

THE URBAN HERITAGE CHARACTERIZATION USING 3D GEOGRAPHIC INFORMATION SYSTEMS. THE SYSTEM OF MEDIUM-SIZED CITIES IN ANDALUSIA

D. Navas-Carrillo^{1*}, B. Del Espino Hidalgo¹, F.J. Navarro-de Pablos¹, M. T. Pérez Cano¹

¹ University of Seville, Higher Technical School of Architecture. Research Group “Heritage and Urban Territorial Development in Andalusia” (HUM-700), 41012 Seville, Spain - dnavas@us.es, bdelespino@us.es, fnavarro@us.es, tpcano@us.es

KEY WORDS: Cultural Heritage, Intermediate Cities, Urban and Territorial Studies, Urban Parameters, 3D GIS, Urban Heritage

ABSTRACT:

The primary objective of this paper is to approach the use of the 3D Geographic Information Systems (3D GIS), as an instrumental tool that allows us to deal efficiently with the extensive amount of information that characterises a large part of the research carried out in the field of Urbanism and Regional Planning. Specifically, the study focuses on medium-sized cities in Andalusia, the most populous and the second largest region in Spain. The Andalusian urban system is substantially characterised by the historical importance of this type of cities within its territorial organisation, which dates back to more than two thousand years, and whose potential as sustainable and balanced stands out. In particular, it is intended to address features related to urban characterisation as medium-sized cities that have been declared as heritage sites, as well as, the integration of the cultural heritage into urban development planning as an active strategy by the cultural administration of the regional and local governments. In detail, this paper will analyse data relating to the development experienced, their characterisation through urban indicators or the evolution and traceability of their protection. In this sense, the use of 3D GIS will not only allow the efficient recording and the graphical representation of a significant amount of data resulting from the quantitative and qualitative analysis carried out but also model them using the third dimension to facilitate a cross analysis among the cities under study. Definitely, the aim is to demonstrate the suitability use of this technology in this type of scientific research.

1. INTRODUCTION

1.1 Objectives and methodology: the use of 3D GIS within urban and territorial heritage studies

In the last two decades, the use of Geographic Information Systems has expanded in the field of heritage research. (Yogapriya and Senthamil Kumar, 2018). It was not only formed as an interdisciplinary field of research (Bushmakina et al., 2017), but it is also being used for the development of important heritage management programs around the world. (Spiridon et al., 2016). 2D GIS-technology is a fundamental tool for storing and managing the vast amount of information that needs to be analysed in heritage studies (Kaimaris et al., 2011). On the other hand, these systems have become consolidated as a means of graphic representation (Nuñez and Pozuelo, 2009), that moving towards 3D models not only allows to create volumetric objects but it also to enable more complex analyses, visualisation and documentation (Dore and Murphy, 2012). They facilitate and accelerate access to the information (Yakar and Doğan, 2018), helping heritage professionals taking quick and accurate decisions about protection or conservation issues (Gonçalves et al., 2016).

It is important to point out that the possibility of 3D systematisation of the information has facilitated its widespread use in the restoration of cultural assets. (Campanaro et al., 2016:32; Wüst et al., 2004). However, cross-analysis of the data also facilitates the study of cities and territories as a whole, going beyond the simple analysis of architectural objects. Therefore, thanks to the possibility of establishing spatial relationships between the data, it is also possible to approach studies from an urban (Gröger and Plümer, 2012), territorial (Nieto Masot and García Paredes, 2016) or landscape perspective (Marcos Sáiz,

2010). This type of studies involves the identification and registration of a heritage dispersed throughout the territory through the construction of inventories (Li and Song, 2009). However, there are several authors who argue that the heritage approach to this other scale also necessarily requires the use of 3D GIS, as it allows us to understand the geometric and topographical relations with the territory where these cultural assets are located, their shape, components and texture (Marques et al., 2017).

This technology is also used in urban studies that relate present and past reality from the study of historical cartography (Lundberg and Peterson, 2005; Lelo, 2014). For example, it can help to analyse and interpret the past (Dell’Unto, 2016) through the changes produced in the urban fabric, identifying those pre-existing in each of the stages that make up the historical stratigraphy of a given city (Gata et al., 2017: 71). In addition to the on-site recognition, the photographic record and the cadastral planimetry collection, urban-heritage studies involve the compilation and analysis of existing urbanistic information, as well as the current urban planning, with particular emphasis on heritage protection catalogues (Pérez-Cano et al., 2017).

3D GIS allows us to record and analyse cultural heritages in continuous spatial scales (Hea, Liub, Xub, Wub, Zhang, 2015). In this sense, they can also be used in visibility and perception analyses (Delikostidis et al., 2013, Fisher-Gewirtzman and Natapov, 2014, Biljecki, et al. 2015). In this sense, they could be helpful to study the degree of visibility from different parts of the city of certain heritage elements. Elements that constitute landmarks of reference for citizens, and as will be analysed later, their conservation is one of the current challenges in the management of the historic urban landscape of our cities.

* Corresponding author

Visibility is also one of the main factors in determining the buffer zone of an Asset of Cultural Interest (Castillo Ruiz, 1997).

According to all these applications, the central objective of this paper is to approach the use of the 3D Geographic Information Systems in the urban heritage characterisation of the system of medium-sized cities in Andalusia (Spain). To this goal, the research seeks to make a multi-scale approach that addresses some of the 3D GIS applications, from the general, the identification of heritage values as a fact linked to territorial support, to the particular, the analysis of the characteristics that define some buildings or public spaces of heritage interest in some of these cities. Besides, we have worked in the study of the historical evolution of these cities from the analysis of historical cartography. We have characterised these cities through a series of urbanistic parameters, with particular emphasis on protection. Finally, visibility aspects, which are crucial to guarantee the conservation of the historical urban environments, have been analysed.

2. STUDY AREA: MEDIUM-SIZED CITIES IN ANDALUSIA

2.1 Urban-territorial Andalusian structure

Andalusia is the southernmost region of Spain and the Iberian Peninsula. It is located at the south-west end of Europe, bordering Portugal and very close to the African continent, from which it is separated by the Gibraltar Strait, which marks the boundary between the Mediterranean Sea and the Atlantic Ocean. Therefore, it is a territory located in a strategic enclave and with a great diversity in its limits, its relations and its landscapes.

Due to this, among other aspects, it has historically been a fundamentally urban territory. This issue is demonstrated by its population structure from the Ancient Age (ICA, 2009) to the present day when the territorial system is made up of a good number of major cities and numerous medium-sized cities (Feria, 2007).

According to the regional land plan, namely POTA -*Plan de Ordenación del Territorio de Andalucía*- (Junta de Andalucía, 2006), the Andalusian urban system is structured into three categories of urban networks: Regional Centres -which generally constitute metropolitan areas-, networks of Medium-Sized Cities - which, in turn, are divided into Coastal Medium-Sized Cities and Inland Medium-Sized Cities - and, finally, Rural Areas, mainly located in mountainous areas.

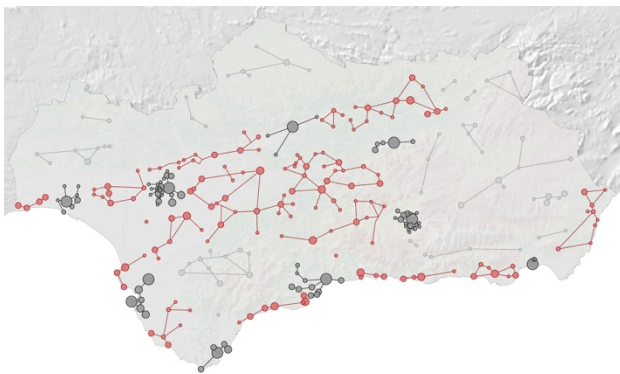


Figure 1. Andalusian Urban System according to POTA (2006). Marked in dark grey, the urban systems formed by Regional Centres, in red those by Medium-Sized Cities and in light grey those by Rural Areas (The authors, 2018)

2.2 Medium-sized cities: a regional-scale heritage

Among the new considerations on the territorial legacy and, more specifically, on the forms of urban organisation in the European territory, the appearance of medium or intermediate cities - considered not only by a numerical categorisation based on their demographic levels but, more often, as a result of their role as intermediaries between rural areas and urban capital- as settlements that deserve a singular place, either for historical reasons of human grouping around strategic points, or as a result of the foundation of new nuclei due to the growth of large cities or particularly dense strips, they acquire a balance that provides values conducive to what is understood as sustainability in the economic, environmental or social spheres.

This validity is evident both in recent international research work - a good example is the UNESCO Chair in Intermediate Cities held between 1997 and 2002 (Bellet Sanfeliu and Llop Torné, 1999) - as well as in official documents governing the guidelines of the European urban system, such as the regional policy *Cities of tomorrow* promoted by the European Commission, which expressly states: *Thriving and dynamic small and medium-sized cities can play an important role in the well-being not only of their own inhabitants but also of the surrounding rural populations. They are essential for avoiding rural depopulation and urban drift and for promoting balanced territorial development* (European Commission, 2011). Medium-sized cities are, therefore, necessary for balanced territorial development.

From the point of view of urban sustainability, its assessment has been justified by the defence of a polycentric territorial model, in which each of its centres is *capable of generating growth and development in its immediate surroundings and of balancing the territory against metropolitan macrocephalies* (Vilagrasa, 2000). In this sense, in recent years, this urban category has aroused particular interest due to the standards of quality of life it presents, as it lacks many of the environmental problems of large cities, as well as in the scale of the town itself, which makes it more humane and accessible. On the other hand, medium-sized municipalities encourage a rational use of resources, guaranteeing access to specialized goods and services under conditions similar to those found in large urban areas (Llop Torné and Hoeflich de Duque, 2007).

Furthermore, the specific case of the medium-sized cities in Andalusia deserves special consideration. As for the territorial organisation provided by POTA, urban systems headed by medium-sized towns structure 60% of the Andalusian regional structure, which places them in the focus of attention from a quantitative and representative point of view. The fact that the clear majority of them have a historical origin is also relevant. Indeed, they have served as intermediate cities (namely they have played a role as secondary territorial centres) for centuries.

The historical relevance of these cities has been shown by historical cartography, both at a national and international scales, such as the case of Joris Hoefnagel (Braun and Hogenberg, 1572). It is also important to consider that the founding cores of many of these cities have been declared as Historic Sites (Navas-Carrillo, 2016). Thus, together they must be regarded as a valuable historical heritage, as they represent the result of the superposition of cultures, ways of life and productive systems that have given rise to landscapes, tangible and intangible assets of unquestionable value both individually and as a set (Díaz Quidiello, 2007).

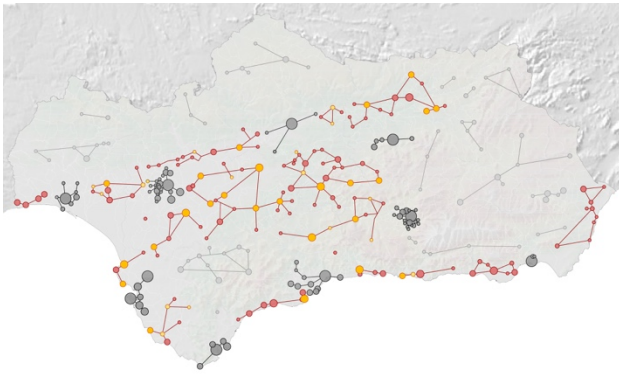


Figure 2. Cities that have been declared as heritage sites (marked in orange) in the urban systems formed by Medium-Sized Cities (The authors, 2018)

3. IDENTIFICATION OF HERITAGE VALUES AS A FACT LINKED TO TERRITORIAL SUPPORT

Once the consideration of historical and cultural heritage as a series of isolated assets has been overcome, generally with associated values closer to the artistic or monumental than to the cultural characterisation of a given society, the territory - and the links of both individual and collective assets to their territorial context - inevitably emerges as one of the bases for the definition of heritage.

3.1 Territorial influence on Andalusian heritage

In the case of Andalusia, this link was strengthened by the enactment in 2007 of the new Law on Andalusia's Historical Heritage, which proposed new measures and forms of protection aimed at considering the territorial as an emerging heritage, and which needed new tools for its conservation and enhancement. In this sense, the creation of the figure of the Heritage Zone as a new category for territorial heritage protection is noteworthy, which defines its territorial component as follows: *the territory articulates an integrated heritage system, in which assets of different nature and chronology coexist, inextricably linked to the existing landscape and environmental values* (Junta de Andalucía, 2007: IV).

The POTA itself, on the other hand, argues that the rich and long history of the Andalusian site has given rise to a varied range of nuances in the forms of land occupation, reflecting the relationship between man and the environment in history. All of this today constitutes a territorial legacy that must be carefully considered, that is to say: both from the point of view of the instrument of management of a larger scale and from the point of view of current legislation on matter, territorial heritage has been given renewed consideration in this case in point, which favours the need for its renewed enhancement and the reformulation of instruments and criteria for its protection.

It is time, then, to deepen our knowledge of the territorial heritage of these Andalusian cities, whose first attempts are based on legislative and planning documents, but also on an academic fabric that is timidly gaining prominence in both national and international publications and events (Rodríguez Martínez and Sánchez Escolano, 2010). Only through the precise and renewed determination of its heritage qualities and from its conception as a unitary territorial entity will it be possible to assess it adequately. We understand that the city is inherent to its landscape and territory, from its conception to its development and especially in the construction of its heritage identity. This

process will naturally lead to the provision of specific instruments for the analysis and protection of a valuable territorial heritage that, latent for centuries, is now emerging as an opportunity for a more sustainable future.

3.2 The study of topography on 3D-GIS and its relationship with the origin of Andalusian medium-sized cities

Out of all the characteristics that can be studied about how a territory conditions human and, consequently, urban settlements, the topography undoubtedly prevails (Llobera, 1996). Relief features conditions other fundamental characteristics in the understanding of the historical functioning of a territory, such as hydrography, the establishment of communication routes, the location of surveillance points and the settlement of communities around these strategic factors for their survival.

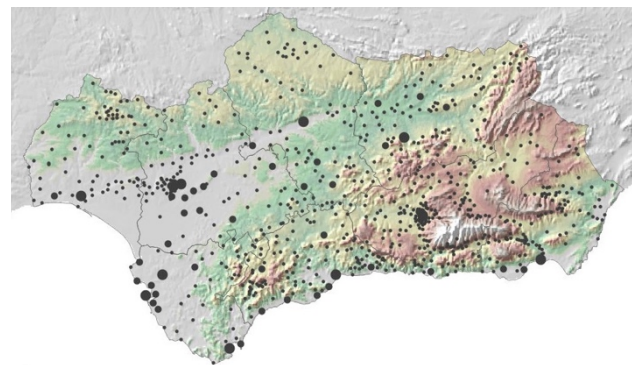


Figure 3. Urban settlements in Andalusia categorised by population ranges (<20.000, 20.000<100.000, >100.000) together with a topography map based on shadows and elevation (The authors, 2018)

Thus, topographic analyses have been elaborated based on GIS geoprocessing of the digital model of the terrain of Andalusia provided by Landsat, the results of which have been contrasted with the model of urban settlements in the region. To this end, three categories of cities have been established according to their population: small towns (less than 20,000 inhabitants), medium-sized municipalities (between 20,000 and 100,000 inhabitants), and large cities (more than 100,000 inhabitants).

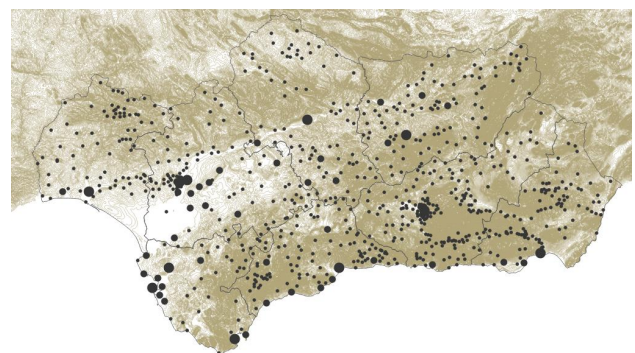


Figure 4. Urban settlements in Andalusia categorised by population ranges (<20.000, 20.000<100.000, >100.000) together with a topography map based on contour lines (The authors, 2018)

Firstly, shadows map has been represented (GDAL *hillshade* geoprocessing from DMT, 30x30m tiles size), and presented together with a coloured range of elevations to a better enhance of the most elevated and rough areas. Secondly, contour lines (GDAL contour lines geoprocessing from DMT, 30x30m tiles

size) every 10m have been extracted and represented, to better detection of river basins and western wetlands.

As for the GIS maps, we can observe now most medium-sized cities are found in areas of low topographic level such as valleys of main rivers and plains. This is probably due to a historical factor of connectivity, both by fluvial navigation or by roads that crossed the region taking advantage of natural corridors produced by the topography. Then, we could point them as places of passage in the territory or crossing points as their territorial heritage characterisation. Some of them are also located on the top of at the top of gentle mountain formations, particularly in the southern and eastern areas, where the relief is generally more sharpened. These cases are usually related to strategic defensive positions along the centuries that became medium-sized cities.

4. URBAN HERITAGE CHARACTERIZATION OF MEDIUM-SIZED CITIES IN ANDALUSIA

The analysis of each of these cities implies what we define as urban-heritage characterisation. The first step is the detection of the principal historical values as a necessary step in the approach to knowledge for the enhancement and protection of any heritage element. The historical evolution contributes factors that help to understand the urban fabric in its globality, but also in its singularities. We work with historical documentation about the main monuments and urban spaces, as well as, pieces of evidence of the evolution of the city: cartography, areal views, photographs, engravings, specific bibliography, oral sources, haemorrhage library, etc.

In this sense, the analysis of historical maps using 3D GIS has allowed localising the consecutive borders of the cities, highlighting the historical city centres (Bushmakina et al., 2017). However, the identification of these historical values should not be understood as a fact that is unrelated to natural support. This growth has been conditioned by the topography of the site, insofar as it has caused it to take place in one or the other direction.

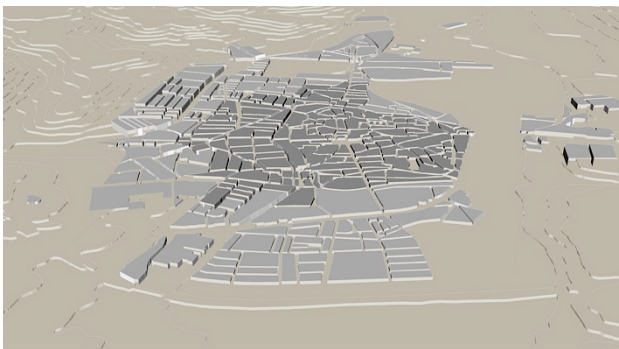


Figure 5. Urban evolution of the city of Ecija. The municipal border in 1900 is marked in dark grey and the current limit in light grey (The authors, 2018)

In addition to the identification of the casuistry relevant examples of civil, military or religious architecture, this study is based on a series of urbanistic parameters, from which we can extract relevant heritage indicators for each of the cities analysed. Some of the chosen variables handled are the following: plot surface, constructed surface, building coefficient, building height, percentage of plot occupation, property status, global and detailed buildings functions, residential typologies, number of residential units, length of the facade, year of construction or conservation details.

The study has also identified those buildings that have undergone a change of use or typological modifications while evaluating the degree of intervention experienced by them. It is important to compare this information with their level of protection, to understand the impact of planning protection in the conservation of the authenticity of the urban fabric in these cities, in the terms that the Nara Document (UNESCO, 1994) establishes. Here, it is worth mentioning the importance that it gives to adequate management of the changes to maintain the cultural meaning of the historic city (UNESCO, 2004). Mainly, it is a question that must be valued in the conservation of heritage, which requires constant adaptations derived from the new society necessities. These changes may have already become part of the cultural asset, so it will be necessary to assess whether specific alterations derive from their cultural significance, while responding to the intangible aspects that underlie their heritagization process. Given this dichotomy, it is not possible to condition the decisions to be taken in each case to the detailed analysis and study using GIS as a helpful tool.

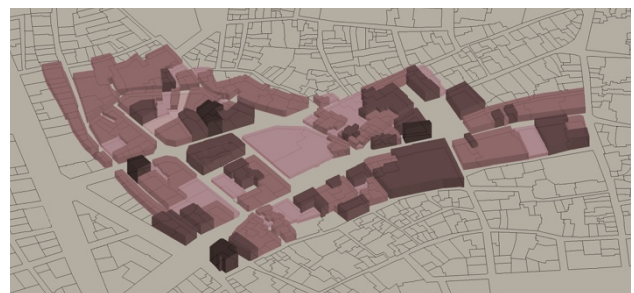


Figure 6. Example of the plot surface analysis of a study area (The authors, 2018)

Given the amount of information handled, the systematisation of this information includes a necessary step in the characterisation of these cities, as well as for a joint analysis of the entire sample. This analysis is crucial to take planning decisions concerning the conservation of the urban environment. We could not only set maximums and minimums for the aforementioned urban parameters (heights, surfaces, units, etc.) but also it will allow us to determine which buildings must be maintained, the level of protection (total, global or partial) or the type of interventions that will be permitted (maintenance, restoration, rehabilitation, reconstruction, etc). Thus, the use of tools such as 3D GIS not only facilitates the registration of a system of verticals and spatial relations but also allows graphically representing the results of this analysis incorporating an additional dimension: Z axis.

5. VISIBILITY OF HERITAGE LANDMARKS WITHIN THE URBAN GRID IN MEDIUM-SIZED CITIES

The model of medium Andalusian cities is mainly articulated in two repeated matrices: the presence of a landmark landscape in the form of an ecclesiastical tower or bell tower and a large residential layer. This binomial, characteristic of the territorial unit studied, presents a series of conflicts when the city grows, buildings rise in height, and the centrality of religious buildings is blurred by the creation of new residential or industrial urban areas.

The historical importance of the first element of the equation, the milestone raised above the rest of the city, is due to the fact that it was a sort of high "loudspeaker" that served to call the farmers to pray, so much so that *the morphology of these agro-cities also revealed the singular character of these urban events: the predominance of almost organic patterns with large irregular*

blocks, the absence of public spaces, tortuous roads and the presence of large religious buildings as the main landmarks of the urban scene, were the external image of a society that remained closely linked to rural activities (Díaz Quidiello, 2007).

The historical weight of these constructions makes them a key to the understanding of the cities of the region. Therefore, within the framework of the successive Andalusian laws on historical heritage, these landmarks have been progressively recognised as Assets of Cultural Value (BIC). Before the entry into force of the Spanish Law on Historical Heritage in 1985, the economic development that Spain experienced in the 1960s and 1970s led, in the absence of specific restrictions, to the loss of much of the relationship between landscape and heritage landmarks. The rupture of these links was mainly since the rapid growth of some industrial centres and provincial capitals generated housing demands that forced the construction of large public or protected housing complexes in the form of open-planning estates (Tomé, 2012).



Figure 7. View of Conil de la Frontera from the 17th century. Engraved around 1600, hand-coloured, by George Joris Hoefnagel. *Civitates Orbis Terrarum*, Braun and Hogenberg (Braun and Hogenberg, 1572)

In this sense, open 3D GIS tools as Google Earth can be used to determine the visual impact that these heritage elements have on the environment and vice versa. This platform, which collects multiple information, makes possible to recognise the points in the landscape where heritage landmarks have a more significant presence and to detect the areas of most significant urban and heritage vulnerability.



Figure 8. Current view of Conil de la Frontera (Google Earth, 2018)

This initial analysis has been intensely developed in different case studies of varying scale and scope. In the case of the city of Ronda (Málaga, Spain), a 3D model generated through GIS was included as part of the environmental impact assessment. The images provided a fundamental idea for the drafting of the Special Plan for the Protection of the Historical Settlement (legislative figure for the protection of cultural centers of interest in Andalusia): the need to maintain a height of the building that does not alter the landscape view of the complex from the lowest points of the gorge that surround the city.

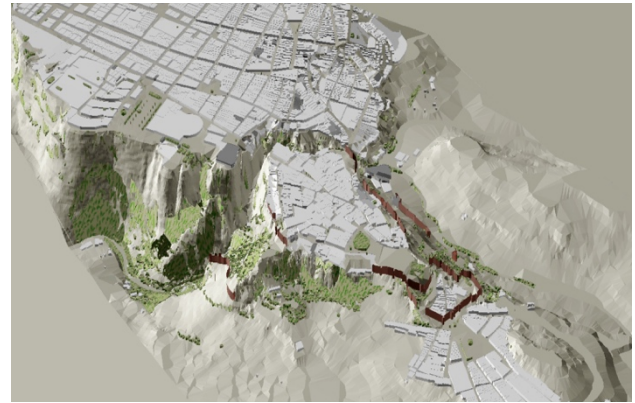


Figure 9. 3D view of Ronda. The importance of topography in this city is crucial to the understanding of its historical structure and position (The authors, 2018)

This analysis is primarily necessary due to recent cases of invasion of the urban landscape. The conflict generated by the visual impact of new constructions could have a precise origin: an erroneous delimitation of the historic settlement. This situation could have been avoided through 3D simulation applied by GIS programs. In this way, the visual cones and the maximum height to be built could have been identified without affecting the cultural values of this settlement. In this way, the relevance and open opportunity in heritage protection are proven by the use of these tools: through traditional planning we are only able to analyse the current circumstances, leaving aside the possibility of foreseeing the maximum permitted heights or the environmental affection of new urban developments.

5.1 The height of the building as a preferential criterion in the delimitation of a Buffer Zone.

Within the range of urban parameters that the geographic information system used for the study of medium-sized cities handles, the height of the building stands out. This data is especially useful when analysing unique heritage elements. In the areas affected by the declaration of protected cultural assets (BIC), the height of the adjoining buildings, together with the formalisation of the streets and the articulation of the public space, defines the relationship of each element with the environment. This legislative figure of protection implies the delimitation of a protection zone, where affected buildings have a series of limitations regarding height, decorum, occupation or buildability.

It should be remembered that of the Spanish Law on Historical Heritage (Law 16/1985) defines these zones as a surrounding and indissoluble space linked to the Cultural Heritage of which it forms part, of an urban or territorial nature, and susceptible to intervention depending on the characteristics of the properties it affects, as well as their physical and visual protection. This concept is specified in Andalusian Law on Historical Heritage (Law 14/2007) from the understanding that an alteration in the adjacent, non-adjacent or remote buildings that form this protective zone may affect the values of the asset, its contemplation, appreciation or study.

6. INFOGRAPHIC TREATMENT OF 3D IMAGES AS A COMPLEMENTARY TOOL

Having explained the relevance of the use of 3D modelling tools in their application to multi-scale heritage studies, we conclude with some examples of buildings or public spaces of heritage

interest in some of these cities. GIS and graphic post-production tools constitute a useful tandem to determine the degrees of impact (heights, perspectives, buildability or occupation) in historic settlements declared as Asset of Cultural Interest (BIC) according to Andalusian legislation.

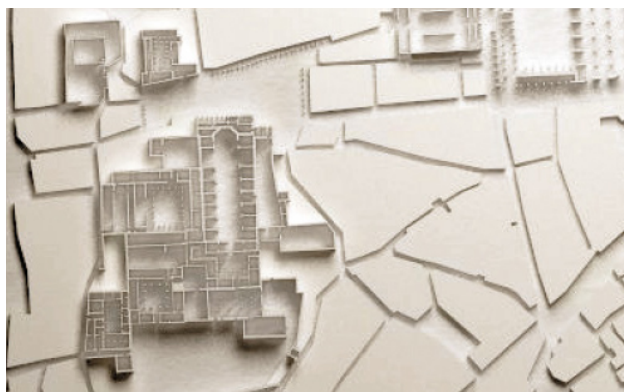


Figure 10. City scale. The reconstruction of urban hypotheses serves as a support to explain the historiography of cities (The authors, 2018)

The main advantage of its use is its capacity to be applied at different scales: from a general recognition of a city to the analysis of remarkable buildings, the integral vision offered by the system enables it to respond to two fundamental objectives. First of all, to reach a metric-scientific definition of the spatial parameters of the city and secondly, to facilitate the spreading of urban heritage thanks to its graphic potential. Other transversal objectives of its application are the improvement of the knowledge of urban evolution or its use as teaching material.

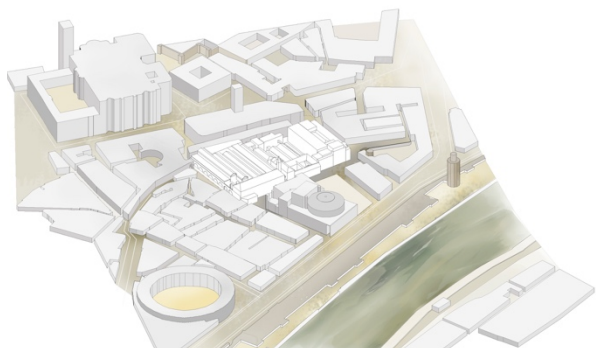


Figure 11. Neighbourhood scale. The use of these perspectives has also served to simulate the visual impact of contemporary architectural performances (The authors, 2018)

In work carried out on smaller scale environments, the need for larger scale post-production work is highlighted due to the increase in detail and the lack for higher accuracy in distances and heights. Belonging to this level are considered public spaces and buildings of heritage interest. For this reason, the results of the GIS programs used with other graphic design programs have been supported. The application of material textures, colours and perspectives allows extending its use as an educational and comprehensible material, besides facilitating its inclusion in technical documents that should be valued by professionals who are not involved in architecture and traditional planimetry readings. The versatility of the GIS-post-production software binomial allows for an immense variety of results, making it easy to adapt to different requirements.

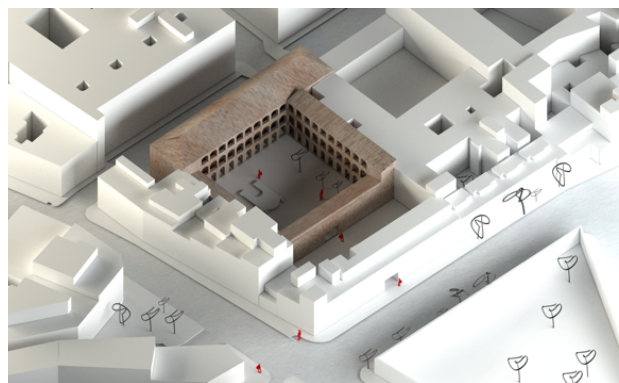


Figure 12. Detailed scale. The restrictions on access to the interior of the building make it necessary to make perspectives that allow us to see the relationship and proportion with its surroundings (The authors, 2018)

The results demonstrate its consolidation as a useful tool for assessing the possible effects of buildings on the environment, with the added possibility of generating human-scale perspectives by introducing cameras inside the structures under study. Its usefulness is demonstrated by the use of visual documentation in several technical reports that have managed to unblock lengthy disputes between heritage organisations and various public promoters.

7. CONCLUSIONS

In the previous lines, results have demonstrated the suitability use of the 3D Geographic Information Systems to deal efficiently with the extensive and diverse amount of information that characterises heritage researches concerning urban and territorial scales. Research has approached the inexorable multi-scale work required by this type of study.

The work has started from the territorial analysis of the group of Andalusian medium-sized cities to extract some first heritage considerations linked to the territory. From these, different aspects of each of the municipalities that make up the sample have been analysed. From the study of historical cartography, its evolution has been interpreted. The detailed register of urbanistic information has enabled us to propose improvements in urban planning concerning the conservation of the urban environment, especially concerning its historic centres. Among them, the impact that the height of the new buildings can have on the perception of monuments and the conservation of a specific historical urban environment has been highlighted.

Being the research under development, the use of 3D GIS will not only allow us to register data resulting from the quantitative and qualitative analysis carried out on the group of medium-sized cities that are made up of the urban system of Andalusia, but also to analysis and graphical representation on multiple scales using the third dimension to facilitate a cross analysis among the whole information.

ACKNOWLEDGEMENTS

This paper has been developed under the project entitled “Caracterización Urbano Patrimonial y Modelo Turístico Cultural en Ciudades Medias. Potencialidades y Retos para su Internacionalización: Bética Interior” (HAR2016-79788-P), financed by the competitive call of the State Plan 2013-2016 Excellence - R&D Projects of the Ministry of Economy and Competitiveness of the Government of Spain.

REFERENCES

- Bellet Sanfeliu, C., and Llop Torné, J.M., 1999. *Ciudades Intermedias y Urbanización Mundial*. UNESCO, Ayuntamiento de Lleida, UIA, Ministerio de Asuntos Exteriores, Lleida, Spain.
- Braun, G., and Hogenberg, F., 1572. *Civitates Orbis Terrarum. Antuerpiae Apud Philippum Gallaeum Coloniae Apud Auctores*. Biblioteca Digital Hispánica [accessed 07/10/2018]
- Campanaro, D. M., Landeschi, G., Dell'Unto, N., and Leander Touati, A.M., 2016. 3D GIS for cultural heritage restoration: A 'white box' workflow. *Landscape and Urban Planning*, 18, pp. 321-332. <https://doi.org/10.1016/j.culher.2015.09.006>
- Castillo Ruiz, J., 1997. *El entorno de los bienes inmuebles de interés cultural: concepto, legislación y metodologías para su delimitación*. Evolución histórica y situación actual. Universidad de Granada. Spain.
- Del Espino Hidalgo, B., 2017. Las ciudades medias del centro de Andalucía. Aproximación a un fenómeno territorial y urbano. *Revista de Estudios Regionales*, 108, pp. 165-191.
- Delikostidis, I., Engel, J., Retsios, B., van Elzakker, C.P.J.M., Kraak, M.J., and Döllner, J., 2013. Increasing the usability of pedestrian navigation interfaces by means of Landmark visibility analysis. *Journal of Navigation*, 66, pp. 523–537. <https://doi.org/10.1017/S0373463313000209>
- Dell'Unto, N., 2016. Using 3D GIS Platforms to Analyse and Interpret the Past. In: *Digital Methods and Remote Sensing in Archaeology*, pp. 305–322. Springer, Cham, Germany.
- Díaz Quidiello, J. L., 2007. Las ciudades medias interiores en el Plan de Ordenación del Territorio de Andalucía. *PH Boletín del Instituto Andaluz del Patrimonio Histórico*, 63, pp. 42-91.
- Dore, C., Murphy, M., 2012. Integration of Historic Building Information Modeling and 3D GIS for Recording and Managing Cultural Heritage Sites. In: *18th International Conference on Virtual Systems and Multimedia: "Virtual Systems in the Information Society"*. Milan, Italy.
- European Commission, 2011. *Cities of tomorrow. Changes, visions, ways forward*. European Union, Brussels, Belgium.
- Feria Toribio, J.M., 2007. *Andalucía 2020: comportamiento del sistema urbano*. Centro de Estudios Andaluces, Sevilla, Spain.
- Fisher-Gewirtzman, D., and Natapov, A., 2014. Different approaches of visibility analyses applied on hilly urban environment. *Survey Review*. 46(338), pp. 366–382. <https://doi.org/10.1179/1752270614Y.0000000117>
- Gattaa, G., Elisabetta Ariotti, E., and Bitelli, G., 2017. Geomatics science applied to cartographic heritage and archive sources: A new way to explore the XIXth century Gregorian Cadastre of Bologna (Italy), an ante-litteram 3D GIS. *Journal of Cultural Heritage*, 23, pp. 68–76. <https://doi.org/10.1016/j.culher.2016.06.009>
- Gobierno de España, 1985. Ley 16/1985, de 25 de junio, de Patrimonio Histórico Español. *Boletín Oficial del Estado*, 155, pp. 20.342-20.352.
- Gonçalves, L.M.S., Almeida, A., Falcão, A. P., and Sónia Ildefonso, S., 2016. 3D-GIS Heritage City Model: Case study of the Historical City of Leiria. In: *The 19th AGILE International Conference on Geographic Information Science Geospatial Data in a Changing World*
- Gröger, G. and Plümer, L., 2012. CityGML–Interoperable semantic 3D city models. *ISPRS Journal of Photogrammetry and Remote Sensing*, 71, pp. 12–33. <https://doi.org/10.1016/j.isprsjprs.2012.04.004>
- Hea, J., Liub, J., Xub, S., Wub, C., and Zhang J., 2015. A GIS-based cultural heritage study framework on continuous scales: a case study on 19th century military industrial heritage. In: *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, Volume XL-5/W7, pp. 215-222. <https://doi.org/10.5194/isprsarchives-XL-5-W7-215-2015>
- ICA (Instituto de Cartografía de Andalucía), 2009. *Atlas de la historia del territorio de Andalucía*. Consejería de Vivienda y Ordenación del Territorio de la Junta de Andalucía, Sevilla, Spain.
- Junta de Andalucía, 2006. *Plan de Ordenación del Territorio de Andalucía*. Consejería de Medio Ambiente y Ordenación del Territorio, Sevilla, Spain.
- Junta de Andalucía, 2007. Ley 14/2007, de 26 de noviembre, del Patrimonio Histórico de Andalucía. *Boletín Oficial de la Junta de Andalucía*, 248, pp. 6-27.
- Kaimaris, D.; Sylaiou, S.; Georgoula, O. and Patias, P., 2011. GIS of landmarks management. *Journal of Cultural Heritage*, 12, pp. 65–73. <https://doi.org/10.1016/j.culher.2010.09.001>
- Lelo, K. 2014. A GIS Approach to Urban History: Rome in the 18th Century. *ISPRS International Journal of Geo-Information*, 3, pp. 1293-1316. <https://doi.org/10.3390/ijgi3041293>
- Llobera, M., 1996. Exploring the topography of mind: GIS, social space and archaeology. *Antiquity*, 70(269), pp. 612-622. <https://doi.org/10.1017/S0003598X00083745>
- Llop Torné, J. M., Hoeflich de Duque, S., 2010. *Ciudades intermedias*. Secretariado de la Red Mundial de Ciudades y Gobiernos Locales Unidos, Barcelona, Spain.
- Lundberg, C., and Peterson, L., 2005. Land use history of central Lulea: a case study in the use of historical maps together with modern geographic municipal information. *Applied GIS*, 1(3), pp. 1–30.
- Marques, L.F., Tenedório, J. A., Burns, M., Romão, T., Birra, F., Marques, J., Pires, A., 2017. Cultural Heritage 3D Modelling and visualisation within an Augmented Reality Environment, based on Geographic Information Technologies and mobile platforms. *ACE: Architecture, City and Environment*, 11(33), pp. 117-136. <https://doi.org/10.5821/ace.11.33.4686>
- Navas Carrillo, D., Rosa Jiménez, C., Pérez Cano, M.T., 2016. Between Historic Sites and New Tourist Destinations: The Development of the First Periphery in Medium-sized Andalusian Coastal Cities (1950-1980). *Athens Journal of Tourism*, 3 (4), pp. 287-318. <https://doi.org/10.30958/ajt.3.4.3>
- Nieto Masot, A., and García Paredes, C., 2016. SIG y patrimonio: el caso de estudio de la ribera del marco en extremadura. Grupo

de Investigación en Desarrollo Sostenible y Planificación Territorial de la Universidad de Extremadura, Cáceres, Spain.

Núñez Andrés, M.A., and Buill Pozuelo, F., 2009. Evolution of the architectural and heritage representation. *Landscape and Urban Planning*, 91, pp. 105–112. <https://doi.org/10.1016/j.landurbplan.2008.12.006>

Pérez-Cano, M. T., Del Espino-Hidalgo, B, And Navas Carrillo, D., 2017. Patrimonio urbano y planeamiento: la protección del paisaje patrimonial a través del planeamiento. In: *Territorio, Paisaje y Turismo: metodologías docentes en las escuelas de arquitectura*. Geometría, Málaga, Spain.

Rodríguez Martínez, F. and Sánchez Escolano, L. M., 2010. Sobre la nueva dimensión territorial de las ciudades medias en Andalucía. In: *Ciudad, territorio y paisaje: Reflexiones para un debate multidisciplinario*, pp. 272-287. CSIC, Madrid, Spain.

Spiridon, P., Ursu, A., and Sandu, I., 2016. Heritage management using GIS. In: *SGEM2017 Conference Proceedings*. pp. 263-270. <https://doi.org/10.5593/SGEM2016/B23/S11.034>

Tomé, S., 2012. Comercio y Ciudades medias en la España del Desarrollismo. *Revista Bibliográfica de Geografía y Ciencias Sociales*, XVIII (1003)

UNESCO, 1994. The Nara Document On Authenticity. United Nations Organization for Education, Science and Culture, Nara, Japan.

UNESCO, 2004. *Algunas reflexiones sobre autenticidad*. United Nations Organization for Education, Science and Culture, Paris, France.

Vilagrasa, J., 2000. Ciudades medias y ciudades intermedias: posicionamiento en la red urbana y procesos urbanos recientes, <http://www.etsav.upc.es/personals/monclus/cursos/ibarz.htm> (10 July 2017).

Wüst, T., Nebiker, S., Landolt, R., 2004. Applying the 3D GIS DILAS to Archaeology and cultural heritage projects requirements and first results. In: *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, VolumeXXXV/P-B5, pp. 407–412.

Yakar, M., and Doğan, Y., 2018. GIS and three-dimensional modeling for cultural heritages. *International Journal of Engineering and Geosciences (IJEg)*, 3(2), pp. 50-55. <https://doi.org/10.26833/ijeg.378257>

Yogapriya G., and Senthamil Kumar. S., 2018. Review of application of GIS in built heritage conservation. *International Journal of Recent Trends in Engineering & Research (IJRTER)*, 4(6), pp. 67-70. <https://doi.org/10.23883/IJRTER.2018.4317.GJKZ6>