Analysis of the impact of high voltage power lines on the value of properties in environments of high ecological value and rural tourism: the case of the Lecrín Valley (Granada – Spain)

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Abstract: Plenty of studies analyse the impact of the passage of high voltage power lines (HVPLs) through areas of high ecological and tourist value in specific ecosystems. However, there are no similar studies conducted in Spain especially with regard to the impact on the value of proximate properties as well as the loss of business to tourist establishments and commerce in areas with high environmental value. This study analyses the case of the Lecrín Valley in Granada (Spain) through which a HVPL project intended to cross over the region. Through a comparative methodology, the projected losses to property values in the municipalities of the area and the economic and social implications caused by the visual impact of the HVPL are quantified. The conclusions point out that the infrastructure would rupture of the regional balance while generating precariousness, loss of wealth in economic and patrimonial terms for the region as a whole.

Keywords: high voltage pylons; environmental impact; property values; local economies; tourism management; rural tourism; Spain.

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1 Introduction

The scientific literature related to the impact of the passage of high voltage power lines (HVPL) through areas of high ecological and tourist value has focused both on the impact on the value of adjacent properties as well as the loss of business for the local tourist establishments. The impact of the passage of HVPL on the value of the assets within the area is expected to be directly proportional to the ecological and tourist value of the environment. Though, this debate is not new. Recent movements to avoid pylons building and wind turbines in specific zones like Somerset, Yorkshire and North Wales in England indicate that still environmental visual impact generates hostility in local populations (Cotton and Devine-Wright, 2012). Basically, two arguments come into opposition between pro-and-against pylons communities. The first argument states that local inhabitants behave in selfish way while lacking the basic knowledge to understand technological progress. The second refers to the costs to be supported by local inhabitants who will suffer the artificialisation of the environment they feel emotionally attached to while also surrendering to capitulate a part of their identity. These costs involve losses the development of the tourism industry, especially for rural environments (Jones and Eiser, 2010).

NYMBYism, also known as the not-in-my-back-yard syndrome has been pointed out as catch-all explanation for communities standing against supposedly social good developments (Wolsink, 2000). Environmental economists such as Bateman and Langford (1997) have differentiated between option values and bequest values related to areas with potential economic development. This fact involves that those environments with low ecological and tourist value suffer a much lower impact in the face of changes in their environment than those with ecosystems considered to have a high level of

environmental value. In fact, the environment and biological diversity are considered as intangible assets of a region that, in the case of being affected, considerably reduce the cultural, social, economic and geo-ecological value of the area (see among others, Dudley et al., 2005; Romero, 1997; Verschuuren and Brown, 2018).

In addition, there is a growing interest in management to integrate environmental objectives into the firm operations strategy while measuring its impact (Arias-Aranda and Minguela-Rata, 2018). Hence, issues related not only to the impact on the value of real estate or business assets, but also on the health effects of the HVPL in the areas through which they pass, have also been the subject of attention in the specialised literature and include interrelated effects between both. The effect on landscapes of high environmental value and natural beauty make up part of the studies on the impact caused by their passage (see among others, Delaney and Timmons, 1992; Elliott and Wadley, 2002). On the other hand, epidemiological studies related to exposure to electromagnetic fields (EMF) have shown a tendency to increase the risk of two types of cancer, such as childhood leukaemia and chronic lymphocytic leukaemia in adults exposed to occupational exposure to EMF according to the study carried out in 1992 by the USA Congress. In fact, the National Institute of Environmental Health Sciences (NIEHS) of the USA determines that exposure to EMF cannot be considered as completely safe even when there are also inconclusive studies (NIEHS, 2002). In any case, the greater dissemination of information in the media about these possible health risks (cancerphobia) (Bryant and Epley, 1998) affects the perception of individuals when valuing real estate assets and the tourist attraction of the areas near the HVPL pass.

In this study, we analyse a case of the impact that the passage of HVPLs would have on the valuation of the properties of the Lecrín Valley region in the Granada province (Spain), this being an area of high ecological and landscape value and whose economic activity is primarily based on non-intensive family managed agriculture and with a high percentage of wealth derived from rural tourism. A popular activism movement started when local inhabitants reacted against the HVPL project considering it could harm their economy as well as their lifestyle. Even though some previous studies such as Kapper (2004) or Daniel et al. (1989) have considered scenic beauty in studies about environmental impact, this is the first study which analyses such impact on a local economy considering and valuing scenic beauty as a public asset in a specific case within a rural area.

This paper focuses on the valuation beauty as a crucial asset of economic wealth measured by real estate prices in a rural area and how it can be affected by the construction of a HVPL infrastructure. It is made up following this structure: first, we analyse the impact of the passage of HVPL on the valuation of real estate differentiating by levels of scenic beauty. Then, we describe the specific case of the Lecrín Valley

2 Impact of the passage of HVPL on the valuation of real estate

In this section, a literature review on the impact of HVPL on different locations will be discussed differentiating by levels of scenic beauty considering residential and rural areas. Some studies on the impact on rural tourism will be also included.

Table 1 Summary of the studies about real estate valuation in non-touristic environments

Study		*Sample*	*Analysis*	*Conclusion*
1	Kinnard (1967)	17 urban municipalities in Metropolitan Hartford, Connecticut EE.UU.	Closeness to a HVPL	Owners of the highest value properties show higher level of rejection
2	Morgan et al. (1985)	116 individuals with high education level in the USA	Perception on the risks of living near HVPL	Direct relationships between higher level of information and worries
3	Delaney and Timmons (1992)	219 individuals in residential zones in the USA	Valuation of properties near HVPL	Average loss of 10,01% in closet o HVPL property value
4	Kung and Seagle (1992)	Sample of real estate market at Tennessee (USA)	Mapping on the values of properties according to HVPL closeness	Potential harming health effects (conclusive or not) affect negatively property prices
5	Gregory and Winterfeldt (1996)	Metanalysis	Differences in valuation of homes closed to HVPL along time	Differences from 10% to 30%
6	Rosiers (2002)	507 homes outside Montreal (Canada)	Properties values and HVPL closeness	Losses of value in a rank between 5% to 20% proportional to HVPL closeness
7	Elliott and Wadley (2002)	Different residential zones at US	Stigmatisation of HVPL zones	Stigmatisation due to visual impact, coercion and decrease of property values
8	Sims and Dent (2005)	London surroundings (UK)	Properties values and HVPL closeness	Dramatic reductions in price up to 38%
9	Sims et al. (2009)	Different locations at UK	Price valuation according to perceived risk	Reductions in price up to 34%
10	Lane et al. (2013)	Experimental study on 357 individuals in US	Closeness to HVPL on real estate pricing	Differences of about $10,000 in properties valued $200,000
11	Tatos et al. (2016)	150,000 transactions in a 14 years old period and analysis of y 450 characteristics in Salt Lake City (USA)	Aggregate effect of value loss for properties near HVPL	Aggregate effect affects value loss for properties near HVPL
12	Wyman and Mothorpe (2018)	5,455 properties between 2000 y 2016 in South Carolina (USA)	Analysis of HVPL closeness and visibility	Losses up to 44.9% in properties closet o HVPL

Source: Own processing

2.1 Studies in locations not defined by environments of great scenic beauty

Even though energy needs increase in countries such as China, this is not the case when considering projections for continental Europe (Mardani et al., 2018). Studies carried out in areas with low or no landscape value or tourism show a different impact on different levels of population according to income in relation to the implementation of HVPL and the propensity of the population to refuse to select their primary home nearby. Thus, one of the first studies was carried out by Kinnard (1967) conducted in 17 subdivisions of nine suburban municipalities in Metropolitan Hartford, Connecticut. All these subdivisions had an electric line and pylons that crossed them. In the study, the owners of the most expensive homes showed greater rejection than those of lower-valued homes given that they perceived that their loss of equity value was greater.

In this regard, the study by Morgan et al. (1985) demonstrated how the sensitivity to the placement of high voltage lines near homes is directly proportional to the information about the risk involved, thus increasing the concern of the affected population as they were provided with more information. Subsequently, Delaney and Timmons (1992) analysed the impact of HVPL on the perception of owners of holiday and recreational homes. Their greatest concern was the loss of equity value (established as approximately 10% and attributed to the loss of attractiveness of the area), followed by the potential health risk, annoying noise and potential safety problems. In any case, none of these studies were conducted in areas of special ecological and landscape value where damage would be even greater.

In fact, Tatos et al. (2016) took a step forward in a much larger and systematised recent study in which they analysed a period of 14 years (from 2001 to 2014) in Salt Lake City in Utah (USA) on 150,000 transactions and 450 different characteristics in relation to different types of HVPL. This study estimates a positive and significant added effect of all these factors in the decrease in the price of homes for all types of HVPL from 46 kV to 500 kV. Lane et al. (2013) conclude in their experimental study that the passage of HVPL through residential areas not only decreases the value of the properties, but can scare away those buyers with higher income who seek higher-value housing, who will move to other HVPL-free zones. In this way, in the areas adjacent to HVPL, mostly families of limited income become established as they will not be able to afford housing of high quality and thus have to assume the aesthetic and environmental cost.

When considering the factors that lead to the depreciation of properties close to HVPL, Wyman and Mothorpe (2018) primarily point four of them: visual impact, perceived impacts on health, noise nuisance and limited access to green spaces due to restriction of specific areas. The visual impact generating a decrease in the attractiveness of the area is cited by 94% of potential customers; 59% cite potential health problems and 43% annoying noises (Delaney and Timmons, 1992). From these four factors, the study by Wyman and Mothorpe (2018) of 5,455 homes sold between 2000 and 2016 in South Carolina (USA) establishes a loss of value of 44.9% for homes adjacent to HVPL. In fact, developers tend to add larger patio areas or increase the number of bedrooms to counteract the loss of value.

Other studies conducted outside the USA like the one of Rosiers (2002) in the surroundings of Montreal (Canada) show depreciations in the values of the houses that surpasses 20%. In the case of London, the reduction in value reaches 38%, requiring new construction houses to have larger back yards to compensate for the large depreciation (Sims and Dent, 2005). Moreover, even when studies on the impact on health due to

living near a HVPL may not be conclusive, the perception of potential buyers does consider the potential risk to health in their assessment (Sims et al., 2009). That is why the population's knowledge of health risks, whether conclusive or not, has a profound downward effect on the price of properties close to HVPL (see among others, Elliott and Wadley, 2002; Gregory and Winterfeldt, 1996; Kung and Seagle, 1992). Table 1 summarises the studies on valuation of properties close to HVPL in non-tourist residential environments.

From these studies, the real percentage depreciation of real estate oscillates around an average of 36% for studies carried out in Europe (studies 8 and 9) compared to 18% in the USA (rest of studies). However, and due to the scarcity of specific analysis, these figures need to be considered with caution. The cancerphobia, as a phenomenon of perception of the buyers detrimentally affects prices, especially in Europe. In any case, previous studies focus on areas of low or no landscape value without interest for tourist activities in suburban areas designed to be primarily for residential use.

2.2 Studies in locations defined by landscape environments of high value and beauty

The studies in the previous section focus on areas whose landscape value is not crucial to tourist activities with no high biodiversity or cultural richness. In fact, those studies mostly analyse residential areas without a special appeal when it comes to attracting tourists. However, studies such as Stefansson et al. (2017) show the rejection of tourists to HVPLs in areas of special attractiveness due to special beauty environments. This study analyses seven tourist locations in Iceland concluding that HVPLs are the infrastructures that generate the greatest negative impact when attracting tourists, especially for domestic tourists. The impact on the landscape needs to be considered from different perspectives. The first one involves the impact on the environment as cultural and ecological heritage, while the second affects the landscape as a source of rural tourism attraction. In fact, an artificialisation of the landscape decreases attractiveness and directly affects the economy of the area. Hence, local economies suffer devaluation of rural properties for both habitual residence and tourist accommodation (Tatos et al., 2016).

Spain is the third country with the most declared World Heritage sites in the world. However, no studies on the impact of HVPL in landscape environments of high beauty and environmental value in Spain have been found. Therefore, and in the absence of studies that serve as a basis in Spain, we had to use tourism in landscape environments of high beauty and value as proxy variable to perform the impact study of HVPL on properties prising while basing this analysis on case studies from other countries.

The landscape significance on the inhabited areas affects not only the economic value of the properties and businesses of the regions but also its own cultural and historical identity (Mallarach et al., 2012). Artificialisation of the environment changes the way of life of its residents as it modifies natural resources and local capabilities. In this context, the resources-based view (RBV) analyses how organisations need to identify internal resources in order to become aware of those assets, capabilities and competencies different from other organisations on which a strategy can be built to profit from larger competitive advantages (Barney, 2001). In this regard, for the whole of a region, the

beauty of the landscape represents an intangible valuable asset (Basu and Waymire, 2008) which, when removed, involves a direct damage to a socio-economic system.

Table 2 Summary of the studies about real estate valuation and touristic activities

Study		*Sample*	*Analysis*	*Conclusion*
1	Williams and Ferguson (2005)	Keswick (UK) after cattle diseases	Impact of unexpected events on rural tourism	Unexpected negative events have a devastating effect on rural tourism
2	Entrena Duran (2006)	La Alpujarra (Granada)	Effects of rural tourism	Economic development and demographic increase
3	Liu et al. (2012)	Natural Reserve in Wolong (China). 220 households 1999–2007	Benefits of rural tourism	In 9 years 2/3 of the households benefited directly from rural tourism
4	Millan Vazquez de la Torre et al. (2014)	Andalusia (Spain) 24 natural parks	Analysis of economic development in rural zones through tourism	Rural tourism helps to balance economic inequality
5	Jimenez Garcia et al. (2014)	Andalusia (Spain)	Analysis of different kinds of rural tourism	Positive impact of rural tourism on local territory
6	Pallarès-Blanch et al. (2014)	Natural Parks of Granada and Catalan Pyrenees (Spain)	Impact on population	Tourism generated wealth estimated in 21.3% of the total local economy
7	Bilbao-Terol and Valdés (2015)	Asturias (Spain)	Effect of natural environment improvement in rural tourism income.	1% increase in environment beauty increases rural lodging prices in 0.38%
8	Stefansson et al. (2017)	7 touristic zones in Iceland	HVPL impact in touristic zones	HVPL are the infrastructures which generate the highest negative impact on domestic tourists

Source: Own processing

Visual environmental impact in terms of the physical deterioration of landscapes of great beauty negatively modify the perception of potential tourists and economies of the inhabitants of the area. This fact has been analysed in different studies both in relation to livestock diseases in rural areas of tourist interest in England (Williams and Ferguson, 2005), as well as economic development of rural tourism and impact on the ecosystem and its planning (Liu et al., 2012). When considering Spanish case studies about tourism economics, many of them show how landscape environments of great beauty encourage, among other activities, rural tourism, which is a development factor that corrects regional imbalances (Entrena Duran, 2006). This positively impacts on the quality of life of the inhabitants of the area, especially those activities enacted in areas of protected heritage and exceptional beauty (Millan Vazquez de la Torre et al., 2014). In fact, rural tourism in environments of high ecological value mitigates depopulation and creates economically

sustainable areas that generate value based on the conservation and improvement of that heritage (Jimenez Garcia et al., 2014) which in turn supports the conservation and improvement of the natural and architectural heritage. The study conducted by Pallarès-Blanch et al. (2014) in natural areas of Granada (including the Lecrín Valley) and the Catalan Pyrenees proved how the promotion and conservation of environmental heritage generated a high rural tourism development for these areas which accelerated the population growth of these areas which, in previous decades, had been a major focus of emigration. In fact, this economic development reversed the emigration trend and generated 'settlement' immigration. In such study, the wealth generated by rural tourism in the protected areas of Granada was valued at 21.3%, based on the process known as 'naturbanisation', which generates value for properties that would otherwise remain semi-ruined but which are reconstructed thanks to the conservationism of the environment.

When assessing the impact on the value of real estate located in rural tourism areas, the study by Bilbao-Terol and Valdés (2015) highlights the fact that an increase of 1% of the arboreal mass (and, therefore, of the beauty of the environment estimated as an intangible), increased the price of a rural accommodation by 0.38%, thus evidencing the great sensitivity that the value of the assets related to rural tourism has on those variables that tend to diminish the beauty of the environment. In this way, Table 2 shows a summary of the studies on valuation of real estate assets and touristic activities.

All these studies point out the vulnerability of local tourism activities as well as real estate value together with the benefits of these activities in rural communities. Studies 2, 4, 5, and 7 are focused in Spain while 1, 3 and 8 are focused on UK, China and Iceland.

3 Valuation of losses due to the proximity of HVPL in environments of high landscape value with economies reliant on rural tourism: description of the Lecrín Valley case

The studies analysed in the previous section show how the impact of HVPL proximity in residential housing varies according to different parameters such as kV, geographical areas and type of housing. For the cases analysed in the USA, the oscillations range from 10% to 44% for residential areas. In the Canadian case they range from 5% to 10% according to HVPL visibility. European studies conducted in the UK demonstrate values in a narrower range of 34% and 38%. In any case, these previous studies analyse residential areas with little or no landscape value and in which rural tourism is not representative of a substantial part of their economy.

Studies performed in environments partially or totally dependent on rural tourism yield much more dramatic conclusions when the attractiveness of the area is reduced. In this study, we consider the insights of previous studies by applying a specific methodology on beauty valuation and HVPL impact on real estate values to a specific case in the Lecrín Valley (Southern Spain).

The Lecrín Valley is a Spanish region located in the centre-south of the province of Granada in Spain formed by eight municipalities, enjoying a unique environment with a fertile valley of agricultural diversity including orange and lemon plantations and an architectural heritage including old flour mills, Muslim castles and charming farmhouses. This area, located about 40 km from Granada capital, with a total of 22,440 inhabitants, is

characterised by having an ecosystem with a high historical and landscape value with several protected areas, such as the Natural Area of Sierra Nevada, Special Protection Areas for Birds and Biosphere Reserve together with the Wetlands and Peatlands of Padul, among others (Moreno, 2011). This area could be affected by a HPVL project that would divide such landscape environment considered of great beauty, thus generating a great visual and environmental impact with pylons of an approximate height of between 65 and 80 m with bases of up to 250 m^2. After the HPVL project was known in 2018 by the local community, a specific activist platform was created to study the economic and environmental impact and start legal actions to avoid the implementation of such a project.[1] A year later, the project was delayed. In 2020, there is no still a clear response by the local and state authorities about the future of the project.

4 Methodology

In order to analyse the value of properties under different scenarios, different approaches have been considered. At the cadastral level, the valuation of real estate is key in two aspects: the first, is the requirement to calculate the payment of taxes such as the real estate tax and the second aims to create a database that serves to assess the real estate wealth of a population. In the latter case, a multifunctional cadastral approach is used to converge into a single value of the assets as required under the relationship of the various administrations with the citizens, not only to calculate taxation but also to allow for expropriations and land management (Caballer Mellado, 2002). In this way, when properties are transferred, the cadastral documentation uses the probable stochastic or probabilistic market value. However, for goods that cannot be exchanged, such as architectural and archaeological heritage or environmental resources, methods like contingent or hedonic value, among others, are applied (Romero, 1997). When the goods are considered consumables (housing, parking, etc.) the market value used is congruent with the cadastral value. However, in goods considered as production factors, such as land, commercial premises or housing dedicated to tourism use, the calculation is more complex. This is particularly true when the asset is a scarce natural resource of which ecological factors such as beauty, climate or availability of water depend, especially in areas with high landscape value and economies based on rural tourism (Caballer Mellado, 2002).

In summary, the main valuation methods are divided into three categories:

- Synthetic or comparative methods: These compare similar properties of which the purchase price of some are known formulated as

  $$V = aX + b$$

  where

  V market value

  X explanatory variable.

  Being a and b are the parameters of the equation with dependent and independent variable if there is one.

- Analytical or capitalisation methods: These update economic returns formulated as:

$$V = \sum_{i=1}^{n} \frac{Q_i}{(1+r)^i}$$

where Q is the form of income, gross margin or expected cash flows, n is the number of years by which the investment is valued and r is the capitalisation rate, being V the market value.

- Regression methods: These estimate the value of a property as a function of several explanatory or exogenous variables x so that:

  $$V = f(x_1, x_2, x_3, x_n)$$

  In order to apply regression methods, it is necessary to have large databases that give robustness to the data, avoiding problems of multicollinearity and heteroscedasticity.

In the absence of a broad database and in order to evaluate the impact on real estate depreciation, estimates based on the regression equations would generate unacceptable errors. Furthermore, any estimation of the cash flows for capitalisation methods would be based on weak estimators given the variable casuistry of the area. We therefore, of the three valuation methods of properties developed in the previous section, have opted for the application of the synthetic method counting on the data of the studies analysed in the section above which covers the literature review and which expressed generically as $V = aX + b$ taking as exogenous variables the distance to the pylons in metres and the visibility of them and distinguishing three types of properties:

1 Those dedicated to tourist activities (including accommodation, restaurants, leisure activities enacted in the surroundings, etc.)

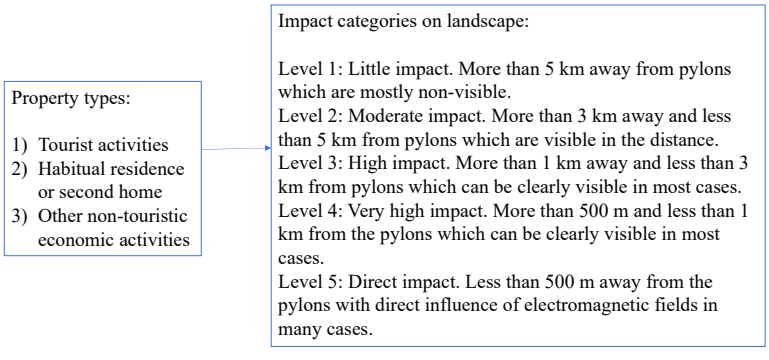
2 Those not affected by tourism and domestic activities dedicated to a habitual residence or second home.

3 Those affected by economic activities not related to rural tourism.

Therefore, according to the studies analysed in Sections 2 and 3, for habitual residences or second homes, average values of depreciation of 45%–50% would be applicable considering the special beauty of the zone. Such values would increase, as established by previous studies, in consonance with increased proximity to the pylons and can reach percentages close to 70%. That is why the two variables used to categorise the impact of the passage of the HVPL on the real estate value are the proximity to the pylons and visibility, as shown by the studies. The impact, however, is greater in a scenic area of great beauty where there are constant leisure and work displacements of both the resident and tourist population. In addition, the absence, in some cases, of businesses that meet daily needs requires commuting. The prevalent crops in the Lecrín Valley, especially vegetables and cereals, also require regular displacements since most of its inhabitants as a way of life, as a commitment, or even as a hobby, dedicate a significant part of their time to micro-crops typical of the area. That is why the non-visibility of the towers from a certain point does affect the value of the property due to this play and work-related effect that does not occur in residential areas of large cities. In this way we can establish five impact categories according to these two variables (see Figure 1):

- Level 1: Properties that are still located in the Lecrín Valley but are so far from the area of influence of the pylons that their impact on the value of them is very low because they have almost no visibility of them (more than 5 km).
- Level 2: Properties with a closeness of less than 5 km and more than 3 km to the pylons, which are visible in the distance or not visible because they are hidden by hills, ravines or similar geographical features.
- Level 3: Properties with a closeness of less than 3 km and greater than 1 km, which are clearly visible due to the height of the pylons or not visible because they are hidden by hills, ravines or similar geographical features.
- Level 4: Properties with a proximity of less than 1 km and more than 500 m with a high visual impact, the towers being generally visible totally or partially, except if the view is interrupted by high-altitude geographical features (unlikely).
- Level 5: Properties with a proximity of 500 m or less with very high total or partial visual impact and directly impacted on by the EMF generated by the power lines.

Figure 1 Properties types and impact categories (see online version for colours)



5 Data analysis and results

In this way, and in order to calculate the total value of the impact that the HVPLs would generate on the Lecrín Valley, we proceeded to calculate the average value of the properties of the eight municipalities through a sample representative obtained by real estate for sale in different village.

An approximate correction factor of 10% has been applied to this sample to correct the differences between the announced sale price and the definitive one after the negotiation between buyer and seller. On the other hand, and to assess the landscape environment, considered as an intangible asset with regard to the concept of beauty, we have compared property values with municipalities located within a radius of 30 to 40 km from the city of Granada that do not have the special environment and differentiating beauty of the landscape of the Lecrín Valley (see Figure 2). In this way, we isolate the intangible effect 'beauty' as a differentiating fact. In Table 3 we show for each

municipality and type of property the corrected sale value and the loss of value due to the passage of HVPLs.

Figure 2 Calculation method of the impact of HVPL on real estate value (see online version for colours)

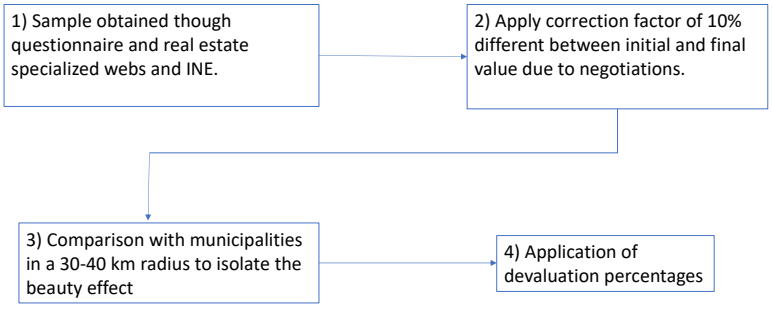


Table 3 Percentage of dwellings according to surface in square metres

Town/range (sq.m)	*53 m²*	*68 m²*	*83 m²*	*98 m²*	*113 m²*	*135.5 m²*	*165.5 m²*	*180 m²*
Durcal	0.0%	7.1%	18.5%	20.3%	14.4%	18.4%	11.4%	9.8%
Lecrín	0.0%	0.0%	21.5%	20.3%	15.4%	18.0%	11.2%	13.5%
Niguelas	0.0%	0.0%	13.4%	18.1%	21.1%	19.2%	13.8%	14.3%
Padul	4.3%	7.2%	18.6%	14.0%	20.4%	15.8%	9.8%	10.0%
El Pinar	0.0%	0.0%	27.4%	0.0%	23.2%	27.0%	0.0%	22.5%
El Valle	0.0%	0.0%	28.9%	17.2%	18.6%	18.1%	0.0%	17.2%
Villamena	0.0%	0.0%	10.1%	20.6%	21.7%	25.5%	0.0%	22.0%
Albuñuelas	0.0%	0.0%	22.1%	12.6%	21.2%	23.5%	0.0%	20.6%

Source: Instituto Nacional de Estadística (http://www.ine.es)

Table 4 Total of dwellings according to surface in square metres

Town/range (sq.m)	*46 m²*	*61 m²*	*76 m²*	*91 m²*	*106 m²*	*121 m²*	*151 m²*	*180 m²*	*Total*
Durcal	-	258	669	732	521	665	412	353	*3,610*
Lecrín	-	-	309	291	220	258	161	195	*1,434*
Niguelas	-	-	107	145	169	154	111	115	*801*
Padul	211	355	922	696	1,011	783	485	495	*4,958*
El Pinar	-	-	206	-	174	203	-	170	*753*
El valle	-	-	205	122	132	128	-	121	*708*
Villamena	-	-	65	131	138	162	-	140	*636*
Albuñuelas	-	-	166	94	158	176	-	154	*748*
Total	*211*	*613*	*2,649*	*2,211*	*2,523*	*2,529*	*1,169*	*1,743*	*13,648*

Source: Instituto Nacional de Estadística (http://www.ine.es)

Table 5 Total dwelling surface per sq. m range and municipality

Town/range (sq.m)	*46 m^2*	*61 m^2*	*76 m^2*	*91 m^2*	*106 m^2*	*121 m^2*	*151 m^2*	*180 m^2*	*Total m^2*
Durcal	-	17,544	55,527	71,736	58,873	90,108	68,186	63,540	*425,514*
Lecrín	-	-	25,647	28,518	24,860	34,959	26,646	35,100	*175,730*
Niguelas	-	-	8,881	14,210	19,097	20,867	18,371	20,700	*102,126*
Padul	11,183	24,140	76,526	68,208	114,243	106,097	80,268	89,100	*569,764*
El Pinar	-	-	17,098	-	19,662	27,507	-	30,600	*94,867*
El valle	-	-	17,015	11,956	14,916	17,344	-	21,780	*83,011*
Villamena	-	-	5,395	12,838	15,594	21,951	-	25,200	*80,978*
Albuñuelas	-	-	13,778	9,212	17,854	23,848	-	27,720	*92,412*
Total	*11,183*	*41,684*	*219,867*	*216,678*	*285,099*	*342,680*	*193,470*	*313,740*	*1,624,400*

Source: Instituto Nacional de Estadistica (http://www.ine.es)

Table 6 Inhabitants, households, companies and price of built sq. m per municipality

	Inhabitants	*Households*	*Companies*	*€/sq.m*
El Valle	938	708	44	908.05
Albuñuelas	836	748	19	862.55
El Pinar	933	753	-	830.77
Lecrín	2,089	1,434	129	809.62
Niguelas	1,195	801	67	724.67
Padul	8,454	4,958	567	703.77
Villamena	967	636	50	676.27
Durcal	7,028	3,610	464	524.20

Source: Own processing from INE and idealista.com

When evaluating the real estate stock of the Lecrín Valley, data was extracted from the last census of the Spanish National Institute of Statistics (INE) of 2011 with the limitation that for populations with less than 2,000 inhabitants, they do not reflect the quantitative and qualitative changes to the housing stock that has occurred in the last 8 years. That is why as a second source of information in relation to the price per square metre in euros, the database from one of the most used websites por real estate property in Spain (http://www.idealista.com) has been used, where advertisements of properties for sale are collected from both individuals and real estate companies.

In relation to the percentage of dwellings by area in each municipality, Tables 3 and 4 show the percentage and total number respectively of dwellings from INE data. Every column represents the range from the previous column. In most municipalities, the most common dwelling size is in the range of 83 and 98 m^2 with slight variations for municipalities such as Padul, Villamena or Nigüelas where average m^2 rises to the range of 98 to 113 m^2. Likewise, dwellings with areas larger than 180 m^2 were excluded as they mostly correspond to industrial instead of residential use. Table 5 shows for each municipality the total m^2 of constructed property. In this way, a total of 1.62 million square metres of family housing is estimated, with 119.02m^2 being the average family dwelling. Finally, Table 6 indicates the number of inhabitants, family dwellings, businesses and price of €/m^2 per municipality of Valle de Lecrín.

By multiplying the average €/m^2 calculated for each municipality and extracting the total value of the urban real estate stock in the Valle de Lecrín from the information in Tables 3 to 6, the total derived value is estimated at 1,128.98 millions of euros for the single occupancy urban housing stock in the Lecrín Valley, with an average valuation per property of €82,751.82. The highest valuation of the real estate stock of the Lecrín Valley corresponds to the municipalities with the highest density of housing and, therefore, of population. Therefore, Padul and Dúrcal represent 55.3% of the valuation of the valley, bringing together 62.8% of the total real estate stock.

The case of the Lecrín valley is of special interest due to its environmental beauty when compared to residential zones with real estate values directly related to other different variables that affect the decision to buy a property such as closeness to a focus of economic concentration, such as a city with adjacent industries and services. That is, the economic impact in property value by nearby HVPL pylons would be eclipsed by many other variables that affect the decision to locate a home near a large city (proximity to work, employment opportunities, family, etc.). On the other hand, the impact HVPL

pylons and layout for environments of high ecological value in which municipalities coexist with economic structures dependent on the value of this environment, would be devastating. The economic structure of the Lecrín Valley is extremely vulnerable not only to an attack on its visual beauty due to an HVPL project, but also to any other type of alteration in its natural and landscape environment, such as, for example, the installation of an electrical substation or open pit mining.

The link between natural beauty and real estate value is sustained by two main factors:

- Investment in restored housing: Real estate price per square-metre of towns such as El Valle or Albuñuelas, with very few services and scarce population, cannot be explained without taking into account the factor of investment in restored housing, especially by foreigners who invest to foresee spending their retirement in the valley plus the 'neo-rural' families that decide to change their life style settling in places with a high natural and landscape added value, and who setup small businesses related to the services and agrarian sectors.
- The growth in rural tourism: The growth in the last five years of the tourism sector in the Valle de Lecrín has been vigorous (40% in the four-year period 2014–2018 according to INE data). This growth has led to investment in rural houses and businesses dependent on the tourism sector (hotels, restaurants, handicrafts, etc.), creating an entire economic ecosystem supported by the inherent potential of the valley, the beauty of the natural environment. Rural tourists seek first and foremost the disconnection of their daily responsibilities through recreational outdoor activities such as hiking, mountaineering and other sports. They also visit monuments of the cultural and artistic heritage of the surroundings and consume products of local gastronomy and crafts.

Hence, the decision to choose your holiday place in the Lecrín Valley is based on the enjoyment of the beauty of the natural environment. A HVPL installation impacting on that asset would alter such decision, so potential tourist would seek alternative accommodation options elsewhere. Logically this would cause a decline in revenue in businesses that depend on this sector, leading to the bankruptcy of many of them, unemployment and the depopulation of the area.

In addition, the existence of HVPL pylons in the vicinity would foster the decrease in the value of the property, so the retirees and neo-rural groups would stop investing and/or selling their properties already acquired as soon as possible to avoid the consequent depreciation of the value of their investment. The decision of housing location for domestic use would be altered by the visual impact of the towers. These groups would stop consuming and producing products and services in the valley, which would force various businesses to close, thus promoting depopulation, unemployment and the degeneration of the urban and natural heritage of the area.

In this way, in order to measure the economic impact of HVPL pylons construction on the urban heritage of the Valle de Lecrín, we have applied two methodologies:

- Comparative method with similar towns with no similar landscape beauty: We selected an equidistant municipality of Granada with the Valle de Lecrín (approximately 20–30 kms), with a level of public equipment and services similar to that of even greater within the region. The selected municipality is 'Pinos Puente', located in the north-western part of the plain of Granada. The beauty of this Granada

municipality, being away from the main mountain ranges characteristic of the Valle de Lecrín and being located in a plain or 'Vega', is scarce or null (we base this statement on the highest valuation, by tourists of beautiful natural surroundings as those close to or located near geographical features such as mountain ranges or valleys, with high components of natural elements, such as rivers, forests, etc.). We extracted information on the number of homes as well as data related to the real estate market as shown in Table 7.

Table 7 Impact on real estate value of HVPL compared to a town at the same distance of the capital city

Town	*€/sq.m*	*Households*	*Average house price*	*% devaluation*	*Real estate valuation (Valle De Lecrín only)*	*Economic impact on natural beauty*
Pinos Puente	501.49	6,183.00	53.50	-	-	-
Durcal	524.20	3,610.00	61.79	13%	223.06	29.92
Padul	703.77	4,958.00	80.88	34%	400.98	135.73
Villamena	676.27	636.00	86.11	38%	54.76	20.74
Niguelas	724.67	801.00	92.39	42%	74.01	31.15
Lecrín	809.62	1,434.00	99.21	46%	142.27	65.55
El Pinar	830.77	753.00	104.66	49%	78.81	38.53
El valle	908.05	708.00	106.47	50%	75.38	37.50
Albuñuelas	862.55	748.00	106.56	50%	79.71	39.69
Total valuation					*1,128.98*	

Source: Own processing and INE

- Comparative method in with previous research: According to an average of 34.75% devaluation according to Sims and Dent (2005) and Sims et al. (2009), Table 8 depicts the impact of devaluation calculated as 392.32 million euros.

Table 8 Economics impact with a 34.75% devaluation of real estate value

Town	*€/sq.m*	*Households*	*Average house price*	*% devaluation*	*Real estate valuation (Valle De Lecrín only)*	*Economic impact on natural beauty*
Durcal	524.20	3,610.00	61.79	34.75%	223.06	77.51
Padul	703.77	4,958.00	80.88	34.75%	400.98	139.34
Villamena	676.27	636.00	86.11	34.75%	54.76	19.03
Niguelas	724.67	801.00	92.39	34.75%	74.01	25.72
Lecrín	809.62	1,434.00	99.21	34.75%	142.27	49.44
El Pinar	830.77	753.00	104.66	34.75%	78.81	27.39
El valle	908.05	708.00	106.47	34.75%	75.38	26.19
Albuñuelas	862.55	748.00	106.56	34.75%	79.71	27.70
Total valuation					*1,128.98*	
Economic impact on house value HVPL project						*392.32*

6 Discussion and conclusions

This study pioneers the analysis of the valuation of real estate assets in areas of high landscape value and with a high economic component in the rural tourism sector in Spain. The artificialisation of the natural landscape involves in this case a reduction of very serious consequences that threatens the base of the subsistence and of the demography of the different populations of the Lecrín Valley. The consequences of the HVPL project for the economies is incalculable in economic terms as it is a question of sacrificing a regional economy for the sake of a progress that contributes little to the area.

The present analysis serves as a point of reference for the calculation of the corresponding compensations that, in its case, would derive from the alteration of the natural and landscape environment of the Valley of Lecrín, given its vulnerability to projects of these characteristics in economic structures dependent on the landscape beauty as the engine of development and growth. In fact, according to the results presented in the previous tables a total impact value of 392.32 million euros in real estate depreciation was found. Considering the 22,440 inhabitants, it involves a loss of near 17,500 euros per capita in a region with one of the lowest GDP of the European Union according to Eurostat.

That is why, even fulfilling the objectives of transporting electricity through the Spanish territory in order to create an infrastructure of great strategic value, the rupture of the regional balance generating precariousness for these zones and loss of wealth needs to be taken in account before accomplishing such a strategic decision. In addition, loss of wealth involves not only economic but patrimonial wealth for the whole of the region, province, autonomous community, state and European Union as well as the destruction of the bases that generate prosperity in an area that in decades former suffered the syndrome of emigration and economic precariousness.

This study can serve as a basis for calculation of public costs in infrastructure projects in which rural population are deprived of maintaining their wealth due to opportunity costs directly applied to them. Also, this type of population is highly vulnerable as the resources for adaptation to new circumstances are scarce so the impact on individuals forces them to migrate mostly to urban environments enlarging the problem of empty rural zones. These conclusions are aligned with those of Cotton and Devine-Wright (2012) regarding the analysis of public mistrust of infrastructure commissions. This opens new research opportunities in this topic.

This study has focused HVPL impact on real estate value. However, further studies can be developed regarding the impact on other economic activities. As mentioned in the study, the cost of opportunity for tourism is very significant as concluded by the literature. As future lines of research, this study could be replicated for different economic activities as well as for other affected areas. Additionally, the implementation of other infrastructures or even natural disasters can be object of analysis. Also, the application of advanced valuation methods based among others, on neural networks or the application of adaptive neuro-fuzzy inference system (ANFIS) models could help to quantify impacts according to the characteristics of the territory. The main limitations of this study are based on the fact that all conclusions are based on a single case study in a specific area. Impacts on environmental beauty could differ in regions with diverse characteristics which have not been isolated in this study.

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Notes

1 All details about this activist movement are available at http://dinoalastorres.org/es/.