International Congress for Heritage Digital Technologies and Tourism Management
June 20th – 21st, 2024. Valencia, Spain
Doi: https://doi.org/10.4995/HEDIT2024.2024.17718

Results of the joint reading of the Windmills of the Region of Murcia and their context

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How to cite: Silvente-Martínez, M.J. (2024). Results of the joint Reading of the Windmills of the Region of Murcia and their context. In *International Congress proceedings: International Congress for Heritage Digital Technologies and Tourism Management HEDIT 2024*. June 20th – 21st, 2024. Valencia, Spain. https://doi.org/10.4995/HEDIT2024.2024.17718

Abstract

The use of GIS tools in the preparation of the Master Plan for the Region of Murcia's Windmills has facilitated the documentation work, study and analysis of the complex context in which these heritage elements are inserted, considered B.I.C. (Bien de Interés Cultural - Asset of Cultural Interest) with monument category and therefore subject to unique protection and tutelage.

The GIS analysis allows the integration of information from different sources that respond, among others, to variables such as the territorial variables that link the windmills to a system of corridors of cattle trails and wadis, those of a productive nature associated with their functionality in milling processes or water extraction in agricultural and salt exploitation processes, etc.; those related to landscape values and their impact on the construction and characterisation of the different landscapes. In this way, a model is generated that, by combining or discriminating the different variables, makes it possible to specify relationships between individual elements, identify settlement patterns, or recognise singularities.

The joint vision of all these aspects enables a reading beyond the current situation of the windmills as isolated pieces subject to recovery as unique elements of the landscape but also enables a different way of thinking about the windmill complex, as a whole, as a system. Nodes in an ecosystemic network or, in other words, elements that can become part of a large green network as cultural services associated with nature.

Keywords: *Windmills, GIS, Master Plan for the Windmills of the Region of Murcia*

1. Introduction

The Master Plan for the Windmills of the Region of Murcia[1] (PDMVRM) is the result of a contract tendered by the "Consejería de Turismo y Cultura" in 2019 and awarded to the Temporary Business Association: ZIMA Desarrollos Integrales S.L., Enrique de Andrés Rodríguez and Fernando de Retes Aparicio. The plan goal is *"to establish the general conditions that must govern the conservation and enhancement of this Asset of Cultural Interest (B.I.C.) and their associated landscape to establish a tool that determines their constituent values and serves as a basis for the planning of future actions, from a perspective of preservation of authenticity.*" (de Andrés, 2020).

The PDMVRM is developed by a first phase of documentation, a second phase of analysis and diagnosis, and a third phase of a propositional nature based on the previous ones. Geographic Information Systems (GIS) are incorporated from the outset as a project to establish the territorial context in which to dump different levels of information and facilitate its analysis based on the cartographies generated. Participation in the PDMVRM has been carried out by a multidisciplinary team that collaborates and supports the different demands required in each phase.

It is necessary to highlight the scope of the information to be processed; the PDMVRM deals with the 224 windmills included in the list of properties listed as Assets of Cultural Interest (Bien de Interés Cultural, BIC), a document available on the Cultural Heritage Portal of the Region of Murcia (PATRIMUR, 2019), all of them declared BIC by the first transitory provision of the Law 4/2007, of Cultural Heritage of the Autonomous Community of the Region of Murcia, according to which *"…windmills located in the territory of the Autonomous Community of the Region of Murcia are considered to be assets of cultural interest by operation of Law, with the category of monuments."* As shown in Figure 1, windmills are distributed heterogeneously throughout the Region of Murcia, meaning they cover a territorial extension of over 11.000 km^2 and use information of very different origins and formats. Thus, using GIS tools is necessary to compose a model on which to document and identify the windmills, analyse the dialogue of these elements with their environment and each other, and provide the basis for devising a maintenance and recovery strategy.

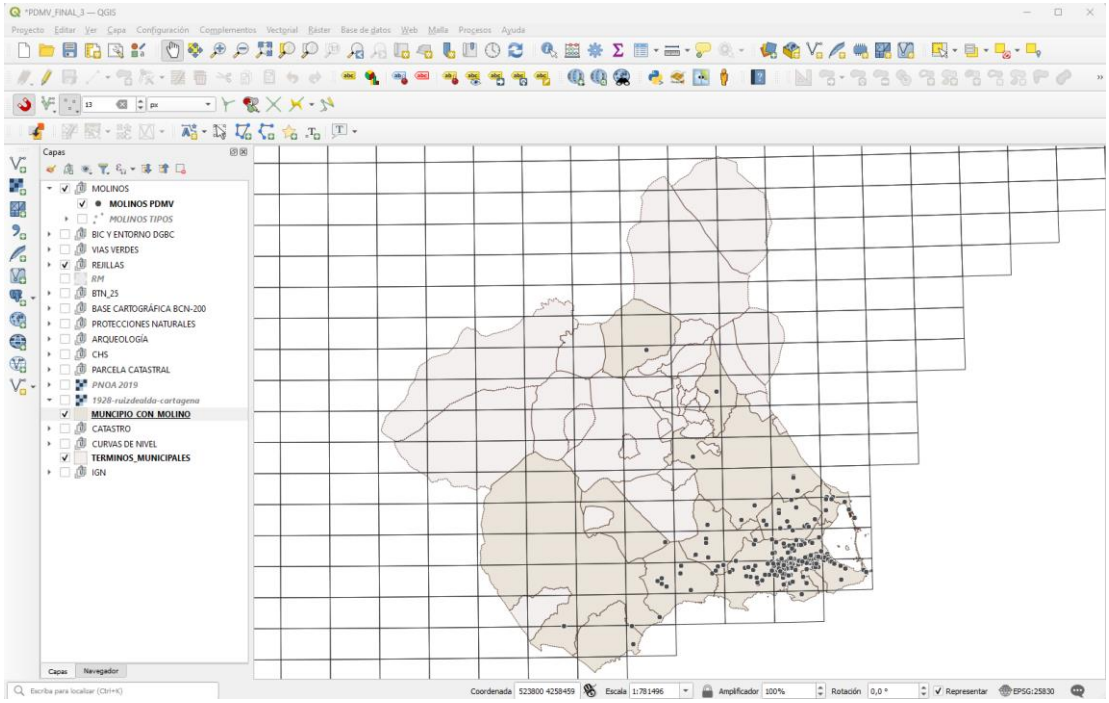


Figure 1. QGIS Base Project. Territorial scope: Region of Murcia. Source: Author's elaboration.

[1] The document can be found at https://www.patrimur.es/web/patrimonio-cultural/plan-director-molinos-de-viento

2. Aims and objectives

The specific objectives of the Master Plan are divided into three distinct phases: Phase I, Preliminary studies and documentation; Phase II, Current situation and diagnosis. Specific collection of information, analysis of such information, and diagnosis of the current state. Phase III Conclusions and proposal for conserving and enhancing the Region of Murcia's Windmills. This communication aims to identify the scope of GIS in each of the phases and the importance of the cumulative generation of information in successive decisions and phases.

The GIS tool is particularly useful in Phase I, which includes aspects such as the georeferencing of the property and its surroundings and the establishment of a precise planimetry for the description of both; the incorporation of administrative data that allows the identification of data relating to address, owner, as well as those corresponding to the plot on which it is located and that of its boundaries; the historical study carried out based on historical orthophotographs in which it is possible to recognise related constructions and their transformation; the urban analysis in which situations and conditions are identified by existing regulations.

Phase II, although it involves the detailed analysis of each of the windmills, also refers to aspects that can be incorporated into the GIS project, such as the environmental and territorial studies of the landscape, which involves the analysis of environmental variables, existing vegetation, orography, water resources, climatic conditions, land use, links with the territory and the relationship with the natural environment, among others.

Phase III, of a propositional nature, is based on the graphic documentation obtained in the previous phases and the results of the previous analyses to generate management and improvement proposals for conserving the windmills. The current state of most of the mills and the transformation their restoration implies can be seen in Figure 2 through the example of the windmill n.115 and its situation in 2014 and 2024.

Determining the environment affected by the declaration of the BIC is one of the objectives of Phase I of the PDMVRM. However, it is considered that an in-depth study is necessary for its definition. Therefore, a first approximation is proposed for this phase, followed by a revision in subsequent phases based on greater knowledge.

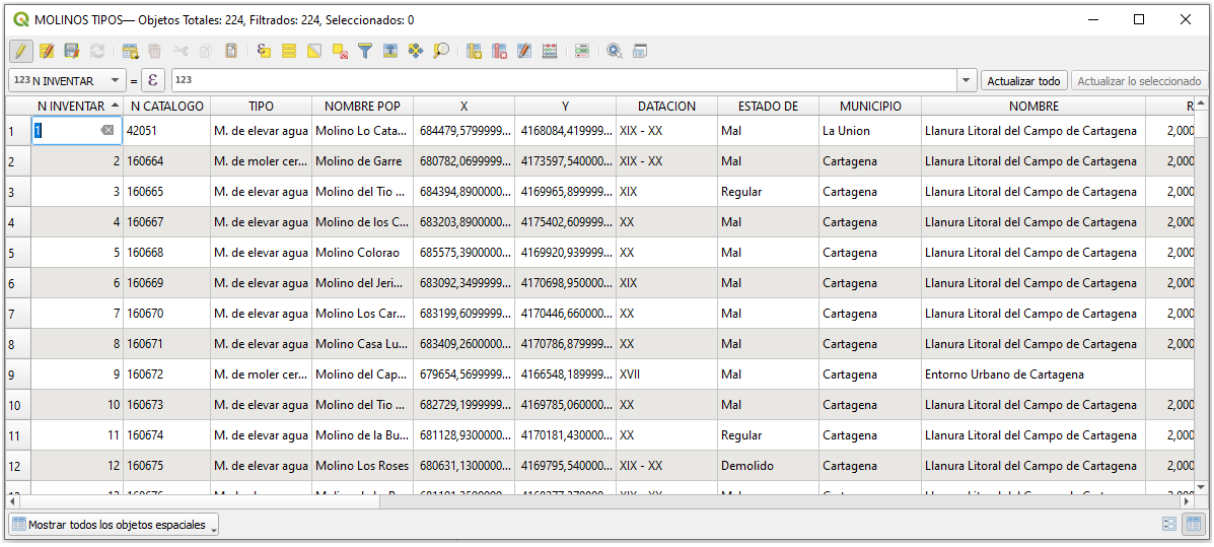
Figure 2. Windmill n. One hundred fifteen in the years 2014 and 2024.
Source: De Andrés et al. (2020) and Author's elaboration.

3. Methods and procedure

Based on the objectives set out for Phase I, the premise is the generation of cartographies using GIS that should serve as a basis for identifying and characterising the windmills and for the analyses and studies corresponding to the subsequent phases. Phase II, referring to the analysis and diagnosis of the current situation of the different elements, involves the location and incorporation of thematic cartography according to the object of analysis. The combination of the different levels of information reveals similarities and homogeneous groupings from which group maps will be generated for the intervention proposals expected in Phase III.

3.1 Cartographic basis for Phase I Preliminary studies and documentation

The generation of the GIS project begins by establishing the territorial scope of the study based on the cartography of the Autonomous Community of the Region of Murcia with the identification of its municipalities and the incorporation of the 224 windmills, which is done as a .csv text file obtained from the tables in which the data compiled in the individual files prepared for each of the windmills are synthesised. In this way, based on the UTM ETRS89 coordinates of the windmills, they are transferred to the project as a layer of points that also contain associated information related to their type, state of conservation, etc. The attribute table corresponding to this layer is shown in Figure 3.


MOLINOS TIPOS— Objetos Totales: 224, Filtrados: 224, Seleccionados: 0

123 N INVENTAR = ε 123 Actualizar todo Actualizar lo seleccionado

	N INVENTAR	N CATALOGO	TIPO	NOMBRE POP	X	Y	DATACION	ESTADO DE	MUNICIPIO	NOMBRE	R
1	1	42051	M. de elevar agua	Molino Lo Cata...	684479,5799999...	4168084,419999...	XIX - XX	Mal	La Union	Llanura Litoral del Campo de Cartagena	2,000
2	2	160664	M. de moler cer...	Molino de Garre	680782,0699999...	4173597,540000...	XIX - XX	Mal	Cartagena	Llanura Litoral del Campo de Cartagena	2,000
3	3	160665	M. de elevar agua	Molino del Tio ...	684394,8900000...	4169965,899999...	XIX	Regular	Cartagena	Llanura Litoral del Campo de Cartagena	2,000
4	4	160667	M. de elevar agua	Molino de los C...	683203,8900000...	4175402,609999...	XX	Mal	Cartagena	Llanura Litoral del Campo de Cartagena	2,000
5	5	160668	M. de elevar agua	Molino Colorao	685575,3900000...	4169920,939999...	XX	Mal	Cartagena	Llanura Litoral del Campo de Cartagena	2,000
6	6	160669	M. de elevar agua	Molino del Jeri...	683092,3499999...	4170698,950000...	XIX	Mal	Cartagena	Llanura Litoral del Campo de Cartagena	2,000
7	7	160670	M. de elevar agua	Molino Los Car...	683199,6099999...	4170446,660000...	XX	Mal	Cartagena	Llanura Litoral del Campo de Cartagena	2,000
8	8	160671	M. de elevar agua	Molino Casa Lu...	683409,2600000...	4170786,879999...	XX	Mal	Cartagena	Llanura Litoral del Campo de Cartagena	2,000
9	9	160672	M. de moler cer...	Molino del Cap...	679654,5699999...	4166548,189999...	XVII	Mal	Cartagena	Entorno Urbano de Cartagena	
10	10	160673	M. de elevar agua	Molino del Tio ...	682729,1999999...	4169785,060000...	XX	Mal	Cartagena	Llanura Litoral del Campo de Cartagena	2,000
11	11	160674	M. de elevar agua	Molino de la Bu...	681128,9300000...	4170181,430000...	XX	Regular	Cartagena	Llanura Litoral del Campo de Cartagena	2,000
12	12	160675	M. de elevar agua	Molino Los Roses	680631,1300000...	4169795,540000...	XIX - XX	Demolido	Cartagena	Llanura Litoral del Campo de Cartagena	2,000

Mostrar todos los objetos espaciales

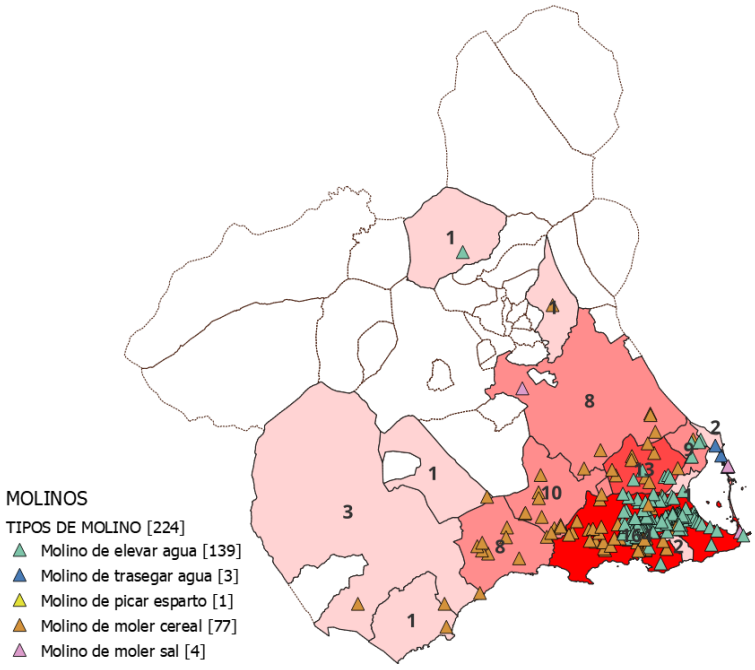
Figure 3. The attribute table of the point layer "Molinos. shp" is embedded as a delimited text file.
Source: Author's elaboration.

From these only two initial layers, it is possible to generate different levels of density, for example Figure 4, about the number of windmills per municipality, and to recognise a heterogeneous distribution in 14 of the 45 municipalities that make up the Region of Murcia, with a greater presence of these elements in the Campo de Cartagena region, or, in terms of type, the concentration of windmills for water extraction in this same area compared to the greater dispersion of windmills for grinding cereal.

This base cartography is supplemented by the battery of historical orthophotographs available on the Sitmurcia geoportal (SITMURCIA, 2019), from which a first reading of each element in its immediate surroundings and its historical evolution is possible, as well as the identification of related constructions.

The territorial characterisation is initially carried out by incorporating the National Topographic Base (BTN) available in the download centre of the website of the National Geographic Institute (IGN, 2019), which includes, among other territorial landmarks, the layers corresponding to roads, railway lines, population centres, watercourses and contour lines. The latter are considered to be of great importance in terms of the definition of altimetry and their graphic relevance in reading the maps. However, the contour lines of the BTN correspond to 10 m intervals, which is excessive for the area of work in which most of the windmills are located, the basin of the Mar Menor. This area is characterised by its flatness, and the definition of the territory requires smaller intervals

to identify slopes and runoff directions. The contour lines are obtained at 1-metre intervals from the Digital Elevation Models, also available on the IGN website, which involves downloading the Digital Terrain Model - MDT05 and generating the contour lines using raster analysis.



MUNICIPIO	
Águilas	1
Cartagena	164
Cieza	1
Fuente Álamo de Murcia	10
La Unión	2
Lorca	3
Los Alcázares	1
Mazarrón	8
Molina de Segura	1
Murcia	8
San Javier	9
San Pedro del Pinatar	2
Torre Pacheco	13
Totana	1

Figure 4. Map of location, identification according to type and number of windmills by municipality. Source: Author´s elaboration based on Map De Andrés et al. (2020).

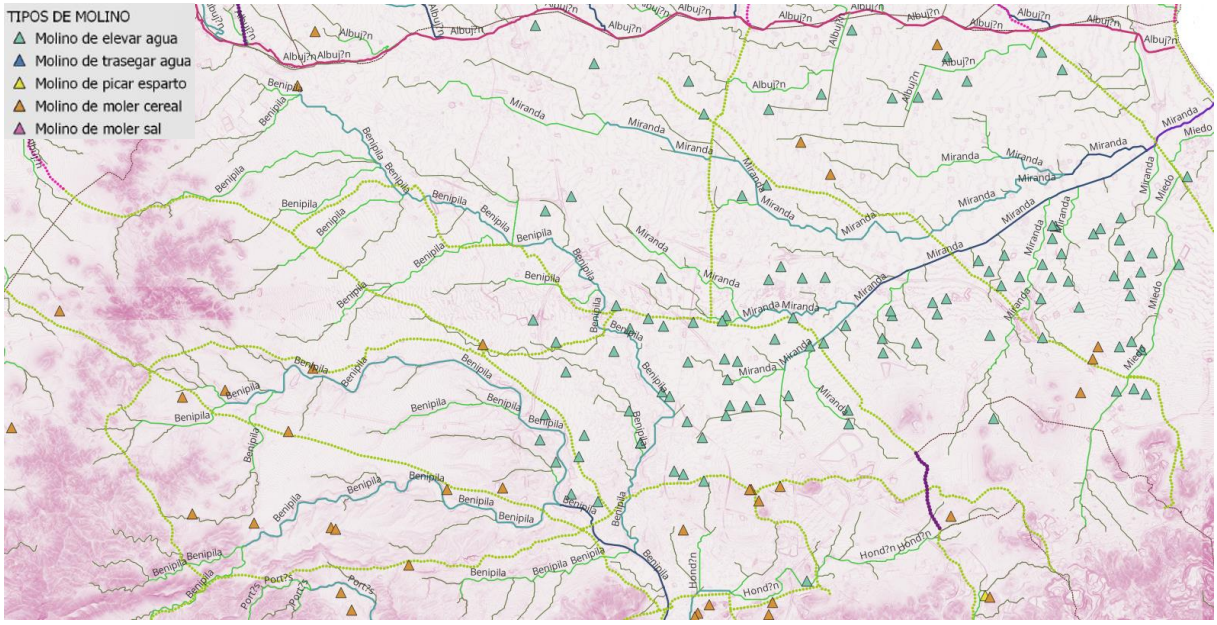


Figure 5. Correspondence of the location of the windmills concerning the orography, watercourses and cattle tracks. Source: Author´s elaboration based on Map De Andrés et al. (2020).

Equally relevant about the location of the windmills is the joint reading of the orography and the layers corresponding to the inventory of watercourses of the Confederación Hidrográfica del Segura and the cattle tracks. Figure 5 shows that the former takes the direction perpendicular to the contour lines while the cattle tracks are mainly oriented parallel to them. In any case, the windmills for raising water are mainly aligned about the watercourses. At the same time, it is possible to identify the proximity of the windmills for grinding cereal to the cattle tracks.

3.2 Delimitation of the environment affected by the BIC declaration

The criteria defined by the Dirección General de Bienes Culturales must be taken into account in the delimitation of the protected environment, which include the inclusion of the fundamental elements, establishing, whenever possible, a minimum perimeter of 50 metres around them in the case of rural environments; in urban environments, the boundaries of the plots bordering the public space perimeter of the property will be taken as limits; the minimum possible number of castral plots in the case of private properties will be taken into account, ensuring, whenever possible, that the property is exclusively affected by the plot where the BIC is located. In the same way, orographic limits recognisable in the terrain, roads, tracks, paths, wadis, watercourses, livestock tracks, greenways, etc., will be considered. In addition, whenever possible, the archaeological area will be established within the protected environment of the property, and the urban and territorial regulations will be considered. The associated buildings will be identified in the Vuelo Ruiz de Alda orthophotography.

In this sense, cadastral information from the Dirección General de Catastro (DG CATASTRO, 2019) is added to the project and made available through the vector mapping download section and a WMS service. This information provides the address, cadastral reference, and surface area of the plot, as well as, for authorised users, the identification of the owners.

By superimposing the affected environments, initially delimited, on the cadastral cartography, it is possible to determine and quantify the surface area and level of affectation for each affected plot. The generation of individual maps for each windmill, Figure 6, helps to definitively define the environments above in Phase III, incorporating, in addition, all the requirements indicated and the knowledge once the analyses corresponding to the different thematic layers have been carried out.

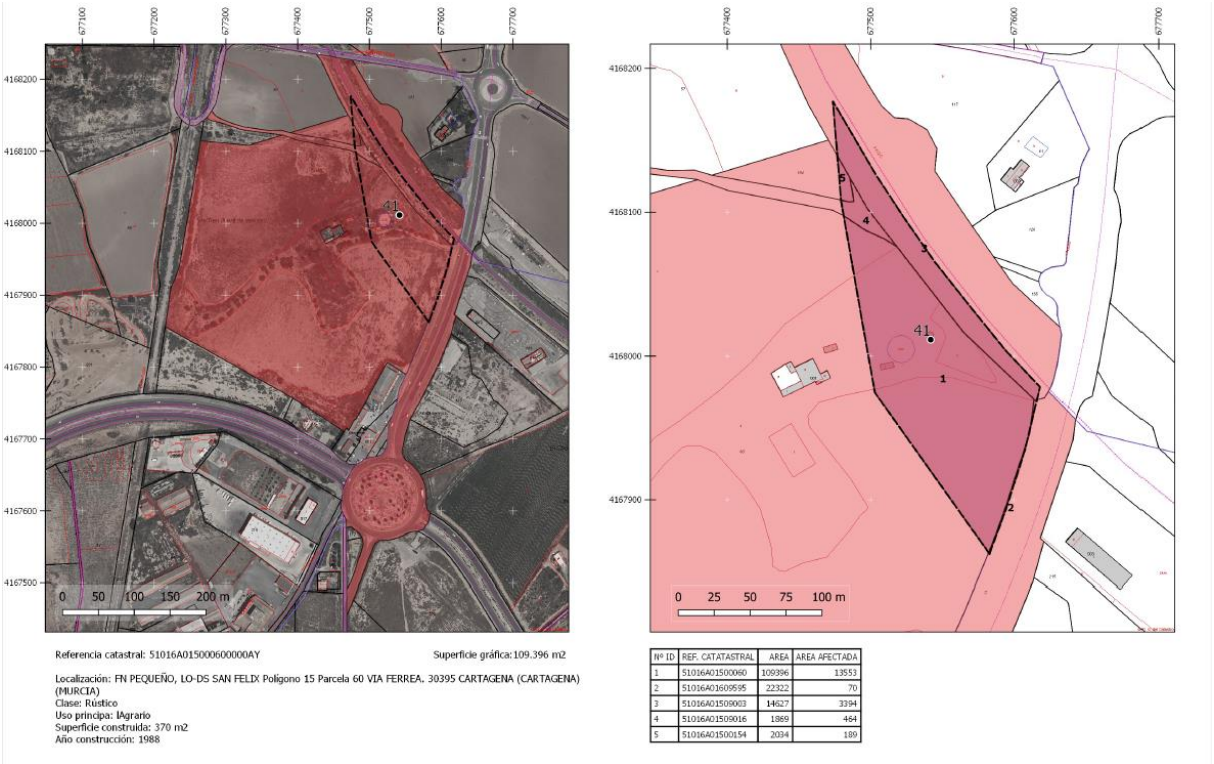


Figure 6. Affected environment on cadastral mapping. Source: Author´s elaboration based on Map De Andrés et al. (2020).

3.3 Historical study

The analysis of the historical evolution is carried out on the collection of orthophotography available as a WMS service of the Cartographic Service: Ortofotos de la Región de Murcia de SITMURCIA (SITMURCIA, 2019), which provides a catalogue of orthophotographs including the valuable black and white photogrammetric flight of the Cuenca del Segura made by Julio Ruiz de Alda between the end of the 1920s and the beginning of the 1930s,

flights *Americano Serie A* from 1945-46 and *Serie B* from 1956-57 and flights *PNOA* from 2004, among others. The WMS incorporation process is shown in Figure 8, which contains the available orthographies catalogue. Figure 7 allows us to appreciate the image quality of the Ruiz de Alda flight compared to the PNOA 2019.

In this meticulous work, each of the windmills is visited in search of variations, appearances or disappearances of associated constructions (historical and industrial elements, machinery, warehouses), paths, ponds, water resources, irrigation networks and historical elements of logistical support about the uses of the windmills, which are plotted and dated to obtain a sequence that narrates the evolution of each one of them.

This study is complemented by analysing texts, images and plans compiled from different archives and catalogues.

Figure 7. Windmills 50, 51 and 218 were on the Ruiz de Alda flight and PNOA 2019.
Source: Author´s elaboration based on Map De Andrés et al. (2020).

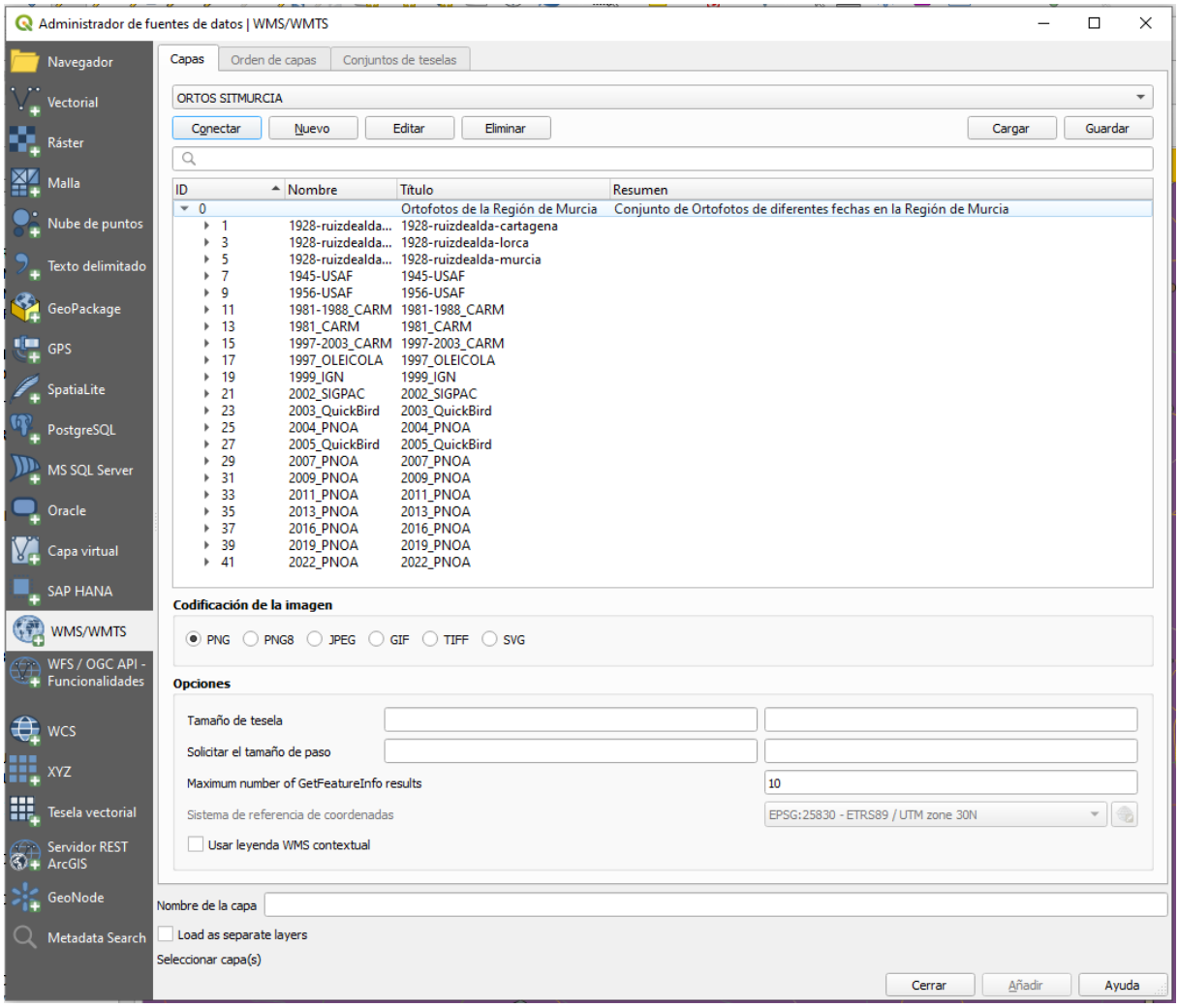


Figure 8. Incorporation of the SITMURCIA orthographic collection as a WMS. Source: Author's elaboration.

3.4 Urban analysis

The urban planning analysis includes, in addition to identifying the applicable regulations by municipal planning, the consideration of those protections that may affect the BIC from different planning instruments. In this sense, the Project incorporates the layers corresponding to the flood risk of the Confederación Hidrográfica del Segura (CHS): Flood Zones associated with return periods of 5, 10, 25, 50, 100 and 500 years, Figure 9, then available on its website (CHS, 2019) and the protections contained in the Guidelines and Land Management Plan of the Coast (SITMURCIA, 2019) that may limit the level of action or condition it by the conditions of the protection imposed, Figure 10.

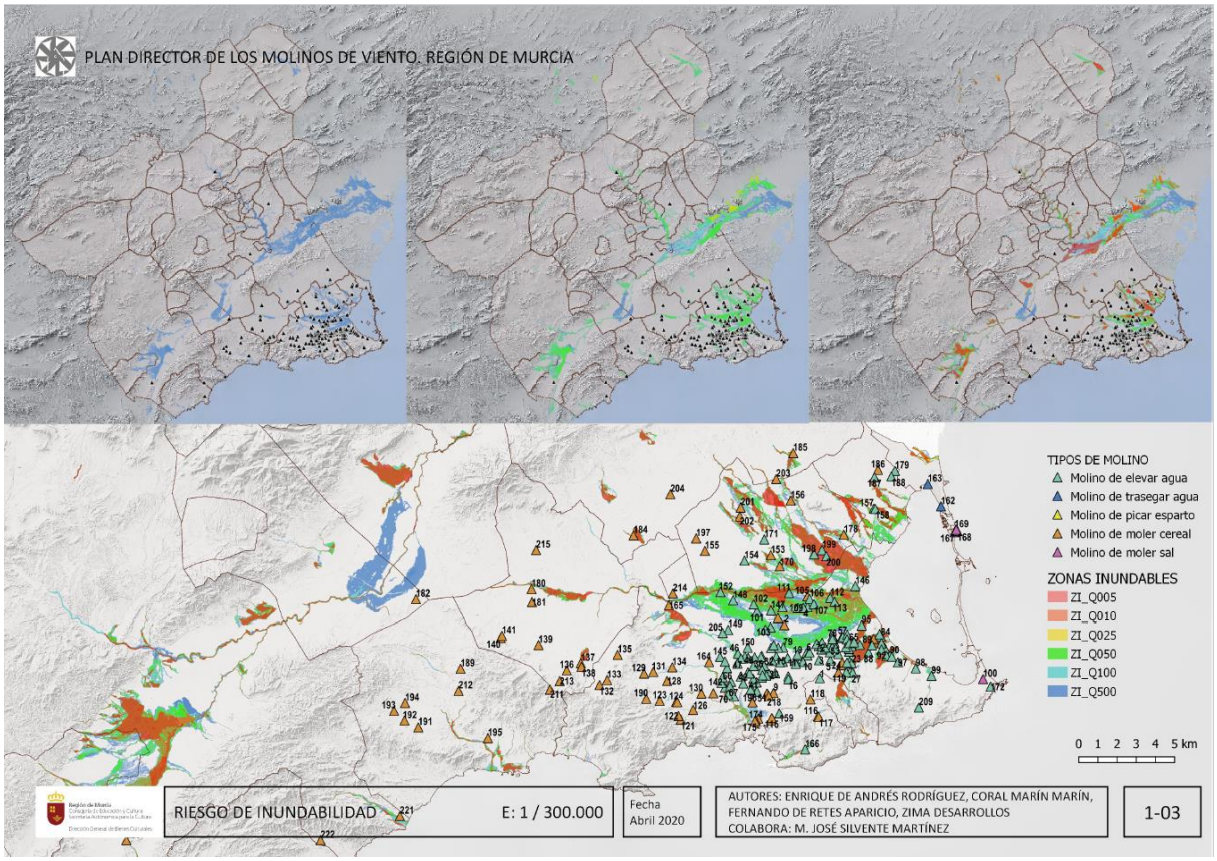


Figure 9. Inability risk map. Source: De Andrés et al. (2020).

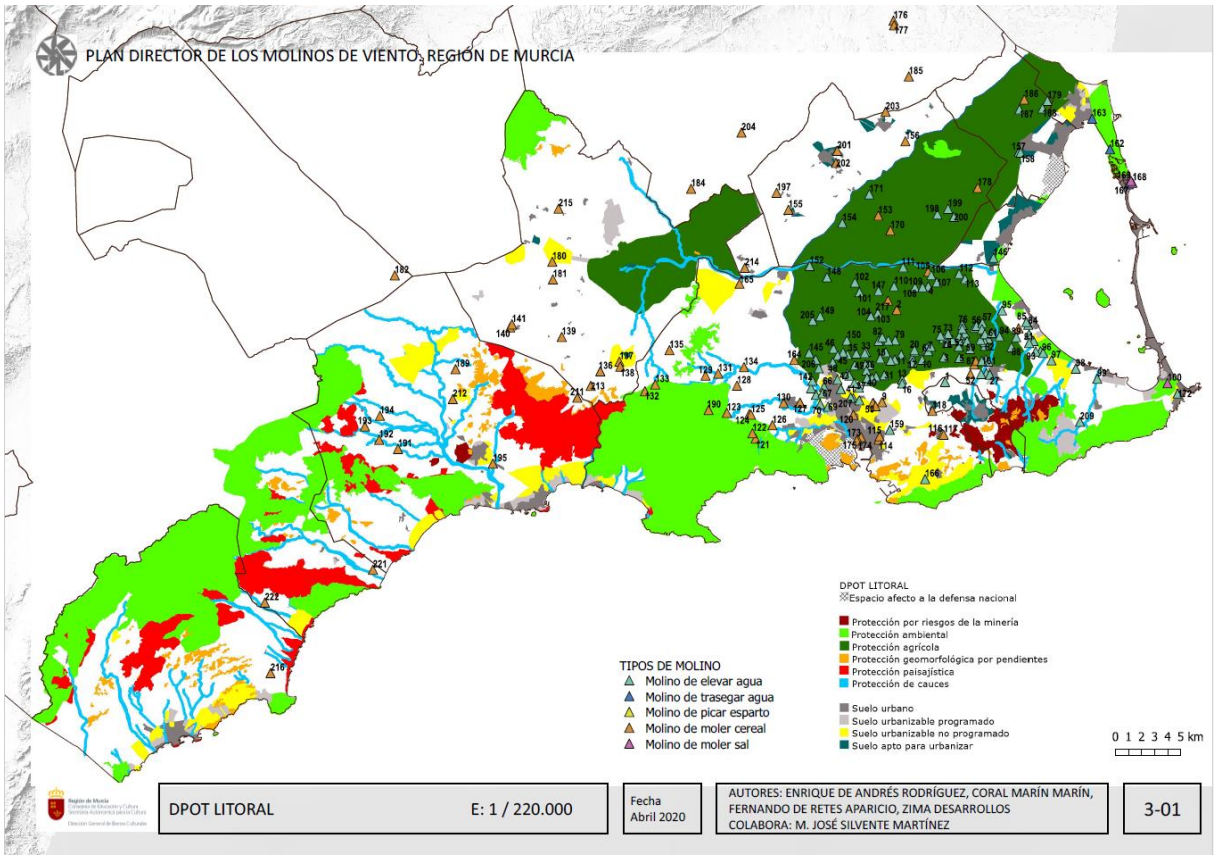


Figure 10. Map of protections of the Coastal DPOTs. Source: De Andrés et al. (2020).

4. Results

Combining more than 60 vector and raster layers incorporated in local or remote service and using the atlas generation functionality, a battery of 224 maps is obtained with the information available for each location. Using a unique symbology defined for each project layer, the maps obtained have a homogeneous treatment that facilitates their reading and comparison. This tool allows the parameterisation of the content, thus automating the referencing of texts and legends, which greatly speeds up the graphic output of such a large collection of maps.

These maps are the basis for defining the environments affected and defining seven Proposed Areas of Intervention (Áreas Propuestas de Intervención, APIs), as shown in Figure 11, to establish joint protection actions that are more effective than individual protection and which must include not only the windmills but also their surroundings. Figure 12 provides an example of applying the ecosystem environment sets in APIs.

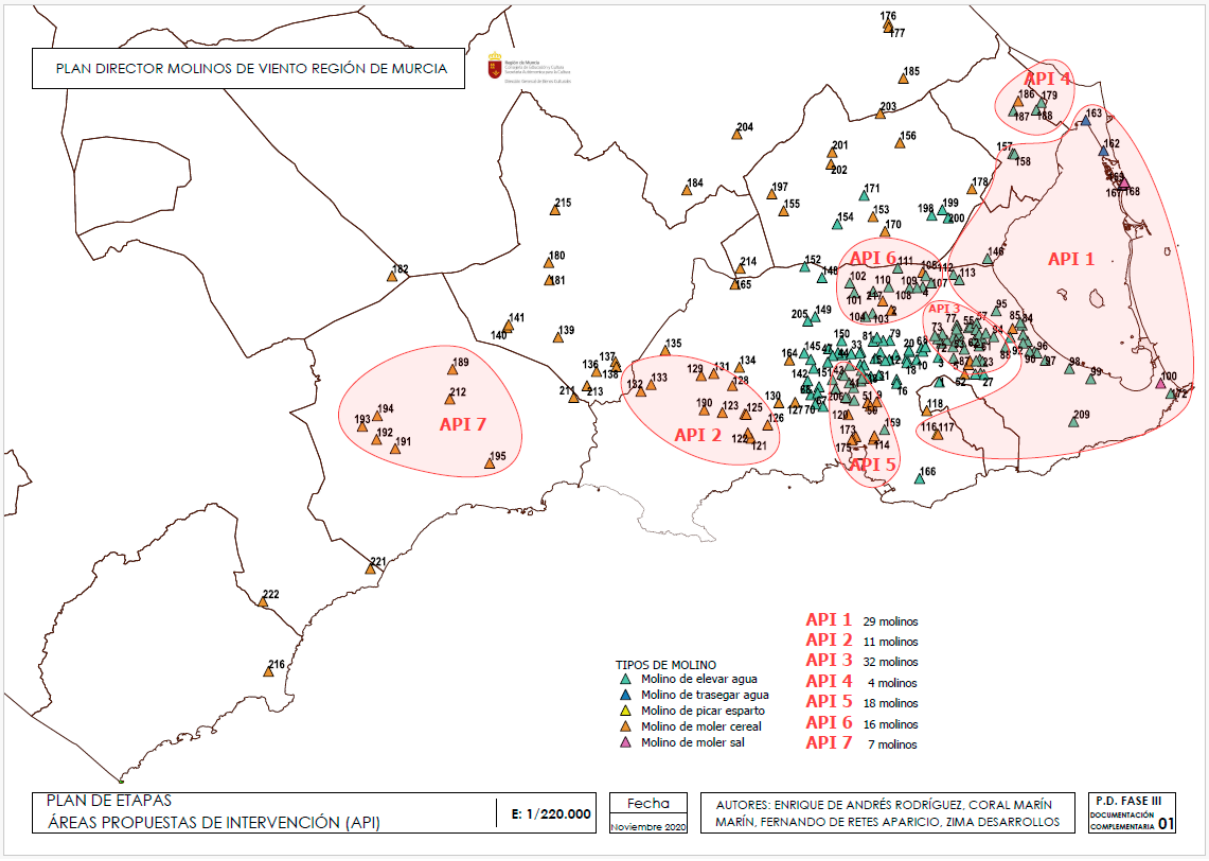


Figure 11. Proposed areas of intervention. Source: De Andrés et al. (2020).

Figure 12. Examples of applications of ecosystem environments are set in APIs 1 and 3. Source: De Andrés et al. (2020).

5. Conclusions

The results show the importance of incorporating GIS tools in the heritage management of elements of territorial and landscape importance, such as windmills in the Region of Murcia. Their functionality has made it possible to generate basic and complex cartographies that define the windmills and their surroundings at different scales by processing very diverse thematic cartographies.

The knowledge provided by the Master Plan for the Windmills of the Region of Murcia (PDMVRM) should serve to reverse the process of deterioration in which a large part of these monuments find themselves and facilitate the management of this heritage through the activation of integrated conservation actions incorporating the environments and territorial connections as a guarantee of maximum protection.

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