Carlos L. Marcos *Editor*

Graphic Imprints

The Influence of Representation and Ideation Tools in Architecture

Springer

Editor
Carlos L. Marcos
University of Alicante
San Vicente del Raspeig, Alicante
Spain

ISBN 978-3-319-93748-9 ISBN 978-3-319-93749-6 (eBook)
https://doi.org/10.1007/978-3-319-93749-6

Library of Congress Control Number: 2018944358

Printed on acid-free paper

This Springer imprint is published by the registered company Springer International Publishing AG part of Springer Nature
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

A New App to Assess the Visual Impact of Buildings in Historical City Centers Called LandArch

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Abstract. We wanted to assess the opinion of citizens on proposed architectural solutions to integrate a set of buildings with a visual impact located in the historical centre of Valencia. Five scenarios were prepared, one of which being the current situation, using spherical photographic panoramas. To prepare the scenarios, a preliminary historiographic study was carried out. Each observer was asked to order the scenarios in order of personal preference and visual integration, using traditional printed images, in addition to a new purpose-built App called "LandArch: Visual Impact Evaluation", available for free from Google Play. This App allows users to dynamically observe spherical panoramas on the screen of any personal device using 3d glasses. Following the preference and integration assessment of the 5 scenarios, we observe significant differences in the results according to the visualization device used, twice for preference and twice for integration. It seems that the traditional printed image facilitates the recognition of height relationships between buildings and can better resemble the historic imaginary. Conversely, dynamic spherical visualization devices predispose observers to give more positive assessments to risky architectural solutions that use reflections and mirror images for example.

Keywords: Landscape · Integration · Architecture · Colour
Visual assessment

1 Assessment of Visual Integration in an Urban Landscape

From a purely visual perspective, the assessment of landscape quality in a particular setting can only be carried out if we can identify the subjective variables that contribute to the perception of the observers. Said participation has considerably improved, from a legislative perspective in recent years and citizens are now much more active stakeholders in urban decision-making process. Nevertheless, consideration must be given to the media being used when people give their opinion on the proposed project that is still in its development stage. Regulations state that "to identify and assess the effects of an action on the landscape, the visual analysis must be completed using visual modelling and simulation that are proportional to the scale of said action, and that allow you to monitor performance, comparing scenarios, backdrops and perspectives, beforehand

C. L. Marcos (ed.), Graphic Imprints,
https://doi.org/10.1007/978-3-319-93749-6_115

and afterwards, and with or without landscape integration measures, such as computer graphics, photocompositions, segments, drawings etc. so that it can be easily understood by a non-specialised public" (LOTUP 2014, An II).

In the historic centres of many cities in the Valencia region, some buildings have been categorised as Assets of Cultural Interest (BICs for its acronym in Spanish) for their special architectural importance. In the immediate are of the BICs, regulations set out a protective environment and this governs permitted urban landscaping, so as to preserve the cultural and visual values of the monument. Often in these environments, we encounter very poor architectural designs, incompatible with the BICs and which the regulations indicate as having a visual impact because "they significantly differ and contrast with the surrounding environment and reduce the visual worth, due to their size, volume, composition, type, texture, colour, shape etc."

The measures set out to adapt the building may vary from surface dressing a visible dividing wall, for example, to replacing the building that is excessively tall or inadequately aligned.

The fact is that replacing a building is scarcely ever carried out and is socially controversial (Fig. 1).

Fig. 1. Orthophoto of some of the facades along *Calle Blanquerías* in Valencia indicating the heights to be respected. Buildings with construction work that exceeds said heights are considered, by the regulation, to have a visual impact

We believe that surface dressing might improve the integration into the urban landscape of buildings with a visual impact until such times as they can be replaced, if in fact they ever are. Accordingly, as part of this research project, we have put forward architectural interventions on the facades to either improve "landscape integration" or "the visual quality of the landscape", as we understand that a mimetic intervention is not necessarily the most suitable one.

Three visualization display devices were used to collect the opinions of the observers: (1) printed panels in a panoramic format (1.189 × 420 mm) and the new *LandArch* application, which allows you to observe the object, which is the subject of study, in any direction, (2) or via a spherical image observed on a screen by moving the device in any direction, (3) or with the help of glasses within a three-dimensional immersive space (Fig. 2). The aim of this paper is to point out certain differences found in the use of these observation media.

Fig. 2. An observer using Google Cardboard glasses with the *LandArch App*

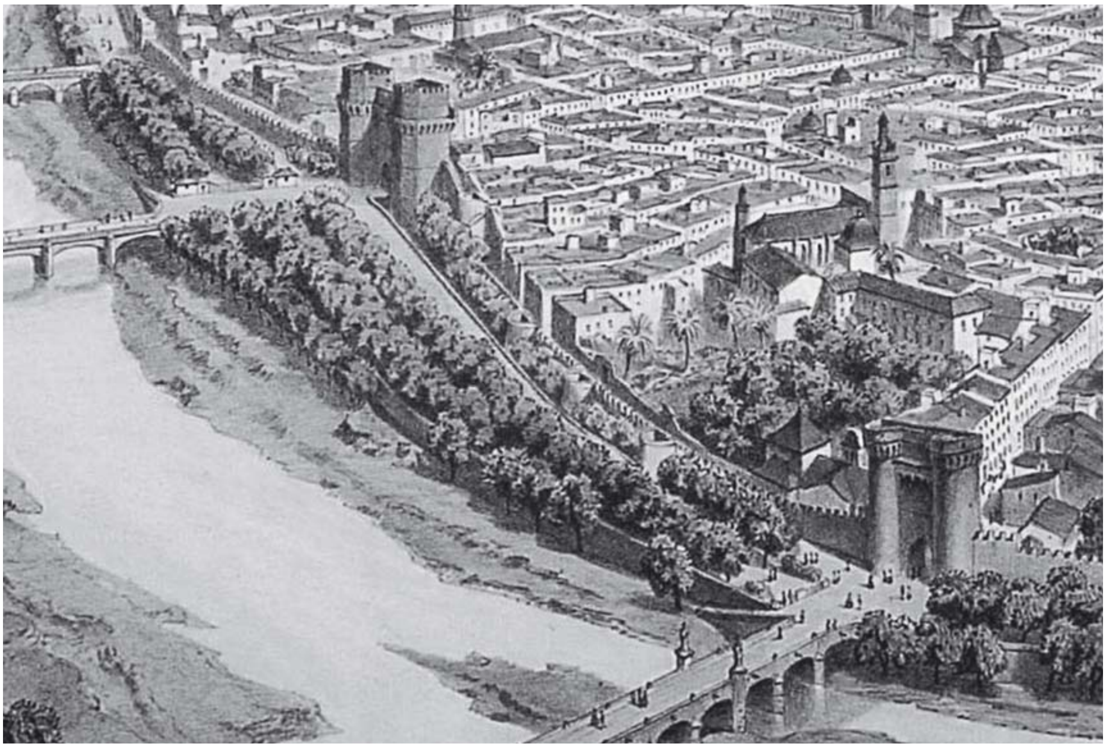

Fig. 3. The Serranos Gate seen from the air (fragment of the original), A. Guesdon, 1853. (In A. Guesdon, *L'Espagne à vol d'oiseau*)

1.1 Research on the Assessment of the Visual Impact on the Landscape

There are few sources of literature that deal with the integration of architectures with a visual impact on the urban landscape and most of the studies refer to the landscape integration of infrastructures and industrial facilities in a natural environment: agricultural industry buildings (García et al. 2003); farms; wind farms (Ladenburg 2009; Tsoutsos et al. 2009; Torres-Sibille et al. 2007; Bishop 1997); solar farms

(Chiambrando et al. 2011); high-tension power lines (Sumper et al. 2010), etc. At a territorial level, there are many studies that use geographic information systems (GIS) to assess the impact on the landscape of future installations (Higgs et al. 2008; Hernández et al. 2001, 2003). Some of these studies include variables such as the population index, the time of observation and the solid angle of observation of an individual (Rodrigues et al. 2010).

1.2 Observation Media Used for the Assessment

In most cases, the assessment of the visual impact is carried out using photomontages or two-dimensional images. In fact, it is a widely documented and accepted in scientific literature (Shafer and Richards 1974; Shuttleworth 1980; Hull and Stewart 1992; Torres-Sibille et al. 2009).

Nevertheless, new technology enables us to go beyond simple two-dimensional images, to immersive reality simulations, which are closer to reality. A methodological enhancement that we wanted to explore, by developing a free application called "LandArch: evaluation of the visual impact of architecture", available for any mobile device from *Google Play*, and which enables you to easily collect the opinions, on a massive scale, of citizens, increasing as such both the scope and dissemination of the work. Using a simple WiFi connection and *Google Cardboard* glasses, any citizen can visualize the photographic panoramas looking in any direction, in an immersive 360° space. A little audio, the ability to interact with the observer and the presence of animated objects, heighten the sense of realism (Fig. 3).

2 Equipment and Method

To develop the App, our case study consisted of buildings in Valencia that did not meet the Torres de Serranos Special Protection Plan *building regulations*, specifically the ones in Calle Blanquerías. These buildings are excessively tall and exceed the 5-floor limit (Fig. 1).

Superimposed over them were 5 possible scenarios in the form of photomontages, each one, a different architectural solution (Fig. 5). These solutions include one "non-intervention" which respects the current situation (A) (Fig. 4), a new wraparound façade covering the building's entire height (B, C), or an attempt to hide only the excess structure (D), in addition to the building's comprehensive replacement by a new five-floor buildings (E).

Having observed each of the 5 scenarios, users of *LandArch* are automatically asked to complete a short form where they must order the proposals from best to worst based on two criteria: their preference (P) and the *degree of landscape integration* (I).

To elaborate the different architectural solutions, it was essential to consider which of the visual properties of the landscape we wish to preserve or recover. In other words, the physical or human components "that visually characterise a landscape and which can be used for analysis or differentiation" (Escribano et al. 1991).

Fig. 4. Fragment of the spherical panorama of the present-day Calle Blanquerías next to the Torres de Serranos, 2016

In the case of Calle Blanquerías, to identify which physical components to preserve or recover, we first had to carry out a preliminary historiographic study to help to identify the iconic image of Valencia, as a compact city as idealized in the imaginary prior to the 19th century, countered by the reality of a dispersed and heterogeneous city, both with a greater architectural quality, which began with the pulling down of the city walls in the second half of the 20th century.

2.1 Historiographic Analysis of the Historical Heritage that Surrounds the Torres de Serranos in Valencia

Calle Blanquerías in Valencia, traces the line of the road that skirted the Cristian wall of the city since 1356, when King Peter the Cermonious commissioned it to be built, expanding the boundaries of the Muslim city, until it was demolished in 1865. It constituted the north face of the city, next to the river and was the perspective of choice for all of the conserved graphic documents from the 16th century through to the end of the 19th century.

The first significant graphic document that can be used to view the appearance of this street belongs to Dutch traveller and sketch artist Wijngaerde in 1563. In it, you can make out the Torres de Serranos with the city wall extending to the *Portal Nou*. Between both access points were a total of seven smaller towers which were also to appear in later drawing by Manceli in 1608 and Father Tosca in 1704 and 1738.

As pointed out by several authors (Llopis Alonso and Perdigón 2016), these drawings portray a small and compact city, with the ever-present river and city wall, and behind them, the notable profiles of the churches and significant civic buildings. A city sketched from the perspective of its enormity and fortitude, an idea which is heightened through the perspective of “bird’s eye views” creating an image that strongly embeds itself in the memory allowing individual citizens to reconstruct their own history: Valencia, clearly defined and easily distinguishable from the vast expanse of farmland surrounding it.

This stonework on this stretch of the city wall was restored in about 1400 and like the adjoining stretch between *Portal Nou* and the Santa Catalina Tower, was one of only two to feature small towers. Although the remaining ones gradually disappeared as the road that skirted the city was widened, those of the present-day Calle Blanquerías continued through until the definitive demolition of the wall in the 19th century.

One feature of the north-west aerial view of the city by Guesdon in 1855 is the urban use of space between the city wall and the river (Fig. 3). Clearly seen is the romantic Isabel II boulevard, which runs at a tangent to the ditch and which is flanked by a garden that extends down to the edge of the river, creating what was popularly known as the "alameditas de Serranos" or Serranos promenades. Trees also appear in the ditch of the city wall, which would indicate that it was no longer used for defensive or sanitation purposes. The ditch appears to be different lengths in each of the graphic documents, with Manceli depicting it stretching to the Portal Nou, Tosca showing it stopping prior to the 6th tower or after the 7th, while it cannot be clearly distinguished in Guesdon because of the heavy vegetation. You also see how the wall increases in height as it approaches the city gates, quite standard at this highly vulnerable point of access, to impede entry, reaching the middle cornice of the Serranos towers.

As of 1950 and with the tearing down of the city walls that the "new photographs (objective testimonials, without any retouching), break away from the notion of harmony of earlier depictions and reveal how references to the ancient city tend to disappear, and announce the need to appreciate Valencia as a disperse urban phenomenon." (Llopis Alonso and Perdigón 2016). Undoubtedly the present-day image of Calle Blanquerías reflects this disperse and poorly controlled urban phenomenon, with a proliferation of buildings with different aesthetical properties, breaking away from a certain concept of unity as it appears in the earlier drawings.

2.2 Panoramas Used for the Visual Assessment

For our project, we used panoramic photography, with a 360° horizontal field of vision and a vertical one of 180°. This allows you to assess how the building integrates with its entire surroundings, and not in a preconfigured frame. The equipment used was a Canon 7D camera, with a Sigma 8–16 fish eye lens set at its minimum focal distance, which enabled us to achieve a spherical panorama using just 13 photos. To avoid parallax errors between the shots, a tripod with a Manfrotto 303 SPH panoramic head was used. Shooting was taken in RAW format to optimise the quality of the images, which also enabled us to adjust the white balance of shots during processing so that all shots share the same settings. Exposure was also blocked during the shots to avoid having light differences and an F8 aperture was used by way of a compromise between having an adequate depth of field and the loss of overall sharpness and clarity due to the diffraction, which intensifies the more the aperture is closed.

The panoramic montage was achieved using Hugin, a freely distributed panorama photo "stitcher", resulting in an equirectangular image that can be visualized in an immersive virtual reality environment (CAVE, Oculus Rift, etc.), so that the spectator has the sensation of being within the photographed scenario itself. The spherical panorama glasses currently on the market create a virtual sphere around which the equirectangular image is mapped with the observer in the epicentre. Of the 3D glasses and devices currently available on the market, for its simplicity and affordability we chose the visor developed by Google (*Google Cardboard Project*), which uses a Smartphone for the screen.

As already mentioned, assessment of the scenarios was carried out using three visualization devices: panoramic printed panels (1.189 $\times$ 420 mm) and the *LandArch* App, and with the help of a 3D Google Cardboard personal visor, like observing the panoramic image on the screen, suitably guided as each user moves their device (tablet, mobile) thanks to the internal position tracker.

3 Comparison Between the LandArch App and Traditional Display Media

The sample size of individuals who responded to the questionnaire was 206, of which 47 (22.8%) viewed the scenarios on printed panels (*Im. Printed*), 109 (53%) on an adjustable 360° screen (*Im. Navigable*) and 50 (24.2%) using immersive glasses (Immersive Glasses).

Each observer was asked to rank the five scenarios (A, B, C, D and E) in order of preference (P) and degree of landscape integration (I), giving as such a value of between 1 ("the worst") and 5 ("the best") for PA, PB, PC, PD, PE, IA, IB, IC, ID and IE. A preliminary analysis was carried out to determine the overall score for each scenario on each of the devices (Table 1).

The preliminary exploratory analysis was completed using analysis of variance (ANOVA) to identify any significant differences in the scores for each scenario according to the visualization device being used. Significant differences are observed (value of less than 0.05) for responses to PD, PE, IB and ID (Table 2).

If we carry out a means analysis of the responses whose differences were significant (PD, PE, IB and ID) according to the observation device, the following is observed (Table 3).

Scenario D contains a new façade envelope to minimize over-construction (Fig. 5). The solution employs a curtain wall with mirrors that reflect the sky and hide the building above the permitted height of the building regulations. In general, D is the second less popular scenario (PD = 2.56) and with less landscape integration (ID = 2.50) followed exclusively by scenario A, which represents its current appearance (PA = 2.50; IA = 2.36). Nevertheless. it would appear that the scores for scenario D significantly improve when an electronic display device is used (PD = 2.82; 2.85. ID = 2.81; 2.74) compared to the traditional printed image (PD = 1.55; ID = 1.55). As the proposed solution consists of a curtain wall with mirrors to reflect the sky, it could be supposed that this proposed solution is easier to understand. and therefore, higher scoring. when viewed using a navigable image, rather than a static one.

Scenario E consists of replacing buildings that exceed height regulations for ones that respect the traditional rooftop levels, in other words, the approach contained in current legislation (Fig. 5). There is a clear preference for this scenario using a two-dimensional printed image (PE = 3.85), compared to the use of immersive glasses (PE = 3.30) and even more so when compared to a navigable image (PE = 2.94). In fact. preference for image E falls from first to third position when the image moves from a printed to a navigable format. It could be said that the sense of order, with all the

Table 1. Table containing the mean and the standard deviation [1.5] for the scores for *Preference* (P) and *Integration* (I) for each of the five scenarios (A, B, C, D, E) on the three visualization devices (*Im. Printed, Im. Navigable and Immersive Glasses*)

		N	Average	Standard deviation
PA	Im. printed	47	2.74	1.170
	Im. navigable	109	2.56	1.371
	Immersive glasses	50	2.16	1.201
	Total	206	2.50	1.298
PB	Im. printed	47	3.19	1.173
	Im. navigable	109	2.99	1.295
	Immersive glasses	50	3.44	1.163
	Total	206	3.15	1.245
PC	Im. printed	47	3.66	1.048
	Im. navigable	109	3.62	1.153
	Immersive glasses	50	3.28	1.443
	Total	206	3.55	1.212
PD	Im. printed	47	1.55	0.951
	Im. navigable	109	2.88	1.425
	Immersive glasses	50	2.82	1.410
	Total	206	2.56	1.433
PE	Im. printed	47	3.85	1.429
	Im. navigable	109	2.94	1.603
	Immersive glasses	50	3.30	1.488
	Total	206	3.24	1.573
IA	Im. printed	47	2.66	1.185
	Im. navigable	109	2.38	1.311
	Immersive glasses	50	2.06	1.252
	Total	206	2.36	1.280
IB	Im. printed	47	3.49	1.159
	Im. navigable	109	2.96	1.209
	Immersive glasses	50	3.20	1.178
	Total	206	3.14	1.203
IC	Im. printed	47	3.38	0.945
	Im. navigable	109	3.03	1.190
	Immersive glasses	50	2.98	1.286
	Total	206	3.10	1.169
ID	Im. printed	47	1.55	0.904
	Im. navigable	109	2.81	1.378
	Immersive glasses	50	2.74	1.139
	Total	206	2.50	1.328
IE	Im. printed	47	3.91	1.501
	Im. navigable	109	3.83	1.574
	Immersive glasses	50	4.02	1.491
	Total	206	3.89	1.533

Table 2. ANOVA for the scores for *Preference* (*P*) and *Integration* (*I*) for each of the 5 scenarios (*A, B, C, D, E*) with the three visualization devices (*Im. Printed, Im. Navigable and Immersive Glasses*)

		Sum of squares	gl	RMS	F	Sig.
PA	Inter-groups	8.977	2	4.488	2.707	0.069
	Intra-groups	336.519	203	1.658		
	Total	345.495	205			
PB	Inter-groups	7.044	2	3.522	2.302	0.103
	Intra-groups	310.587	203	1.530		
	Total	317.631	205			
PC	Inter-groups	4.803	2	2.402	1.646	0.195
	Intra-groups	296.211	203	1.459		
	Total	301.015	205			
PD	Inter-groups	62.233	2	31.117	17.622	0.000
	Intra-groups	358.447	203	1.766		
	Total	420.680	205			
PE	Inter-groups	27.217	2	13.609	5.754	0.004
	Intra-groups	480.127	203	2.365		
	Total	507.345	205			
IA	Inter-groups	8.743	2	4.372	2.714	0.069
	Intra-groups	326.951	203	1.611		
	Total	335.694	205			
IB	Inter-groups	9.320	2	4.660	3.289	0.039
	Intra-groups	287.598	203	1.417		
	Total	296.917	205			
IC	Inter-groups	5.054	2	2.527	1.866	0.157
	Intra-groups	275.004	203	1.355		
	Total	280.058	205			
ID	Inter-groups	55.304	2	27.652	18.333	0.000
	Intra-groups	306.191	203	1.508		
	Total	361.495	205			
IE	Inter-groups	1.323	2	0.661	0.280	0.756
	Intra-groups	480.328	203	2.366		
	Total	481.650	205			

rooftops perfectly aligned in a two-dimensional static image is more obvious than in a dynamic image, where the relationships of height between the buildings are not as easy to assess. Perhaps this fact leads to higher scoring for the printed image when it comes to aligning the heights.

Table 3. Mean value and standard deviation for the scores for *Preference* (*P*) and *Integration* (*I*) for each of the scenarios (*B, D and E*) where the visualization devices (*Im. Printed. Im. Navigable and Immersive Glasses*) were significant

		PD	PE	IB	ID
Im. Impresa	Mean	1.55	3.85	3.49	1.55
	N	47	47	47	47
	SD	0.951	1.429	1.159	0.904
Im. navigable	Mean	2.88	2.94	2.96	2.81
	N	109	109	109	109
	SD	1.425	1.603	1.209	1.378
Immersive glasses	Mean	2.82	3.30	3.20	2.74
	N	50	50	50	50
	SD	1.410	1.488	1.178	1.139
Total	Mean	2.56	3.24	3.14	2.50
	N	206	206	206	206
	SD	1.433	1.573	1.203	1.328

Fig. 5. Fragments of the spherical panoramas for scenarios B, C, D and E

Scenario B assumes that the entire height of the building has a visual impact and consequently proposes a new continuous façade envelope and with a material which is somehow reminiscent of the former city wall and towers (Fig. 5). The solution gets its inspiration from a design by architect Alejandro Zaera Polo, which adapts itself to the atmosphere of Valencia by using pieces of ceramic. Here the building does not aim to “disappear” but rather it wants to “improve the visual value of the landscape”. On the whole. it gets the second-best landscape integration score, after scenario E. It is interesting to highlight how a solution that clearly acquiesces to the excessive building work can be considered a better alternative than replacing the buildings.

As far as the visualization devices are concerned. scenario B is considered a much better integrated approach when observed using the printed image (IB = 3.49) compared to the use of immersive glasses (IB = 3.20) and even more so when compared to a navigable image (IB = 2.96). It is difficult to explain this result. Perhaps simultaneously observing a long length of canvas containing the facades from Calle Blanquerías in the printed image, it is closer to the iconic and slightly idealised image of the city wall from the early representations. Conversely, with dynamic observation, using a navigable image or immersive glasses, the aperture of the field of vision is less, and although a more accurate reflection of reality, it is more difficult to read the façade-covered canvas when it appears as a continuous, two-dimensional image, like a wall.

4 Conclusions

We wanted to gauge the opinion of citizens about potential architectural solutions for the integration, from a landscape perspective, of a series of buildings with a visual impact in the historic centre of Valencia. With this in mind, five scenarios were created in the form of immersive spherical panoramas, ranging from the present-day appearance to the replacement of the buildings. To put together the proposed solutions, a preliminary historiographic study was first carried out. Each observer was asked to rank the five scenarios according to their preferences and the degree of integration. These scenarios were visualised using three devices: a printed panorama, a 360° image, navigable in all directions, and immersive reality glasses.

Taking into consideration the preference and visual integration scores of the 5 scenarios, we observed significant differences between the visualisation devices—twice for *Preference* (PD, PE) and twice for *Integration* (IB, ID). It would seem that in the case of the traditional static image, by covering a broad field of vision, it makes it easier to recognise the height relationships between some buildings and the adjoining ones. Similarly, it better resembles the historic representation that survives within the collective ideals, making it easier as such to examine Calle Blanquerías as a two-dimensional continuum, like a wall. Furthermore, the dynamic and immersive display devices that best resemble reality, allow one to better assess aspects such as reflections and specular images, and perhaps to a certain extent, predisposes observers to give a better score to riskier architectural solutions than when considering the same solution in a traditional static image.

References

Bishop ID (1997) Testing perceived landscape colour difference using the Internet. Landscape Urban Plan 37:187–196

Chiambrando R, Fabrizio E, Garnero G (2011) On the applicability of the visual impact assessment OAISPP tool to photovoltaic plants. Renew Sustain Energy Rev 15(1):845–850

Escribano MM, De Frutos M, Iglesias E, Mataix E, Torrecilla I (1991) El Paisaje. Unidades temáticas ambientales. MOPT, Secretaría de Estado para las Políticas del Agua y Medio Ambiente

García L, Hernández J, Ayuga F (2003) Analysis of the exterior colour of agroindustrial buildings: a computer aided approach to landscape integration. J Environ Manage 69(1):93–104

Hernández J, García L, Ayuga F, García J (2001) Las construcciones agrarias y su integración en el paisaje: estudio de localización mediante sistemas de información geográfica. Ingeniería Civil 122:127–136

Hernández J, García L, Ayuga F (2003) Assessment of the visual impact made on the landscape by new buildings: a methodology for site selection. Landscape Urban Plan 68(1):15–28

Higgs G, Berry R, Kidner D, Langford M (2008) Using IT approaches to promote public participation in renewable energy planning: prospects and challenges. Land Use Policy 25:596–607

Hull RB, Stewart WP (1992) Validity of photo-based scenic beauty judgments. J Environ Psychol 12:101–114

Ladenburg J (2009) Visual impact assessment of offshore wind farms and prior experience. Appl Energy 86:380–387

Llopis Alonso A, Perdigón L (2016) Cartografia histórica de la ciudad de Valencia : (1608–1944). Publicaciones UPV, Universitat Politècnica de València. Ed. Valencia

LOTUP (2014) Ley 5/2014. de 25 de julio. de la Generalitat. de Ordenación del Territorio. Urbanismo y Paisaje. de la Comunitat Valenciana. DOC. núm. 7329 de 31 de Julio de 2014 y BOE núm. 231 de 23 de Septiembre de 2014. Anexo II

Rodrigues M, Montañés C, Fueyo N (2010) A method for the assessment of the visual impact caused by the large-scale deployment of renewable-energy facilities. Environ Impact Assess Rev 30(4):240–243

Shafer E Jr, Richards TA (1974) A comparison of viewer reactions to outdoor scenes and photographs of those scenes. USDA Forest Service Research Paper NE-302. Upper Darby. Northeastern Forest Experiment Station, Pennsylvania

Shuttleworth S (1980) The use of photographs as an environment presentation medium in landscape studies. J Environ Manage 11:61–76

Sumper A, Boix-Aragon O, Villafá fila-Robles R, Bergas-Jane J, Ramírez-Pisco R (2010) Methodology for the assessment of the impact of existing high voltage lines in urban areas. Energy Policy

Torres-Sibille A, Cloquell-Ballester VA, Darton R (2007) Development and validation of a multicriteria indicator for the assessment of objective aesthetic impact of wind turbines. Renew Sustain Energy Rev 13:40–66

Torres-Sibille A, Cloquell-Ballester VA, Artacho MA (2009) Aesthetic impact assessment of solar power plants: an objective and a subjective approach. Renew Sustain Energy Rev 13:986–999

Tsoutsos T, Tsouchlaraki A, Tsiropoulos M, Serpetsidakis M (2009) Visual impact evaluation of a wind park in a Greek island. Appl Energy 86:546–553

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