; > 59).

#### Data processing

Regarding the results come from a Likert-scale based on personal preferences, they were assumed on an ordinal level (Tahvanainen et al. 2001; Cañas et al. 2009; Molnarova et al. 2012) and analyzed using

non-parametric tests (Jamieson 2004; Wackerly et al. 2014).

Additionally, due to the fact that each survey was filled by different people, they were considered as independent samples. In this way, depending on the factor studied, two non-parametric tests were carried out: (i) Mann–Whitney U-test, for differences between landscapes and gender and (ii) one-way variance analysis of Kruskal–Wallis, in the case of education level and age groups. If significant differences were detected by Mann–Whitney U-test, they were analyzed by pairwise comparison including Bonferroni as correction factor. All the tests were carried out by the RStudio (R Core Team 2020) statistical software considering as significance level  $\alpha=0.05$ .

## Results

### Overview

The surveys—with and without wind turbines— were carried out in June 2019 and were available on-line to the general public, i.e., inhabitants and anyone interested, for six months. During this time, they were advertised through different types of media, especially social networks, and were answered by a total of 166 people (85 for without wind turbines and 81 for wind turbines) with different socio-demographic characteristics (Table 1). In this regard, considering the total size of the universe as the 385.927 inhabitants (INE 2021) of Albacete Province, each survey incurred an error margin near to 10% for a 95%

confidence interval, reason why the sample is sufficiently representative of the whole population.

### Perception of natural landscapes and wind turbines landscapes

According to the mean score of each photograph, the results show that in natural conditions forest landscapes (mean=4.58, sd=1.28) have more scenic beauty than agricultural landscapes (mean=3.68, sd=1.31). On the other hand, wind turbines placement into landscape is related to slight improvement or deterioration of its scenic beauty, a situation related to the score achieved by each landscape without wind turbines. In this regard, while for agricultural landscapes (the least attractive) wind turbines increase their perceptual value, for forest landscapes the opposite situation appears (Table 2). Finally, regarding the scores assigned to each photograph, distance and number of wind turbines do not have any significant influence on respondents’ visual preferences for a same landscape.

**Table 2** Average scores according to landscape type and wind turbines presence or absence

Landscape	Forest		Agricultural	
	No wind turbines	Wind turbines	No wind turbines	Wind turbines
Mean	4.58	4.29	3.68	4.01
Median	5	4	4	4
SD	1.28	1.53	1.31	1.48

**Table 1** Respondent’s socio-demographic characteristics

Landscape’s survey without wind turbines				Landscape’s survey with wind turbines			
Socio-demographic characteristic		Total	%	Socio-demographic characteristic		Total	%
Gender	Male	39	45.88	Gender	Male	41	53.25
	Female	46	54.12		Female	36	46.75
Age	<20	9	10.59	Age	<20	4	5.19
	20–29	22	25.88		20–30	21	27.27
	30–49	29	34.12		30–49	30	38.96
	50–59	19	22.35		50–59	17	22.08
	>59	6	7.06		>59	5	6.49
Education level	Non-university studies	56	65.12	Education level	Non-university studies	42	54.55
	University degree	30	34.55		University degree	35	45.45

Perception of wind turbines and socio-demographic characteristics

Regarding the variation in landscape’s scenic beauty scores according to the three socio-demographic characteristics studied (gender, education level and age), only age significantly influences on landscape’s scenic beauty. On the contrary, despite the fact that gender and education level did not have any effect on perception, some different preferences were observed inside the social groups in terms of the average rating assigned to each photograph (Table 3).

Gender

As Table 3 shows, on average men (mean=4.21; sd=0.8) were less critical about natural landscapes’ scenic beauty than women (mean=3.89; sd=0.93). Nonetheless both groups consider that wind turbines placement increases their general landscape’s perception (an average of 2%).

What is more, according to the different landscape types, the same pattern was observed between groups. In this regard, while wind turbines decrease people’s preferences in higher visual scenic landscapes (forest landscapes), in those with lower visual preferences (agricultural landscapes), the presence of wind turbines increase their scores (Fig. 3), especially for male respondents (3% more than female). Additionally, the results also show that there is not a relationship between gender and the perception of landscape’s scenic beauty according to their typology (forest or agricultural landscape), the presence or absence of wind turbines, the number of wind turbines and the distance to them (*p-value*>0.05, Kruskal–Wallis H test and Mann–Whitney U test).

Age

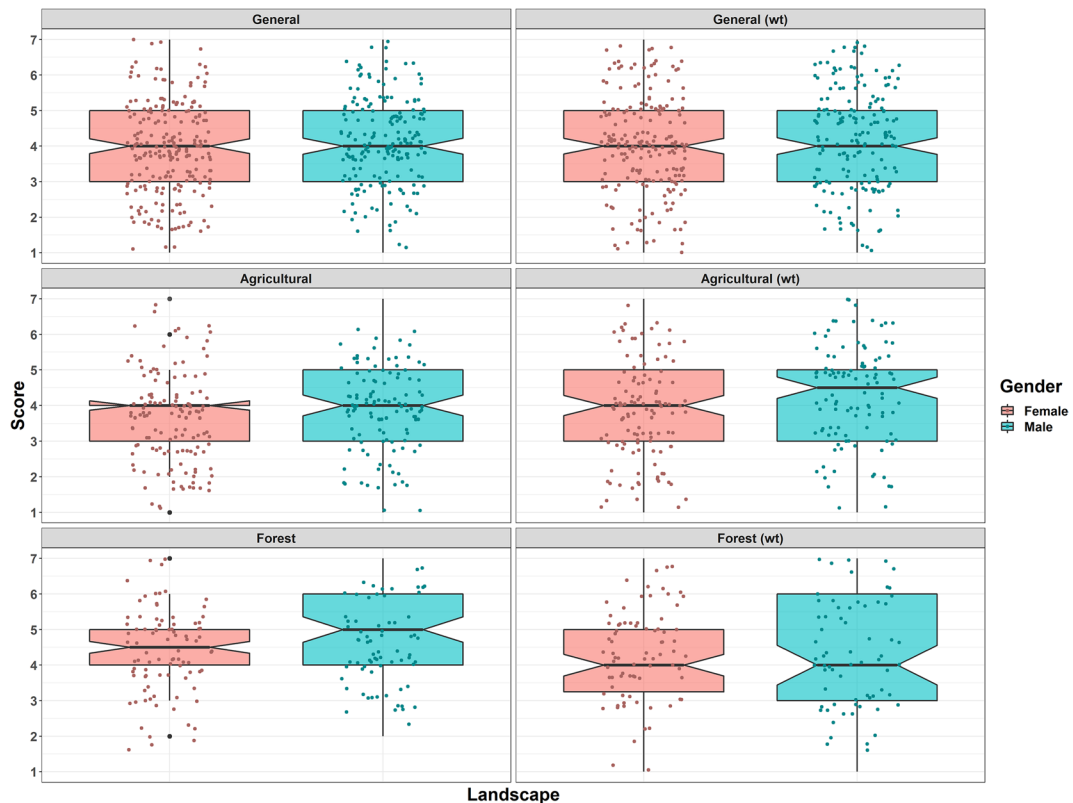
Despite the fact that different preferences were recorded according to this socio-demographic characteristic (Table 3), the results for each age group demonstrate that scenic beauty is not affected by the landscape type, number and distance to wind turbines (*p-value*>0.05, Kruskal–Wallis H test and Mann–Whitney U test).

In this regard, although for all age groups forest landscapes are the most valued (mean=4.49; sd=0.29), respondents between 20 and 59 years tend

**Table 3** Landscape’s average scores according to wind turbines ausence (NWT) or presence (WT) and respondent’s socio-demographic characteristics

Socio-demographic characteristic	Landscape																
	Forest						Agricultural										
	Photo 1		Photo 5		Average		Photo 2		Photo 3		Photo 4		Average				
	NWT	WT	NWT	WT	NWT	WT	NWT	WT	NWT	WT	NWT	WT	NWT	WT			
Gender	Female	4.74	4.56	4.17	4	4.46	4.28	3.63	3.8	3.35	3.88	3.54	3.66	3.51	3.78	3.89	3.98
	Male	5.1	4.69	4.33	3.92	4.72	4.31	4.08	4.5	3.62	4.11	3.92	4.22	3.87	4.28	4.21	4.29
Age	<20	4.44	4	3.89	2.5	4.17	3.25	3.33	4.5	2.56	4	3.89	3.5	3.26	4	3.62	3.70
	20–29	5.05	4.33	3.91	3.95	4.48	4.14	3.91	3.81	3.64	4.05	3.68	3.86	3.74	3.91	4.04	4.00
	30–49	5.03	4.87	4.28	4.13	4.66	4.50	4.21	4	3.62	4.23	3.76	3.9	3.86	4.04	4.18	4.23
	50–59	4.95	4.59	4.79	3.94	4.87	4.27	3.84	4.88	3.63	3.53	3.68	3.82	3.72	4.08	4.18	4.15
Education level	> 59	4.33	5	4.17	4.2	4.25	4.60	2.5	3.4	3	3.8	3.5	5	3	4.07	3.50	4.28
	Non-university studies	5.04	4.43	4.34	3.83	4.69	4.13	3.95	4.19	3.39	3.93	3.89	3.76	3.74	3.96	4.12	4.03
University degree	4.66	4.86	4.07	4.11	4.37	4.49	3.62	4.06	3.62	4.06	3.38	4.11	3.54	4.08	3.87	4.24	





**Fig. 3** Scores in each landscape by gender

to score natural and agricultural landscapes higher than young and older people. In fact, this last age group also scored agricultural landscapes more than the other groups (Fig. 4). On the other hand, even if for all age groups wind turbines increase agricultural landscapes perception, their presence generally decreases forest average landscape's scenic beauty. Additionally, while young people consider that wind turbines greatly decrease forest's scenic beauty but enhance it for agricultural landscapes, for older people the opposite occurs.

#### Education level

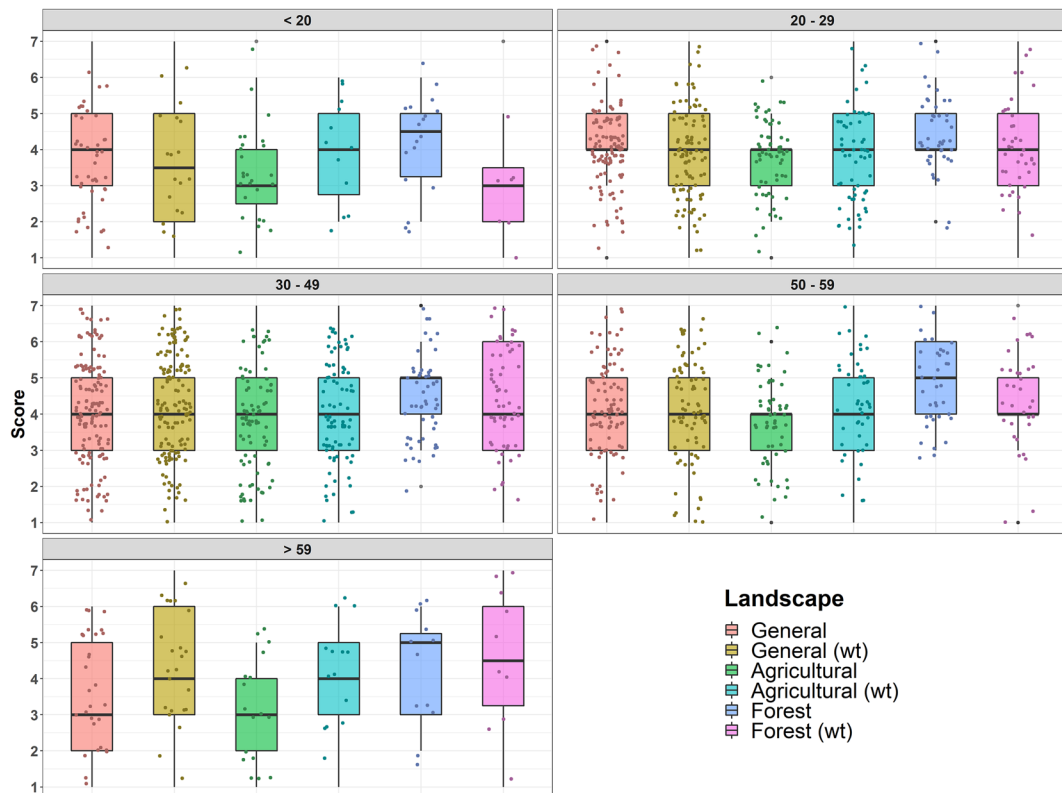
According to the education level of surveyed people, their visual preferences vary with reference to the different landscape types and the presence or absence of wind turbines (Fig. 5). However, despite these diverse visual preferences, from a statistical point of view, this characteristic was found

non-significant ( $p\text{-value} > 0.05$ , Kruskal–Wallis H test and Mann–Whitney U test).

In this regard, although respondents generally prefer forest than agricultural landscapes, surveyed people without university education were less critical for natural landscapes than those with university studies. On the other hand, when wind farms are placed in the landscape, while on average the scenic beauty of both landscapes increases for people with a university degree, especially for agricultural landscapes (more than 0.5 points), on the contrary, it decreases for lower education level respondents, mainly in forest landscapes (near to 0.6 points).

#### Discussion

Overall, this study shows that people's landscape perception in Mediterranean areas is not related to wind farm placement, wind turbines number and their distance to the observer. Moreover, the results also



**Fig. 4** Landscape's scenic beauty by age

confirm that people's landscape preferences are independent of certain socio-demographic characteristics such as gender and education level, but not for age.

#### Landscape preferences

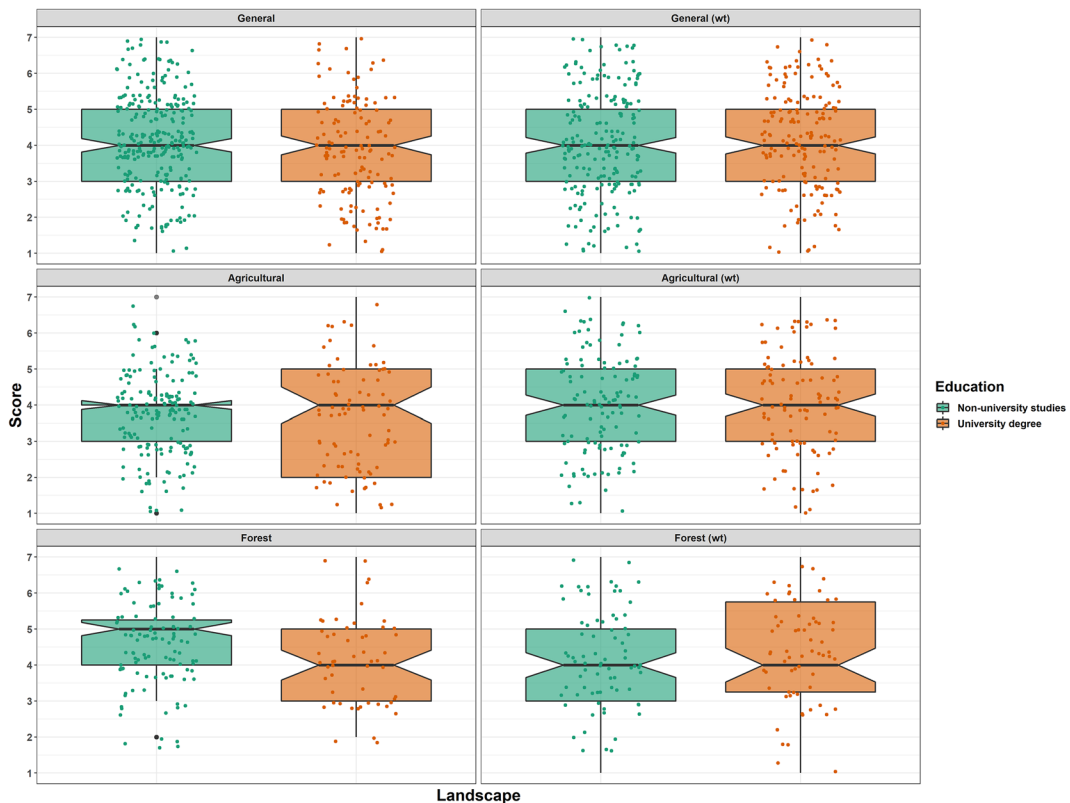
In accordance with previous findings (Van den Berg and Koole 2006; Brown and Brabyn 2012; Svobodova et al. 2012), the survey demonstrates that forests have a positive influence on the landscape's scenic beauty. In fact, they are the landscape most valued (average = 4.59). On the other hand, regardless of agricultural areas (average score = 3.68) are another element positively scored by people (Kaltenborn and Berje, 2002; Arriaza et al. 2004), its influence over scenic beauty is lower than forest.

At this point, the different values assigned to each landscape could be related to the dominant vegetation types in each one. In this regard, Mediterranean vegetation in agricultural areas is typically conformed by rainfed fruit trees, grasses, sclerophyllous species

or shrubs, typologies that are not as highly valued as coniferous or transitional woodland-shrub (Arriaza et al. 2004; De La Fuente and Mühlhauser 2014).

#### Wind farm impacts on landscape

According to the general results, wind farms do not influence significantly on landscape's scenic beauty (Tsoutsos et al. 2009; Maehr et al. 2015; Wilson and Dyke 2016). This finding is opposite to previous conclusions that showed how wind turbines are able to reduce (Lothian 2008; Molnarova et al. 2012; Vries et al. 2012) or to increase (Maehr et al. 2015; Wilson and Dyke 2016) landscape's scenic beauty. However, this main difference between works could lie in how the surrounding landscape influence on wind farms perception (Tsoutsos et al. 2009; Bishop and Miller 2007; Wolsink 2007; Molnarova et al. 2012). In fact, in spite of there are a lot of studies that have evaluated wind turbines influence on landscape (e.g., Bishop and Miller 2007; Pedersen and Larsman 2008; Möller



**Fig. 5** Landscape perception and wind farms influence by education level

2010; Vries et al. 2012), on visual preferences (e.g., Lothian 2008; Tsoutsos et al. 2009; Molnarova et al. 2012) or on scenic beauty (De La Fuente and Mühhauser 2014), only a few of them have been carried out in Mediterranean areas (e.g., Álvarez-Farizo and Handely, 2002; Lothian 2008; Tsoutsos et al. 2009).

On the other hand, it should be emphasized that wind farms placement in landscapes with lower scenic beauty has been better scored than in those with higher scenic beauty (Wolsink 2007; Molnarova et al. 2012). Consequently, this assumption shows how these infrastructures had a positive effect on landscape perception (Lothian 2008), in this work, for agricultural landscapes, areas where landform are more related to an economic point of view than forest (Brown and Brabyn 2012). Moreover, regarding that wind turbines number and distance to the beholder do not influence on landscape's scenic beauty, several circumstances should be mentioned. Firstly, this work considered a different wind turbines range (three as minimum and eight as maximum) that Lothian (2008)

or Molnarova et al. (2012) did it (from one to four and from six to thirteen, respectively). Secondly, the images showed wind farms located at a maximum of 500 m from the observation point, a distance very different from that considered in other works (Bishop and Miller 2007; Lothian 2008; Swofford and Slattery 2010; Molnarova et al. 2012), which are commonly expressed in kilometers. Nonetheless, it is important to considered that at distances greater than 35 km wind turbines are not visible to human eye and, therefore, do not influence on the visual perception of landscape (Molina-Ruiz et al. 2011).

Finally, Bishop and Miller (2007) showed how different atmospheric conditions (e.g. deep haze, fog, clear air or dark clouds) modify the visual effects of wind farms. However, although this factor has not been assessed during the landscape digital image processing, it has also not been considered a good criterion to evaluate wind farms due to: i) in natural conditions is not easy to quantify, therefore mainly it will be assessed in predefined simulations (with the

consequent technical limitations that it supposes) and, ii) is a highly variable factor which value change every day and even along the day.

#### Landscape's preferences and respondents' characteristics

In regard to scientific literature, most papers indicate that people's wind farms perception on landscape is influenced by several personal factors such as gender (Strumse 1996; Kaltenborn and Bjerke 2002; Svobodova et al. 2012), age (Strumse 1996; Tahvanainen et al. 2001; Kaltenborn and Bjerke 2002) or education level (Kaltenborn and Bjerke 2002; Svobodova et al. 2012; Hobman and Ashworth 2013). In contrast, but consistent with other studies, the results showed that visual preferences are not related to surveyed people gender (Van den Berg and Koole 2006; Pedersen and Larsman 2008; Howley 2011;), age (Molnarova et al. 2012; Svobodova et al. 2012) or education level (Cañas et al. 2009; Molnarova et al. 2012).

On this point, these differences could be explained by literature lacks, social and cultural acceptance of wind farms. Firstly, as was mentioned before, while the studies of Álvarez-Farizo and Hanley (2002), Lothian (2008), and Tsoutsos et al. (2009) were developed in a Mediterranean biome (Crete Island, inland location of Australia and la Plana of Zaragoza in Spain, respectively), the influence of personal characteristics on landscape's scenic beauty was not assessed by them. On the other hand, regarding the findings of Molnarova et al. (2012), Hobman and Ashworth (2013), Vries et al. (2012) or Strumse (1996), the main factors that determine people's perception are: (i) attitudes to wind farms (including previous experiences, Gipe 1995; Ladenburg and Dubgaard, 2009), (ii) landscape interest level and (iii) characteristics of the elements introduced. Additionally, due to the fact that local inhabitants have more favorable attitudes to wind farms (Molnarova et al. 2012; Wilson and Dike 2016) and do not consider them as a problem (Kaldellis 2006; Tsoutsos et al. 2009), their influence on scenic beauty could be a positive aspect related to the construction of local landscapes and sense of place (Pasqualetti 2011). This approach, in accordance to the ELC, reinforces the "inverse NIMBYism" defined by Devine-Wright (2005), because these human-made elements are able to provide social or cultural identity to landscape

(Álvarez-Farizo and Hanley 2002; Hammarlund et al. 2016). Nevertheless, it also should be highlighted that this perception is connected to different features (Kaldellis 2006; Pasqualetti 2011; Swofford and Slattery 2010; Enevoldsen and Sovacool 2016), such as economic point of view (Álvarez-Farizo and Hanley 2002; Baxter, et al. 2013), because while private investment or experts regard the visual impact of wind farm lower than other social groups, activists do it greater (Bishop and Miller 2007; Molnarova et al. 2012).

Nonetheless, returning to the results of this work, although the socio-demographic characteristics considered are not related to wind farms influence on scenic beauty, some relevant findings should be emphasized. To start with gender, unlike other research (Strumse 1996; Molnarova et al. 2012; Svobodova et al. 2012), in general men are less sensitive than women. Moreover, while both groups do not prefer wind turbines placement on landscapes with higher scenic beauty (i.e., forest landscapes), men considered that wind turbines improve it for unattractive landscapes (i.e., agricultural landscapes) to a greater extent than women (Molnarova et al. 2012). According to Strumse (1996), this difference lies on a "subcultural" variable, because while women are more positive toward nature than men, when an urban intrusion occurs (i. e., wind farms), the opposite is true.

As regards age, differences on landscape visual preferences only appear for older people (> 59). This finding demonstrates that wind turbines have a negative tendency according to age, especially for forest landscapes (Bishop and Miller 2007; Molnarova et al. 2012; Vries et al. 2012). Conversely, while younger respondents were more critical with their presence on forest landscapes, similar preferences for natural and wind turbines landscapes were found for the other age groups (Molnarova et al. 2012). These different landscapes' perception is related to: (i) familiarity (Thompson et al. 2008; Tveit 2009), because landscape provides an identity (ELC) that is mainly formed during youth, and (ii) interaction (Dramstad et al. 2006; Tveit 2009), but landscape's scenic beauty changes over generations depending on they use them (e.g., economic, recreational or scenic). In fact, both factors have been verified in this work, so while older people identify agricultural

landscapes as their traditional livelihood with an inverse relationship between its industrialization and its rating (Kaltenborn and Bjerke 2002; Van den Berg and Koole 2006), younger people perceived it as open landscapes (Tveit 2009) with recreational or cultural values where green technologies location are positively valued. In this way, technological elements (e.g., wind turbines, solar panels or antennas) will have lower visual landscape impact for future generations (Molnarova et al. 2012; Vries et al. 2012). This assumption has also been demonstrated to natural landscape's elements, such as water bodies, which are perceived differently according to age, especially for older people due to the fear it generated on them (Howley 2011).

Finally, according to education level, respondents with non-university studies tend to be less critical to those with a university degree (Svobodova et al. 2012; De La Fuente and Mühlhauser 2014), a direct relationship that is also higher when wind turbines are placed (Molnarova et al. 2012). In this regard, it was found a connection between education level and naturalness, a factor that is related to attractive landscapes (Ode and Miller 2011). This finding is related to the projection of education or knowledge into visual preferences, so people with higher education level (university degree or quasi-expert in landscape) appreciate more the importance of nature in the environment (Molnarova et al. 2012; Van den Berg and Koole 2006).

#### Suggestions for future research

According to the main results and, in addition to the above mentioned, it has been considered appropriate to point out a series of future research related to wind farms influence on scenic beauty:

- Further focused research on social attitudes to wind farms. Both landscape perception as one whole, as a collection of elements, have been a deeply studied aspect. However, in regard to this work reflect that people have assumed the presence of wind turbines as a landscape additional element, as electric towers did it, it is also necessary to check if this premise represents a general trend or simply a particularity related to respondents and the study area.

- To assess the landscape's capacity to assume wind turbines impacts on scenic beauty. Demonstrated their relationship, the next step is to consider the visual absorption capacity of different landscapes around the world according to their elements (e.g., slope, vegetation or land uses). This situation is especially important in regard to literature shows how several intrinsic landscape attributes such water features (Kaltenborn and Berje, 2002; Arriaza et al. 2004; Brown and Brabyn 2012) or non-traditional man-made elements (Arriaza et al. 2004; Svobodova et al. 2012) are the most and the least factor that influences on people's landscape scenic beauty, respectively.
- To determine the wind turbines number, maximum and minimum, which people are willing to include on landscape without landscape's scenic beauty deterioration (Brown and Brabyn 2012). There is a lack of consensus about how many wind turbines could support the landscape, so it is interesting to evaluate how people landscape's preferences vary according to the number and size of wind turbines placed.

#### Conclusions

This study analyses how general public's landscape preferences in Mediterranean areas vary regarding two criteria: (i) wind turbines visual effects on landscape, and (ii) people's socio-demographic characteristics. According to the results obtained from the two on-line surveys carried out, four important conclusions have been identified. Firstly, the score assigned to each landscape indicates that vegetation has a beneficial effect in landscape's scenic beauty. This finding is especially relevant for arboreal vegetation, i.e., coniferous forest, natural element that has been more positively valued by respondents than agricultural areas.

The second one is related to wind farms perception, because surveyed people do not perceive wind turbines placement as a negative impact on landscape's scenic beauty. In fact, in landscapes with lower scenic beauty or more deteriorated than natural landscapes, in general, wind turbines location was valued as a positive element that slightly improves their scenic beauty. Additionally, it was also found an inverse relationship between landscape's



attractiveness and wind turbines placement, showing how these infrastructures improved visual quality to a greater extent in lower rated landscapes than in higher rated ones.

Thirdly, considering several factors related to wind turbines such as their presence, number and distance to the beholder, the result did not demonstrate any statistical relationship between them and people's landscape preferences. Nonetheless, regarding the findings of previous works, this trend should be deeply studied for future works, especially in regard to Mediterranean areas, because these findings could be related to surveyed people characteristics and background landscapes than a general pattern about wind farm impacts on landscape's scenic beauty.

Finally, despite the fact that the socio-demographic characteristics considered, i.e., gender, age and education level, did not have any influence on respondents' landscape visual preferences, the results evidence a trend between these factors and wind turbines perception. In this way, while women, extreme age groups (<20 and >59 years) and people with non-university studies tended to be more critical with wind turbines placement, especially in those landscapes with higher visual quality (i. e. forest landscapes), several age groups (from 20 to 59 years) and graduated people considered that wind turbines are able to increase landscapes with lower scenic beauty (i. e. agricultural landscapes). In addition, it should be highlighted the different perceptions found between natural and wind turbines landscapes according to age, an attitude related to technological and cultural context.

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**Declarations**

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