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Networked Heritage Management in the Lower Guadalquivir (Spain)

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Abstract: This paper describes the operations carried out to generate a georeferenced heritage inventory at a supra-municipal scale. The tool establishes links between its heritage elements based on the features and characteristics of the territory. The work has been carried out on the fluvial zone of the Lower Guadalquivir, an area of approximately 8500 km^2 located in Andalusia in the south of Spain. The method used is based on the digital inventory of the Andalusian immovable historical heritage generated by the Andalusian Institute of Historical Heritage, in which more than 500 heritage assets in the study area are indexed. The work begins with the expansion and processing of these assets with the aim of reorganizing them and establishing new parameters in their classification schemes. Subsequently, a spatial analysis developed in a GIS environment detects relationships between heritage assets determined by the physical characteristics of the territory. These relationships are contrasted by historical research, and eight heritage networks in the territory are defined as a result. Finally, one of the networks is used to show how, from the graph theory, it is possible to investigate the detected links. Ultimately, it is discussed how this study allows us to move toward new models of the heritage management of territorial dimension and relational vocation.

Keywords: landscape; spatial analysis; graph theory; heritage; relational database

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1. Introduction

In the second half of the twentieth century, a discussion began in the heritage research and management spheres on the economic functionality of culture. In this regard, pioneering events emerged such as the World Conference on Cultural Policies [1], the first conference explicitly focused on the links between culture and development, and the Intergovernmental Conference on Cultural Policies for Development [2]. Slightly more recent experiences include the Faro Convention held by the Council of Europe in 2005; the Hangzhou Declaration [3]; the Habitat III Conference held in Quito in 2016, which adopted the New Urban Agenda that recognizes cultural heritage as a crucial factor in the sustainable development of cities [4]; and the 2030 Agenda for Sustainable Development, which identifies cultural heritage as an essential vehicle for development [5]. These events, among others, have actively contributed to reaffirming the potential of culture and cultural heritage as engines of development, but they also stress that the main value of this heritage must always remain its cultural value. Cultural value includes not only the recognized historic, artistic, and aesthetic significance of heritage but also the meaningful role that cultural heritage plays in shaping the identity of a community or region. Preserving and promoting cultural heritage and local history can strengthen people's sense of belonging, which can have a positive impact on social cohesion and psychological well-being [6].

Therefore, the strategic potential of cultural heritage as an economic driver must be considered inseparably from the social development of the communities that are linked to it [7–9]. In the end, socioeconomic development in relation to heritage is about how the proper preservation and promotion of heritage can contribute to economic growth while favoring social and cultural well-being and encouraging the identity of a community or region [10].

Socioeconomic development linked to cultural heritage represents, on a theoretical level, a path of sustainable progress, because it arises from the specific values of a place and is associated with the activities, customs, and lifestyle of the local population [11]. However, in many cases, the social dimension of development is not sufficiently considered, even to the point of being compromised [12]. Heritage management overly focused on economic growth has ended up creating situations of the saturation and overexploitation of heritage elements and spaces [13] or the trivialization of cultural legacy through tourist discourses with excessive commercial vocation [14]. These situations are often of particular concern in iconic heritage sites such as UNESCO World Heritage sites [15] or the historic centers of many cities [16–19]. This is a relevant issue in many cities and monumental sites around the world. Advancing toward the creation of new heritage management approaches that replace abusive practices in support of more sustainable and socially responsible ones is thus a current challenge in the heritage sphere [20].

Linking heritage management efforts to complex aspects such as identity and sense of belonging is an interdisciplinary task that requires the development of numerous different channels of work. Within this broad framework, we focus here on one of the agreed challenges, which is to move toward spatial and relational heritage readings, treating heritage as a territorial or urban system [21]. That is, to replace the individualistic and somewhat simplistic vision of cultural heritage that focuses exclusively on the most unique heritage pieces [22] with an integrative approach that, in the face of the situations of excessive pressure on iconic heritage spaces and buildings, allows for more cohesive and balanced heritage management [23,24]. In short, if we aspire for heritage to be a vector for sustainable development and social cohesion, the integral treatment of all the heritage elements in their general context is fundamental [25]. For these reasons, the variables of territory (whether urbanized), culture, and heritage must be managed with a unity of criteria when implementing projects in terms of sustainability. Given this current trend toward the interrelation of heritage assets of all kinds and nature in its spatial environment, it is logical that the notion of landscape, promoted in Europe by the Landscape Convention [26], has emerged as a strategic ally [27,28].

The field of geography, supported by a broad multidisciplinary framework [29], consolidated a solid theoretical corpus at the end of the twentieth century that conceives the landscape as a unique synthesis between natural and cultural components that interact dialectically and thus create the characteristic identity of a place and the population that inhabits it [30,31]. It also considers the landscape as a result of settlement dynamics, as ways of organization for the use of resources, and as communication structures—in short, a particular way of managing the territory that leaves its mark over time until it is endowed with unique and differentiated characteristics. For this reason, the landscape is today a useful framework for reflection and action to read heritage in a relational key, since it provides, among other aspects, the necessary approach to recognize the invisible links that exist between physical heritage elements and that have to do with the processes of historical configuration of the territory and the city [32].

In addition to the theoretical and practical body of work generated around the concept of landscape, it is also appropriate to consider the concept of territorial heritage. Until recently, this term was not widely recognized in the international scientific literature and was more closely associated with the specific context of certain Mediterranean countries with historic traditions in cultural and heritage management, such as Spain and Italy [17,33–35]. However, recent advances and developments may progressively be solidifying this term on the international stage [36–39]. The term 'territorial heritage' refers to the idea that the cultural and natural heritage of a region is not limited to individual sites and monuments

but is intrinsically linked to the landscape and the territory as a whole. This implies that heritage is not solely understood as historical monuments but as a collection of cultural and natural elements that contribute to the identity and history of a region. It represents a more holistic view of heritage, recognizing the interconnectedness between history, culture, and the environment [40–43].

The goal of this study is to advance on how to materialize these aspirations of relationality and spatiality in heritage management. The objective is framed within the general challenge of advancing toward new dynamics of heritage management where economic development can coexist in a more balanced way with the existing territorial and urban dynamics and structures, which are linked to the local population.

Regarding the aspiration of relationality, some taxonomic studies dedicated to the generation of heritage networks through standardization and semantic classification processes in digital databases have already been published [44,45]. Other available studies also deal with detecting relationships between heritage assets but using historical research and landscape analysis [46–49]. The issue of spatiality is especially present in landscape-based investigations as well as in other studies that pay greater attention to the possibilities generated by the creation of heritage networks and systems for the design of tourist-recreational resources, such as cultural itineraries [50–52].

In this text, a method for the conceptualization and configuration of digital heritage inventories on a supra-municipal scale is presented, with the aspiration of increasing the capacity of these tools to support integrative readings of heritage. The following section presents the methodology carried out, which consists of three work phases: conceptualization and generation of the database that supports the inventory (1); definition of heritage networks in the territory (2); research on heritage–territory relationships using graph theory. The results section shows the implementation of this methodology on the fluvial area of the Lower Guadalquivir in southern Spain. The discussion offers a reflection on the potential of the digital heritage inventories generated by this method to move toward new models of heritage management with a comprehensive and territorial approach, valuing its potential usefulness for sectors committed to the generation of heritage narratives such as cultural tourism.

2. Materials and Methods

The work methodology is developed in a GIS environment, as it is the tool that allows for the most efficient concentration of large volumes of georeferenced information with associated metadata. In addition, this environment allows for the spatial analysis of such information. The proposed methodology is organized as follows:

2.1. Phase I—Conceptualization and Generation of the Database

The first phase consists of processing the available information on the immovable cultural heritage of a region. Therefore, it is clarified that this study is dedicated to the tangible heritage elements of the territory. It is considered that these elements are in turn bearers of intangible values that can be integrated into the interpretative narratives built around the future networks, but the nature of this study forces us to consider only elements that can be accurately georeferenced. The format of the new inventory is that of a standard digitalized geographic information model, so this first phase includes the possible need to transfer heritage information contained in other media, such as physical catalogs, to this work environment. The criteria that have determined the current classification system of the collected information should be reviewed. Typically, the disparate nature of catalogued heritage elements is mitigated to some extent by classifying their features in several common fields. The existing classification system of the collected heritage information is used as a starting point when obtaining a more complex and structured relational database, which may imply the need to collect new data on the heritage assets. It is not possible to establish a predefined classification system here since it will depend on the specific cultural characteristics of the working region.

The newly generated database does not intend to constitute the reference heritage inventory of a specific area but rather is proposed as an operational instrument in coexistence with other records of a more descriptive nature. Among these, we primarily refer to the heritage inventories already compiled for a specific region or locality by public authorities. These inventories are typically oriented toward a descriptive compilation of heritage for cataloging, protection, and conservation purposes. The purpose of the work presented in this paper is not the extensive identification of all the immovable heritage assets of a place and their characteristics but is a complementary treatment of heritage information that generates effective relationships between the assets, to then build new heritage narratives with an integrating vocation.

2.2. Phase II—Definition of Heritage Networks

The next phase uses spatial analysis to specify a series of heritage networks in the territory. The concept of a heritage network has already been presented in the scientific literature. There are numerous approaches that use it from a digital perspective, as a mechanism of interrelation that aggregates the heritage data on the spatial model and presents it in a numerical, connected system. In this research, heritage networks are defined as groupings of physical heritage elements that have a connection between them determined by characteristics of the territory and confirmed by historical research. For example, the group of human settlements, mobility, and exploitation infrastructures historically generated along a river to ensure the supply and communication of populations could be considered a heritage network associated with the river. Therefore, it is important to clarify that networks are not a mere grouping of heritage elements with common typological, thematic, or historical characteristics, but for these groupings to be constituted as a heritage network, there must also be:

- A territorial structure that supports the links. For this reason, the working environment is inevitably a Geographic Information System, since it is necessary to analyze the relationship between the location and spatial distribution of the grouped heritage elements with respect to the topographical, geomorphological, hydrographic, climatic, etc., characteristics of the territory. Accordingly, the purpose of this study is not to recognize sets of heritage assets that are distributed heterogeneously in the territory and whose common denominator is, for example, a specific heritage typology. The heritage network concept focuses on detecting patterns in the distribution of heritage elements that can be related to the morphological configuration of the territory.
- A historical connection between these heritage elements resulting from territorial linkages. This will be confirmed through historical research primarily using cartographic sources.

Consequently, the methodological process of this phase is conducted as follows: once the database is generated (Phase I) and all layers of information related to the morphological and environmental configuration of the territory are loaded into the GIS workspace, spatial analyses are carried out to detect links between the distribution of heritage assets and the characteristics of the territory. Subsequently, these links are examined from a historical–archaeological perspective to determine if there is historical evidence supporting the detected connections. For example, spatial analysis detects a visual relationship between different defensive heritage elements. Later, historical maps and other documentary sources are reviewed to confirm if this visual link has been active and during which specific moments in history, thus creating interpretive connections that will ultimately generate heritage narratives. It is at this point that the method moves on to Phase III.

2.3. Phase III—Investigation of Heritage–Territory Relationships in Networks Using Graphs

The ultimate objective of this methodology is to construct an interpretative narrative for each of the defined heritage networks. In this regard, the spatial analysis allows us to assess what type of territorial relationships have been more intense or of greater historical depth compared to other more superficial ones, which makes it possible to hierarchize

the originally detected links. The formalization of this hierarchy between heritage links could be approached manually, but there are tools that optimize these processes, bringing us closer to a more complete and systematic understanding of them. In this regard, this methodology proposes the application of graph theory as a third phase of work. As a branch of mathematics, graph theory focuses on the study of relationships between objects or entities through structures called graphs. A graph is made up of nodes or vertices, which represent the entities, and edges or arcs, which represent the connections or relationships between these entities.

Graph theory has been particularly employed for network analysis and pattern detection. A foundational reference for this work is the text by Ferrera and Pinto [53], in which a pioneering methodology is presented based on the use of GIS tools and graphs for the detection of heritage links and the generation of new heritage narratives by uncovering hidden relationships. This referenced article outlines the creation of a database management system (DBMS) used as the underpinning framework for a dynamic spatial model, or a Historical Geographic Information System (HGIS). Additionally, it discusses an abstract-relational model, or dynamic graph model, which allows historians and architects to gain insights into and analyze the intricacies of built heritage at a territorial level.

Applying graph theory in this field of work allows us, firstly, to make the relationships between heritage elements visible, and determine whether they have a thematic, historical, typological, functional, etc., basis. Secondly, the graph methodology further supports the hierarchization and grouping of elements through network analysis [54], thus contributing to the construction of common narratives between heritage resources. These narratives will prove useful, among other aspects, in the design of strategies and activities that reinforce the contextual and relational understanding of immovable heritage, such as cultural itineraries. In the case of areas where the spatial distribution of heritage is dispersed, the use of graph theory becomes especially convenient, since it facilitates the visualization of connections between heritage elements that may not be as evident in such cases. This can assist in generating shared interpretative discourses, thereby advancing toward enhanced territorial cohesion.

Finally, it is necessary to indicate that, to obtain relevant interpretative narratives, it is essential to take care of the quality and precision of the metadata of the spatial elements, which in this case were generated during the first phase of work. A complete and accurate database guarantees the effectiveness of the application of graph theory in the relational study of immovable cultural heritage, enriching the possible readings and consequently guaranteeing a better conservation of its values.

3. Results

3.1. Field of Study: The Lower Guadalquivir

The Guadalquivir River is the main river course in southern Spain. It is in the region of Andalusia, and it runs from east to west along its 657 km length. Given its great extension, the river crosses territories with very different physical and environmental conditions, so it is usual to differentiate in it three courses: high, medium, and low. This research focuses on the lower course, which begins at the entrance of the river in the province of Seville and moves through the municipality of Peñaflor until its mouth in Sanlúcar de Barrameda (Figure 1). The case study area comprises 72 municipalities covering a total of 8900.9 km^2.

In the first section of the Lower Guadalquivir, the river runs close to several rural municipalities of low population density, very close to the Sierra Norte of Seville. In the second section, the river passes through the west side of the city of Seville, the largest urban agglomeration in southern Spain, leaving many towns in the city's metropolitan area on its right. This study does not include the heritage assets of the city of Seville, considering that the urban area has unique heritage characteristics and processes that must be analyzed separately. In its third and final section, the river reaches a semi-swampy area called the Guadalquivir Marshes and flows into the Atlantic Ocean in Sanlúcar de Barrameda.

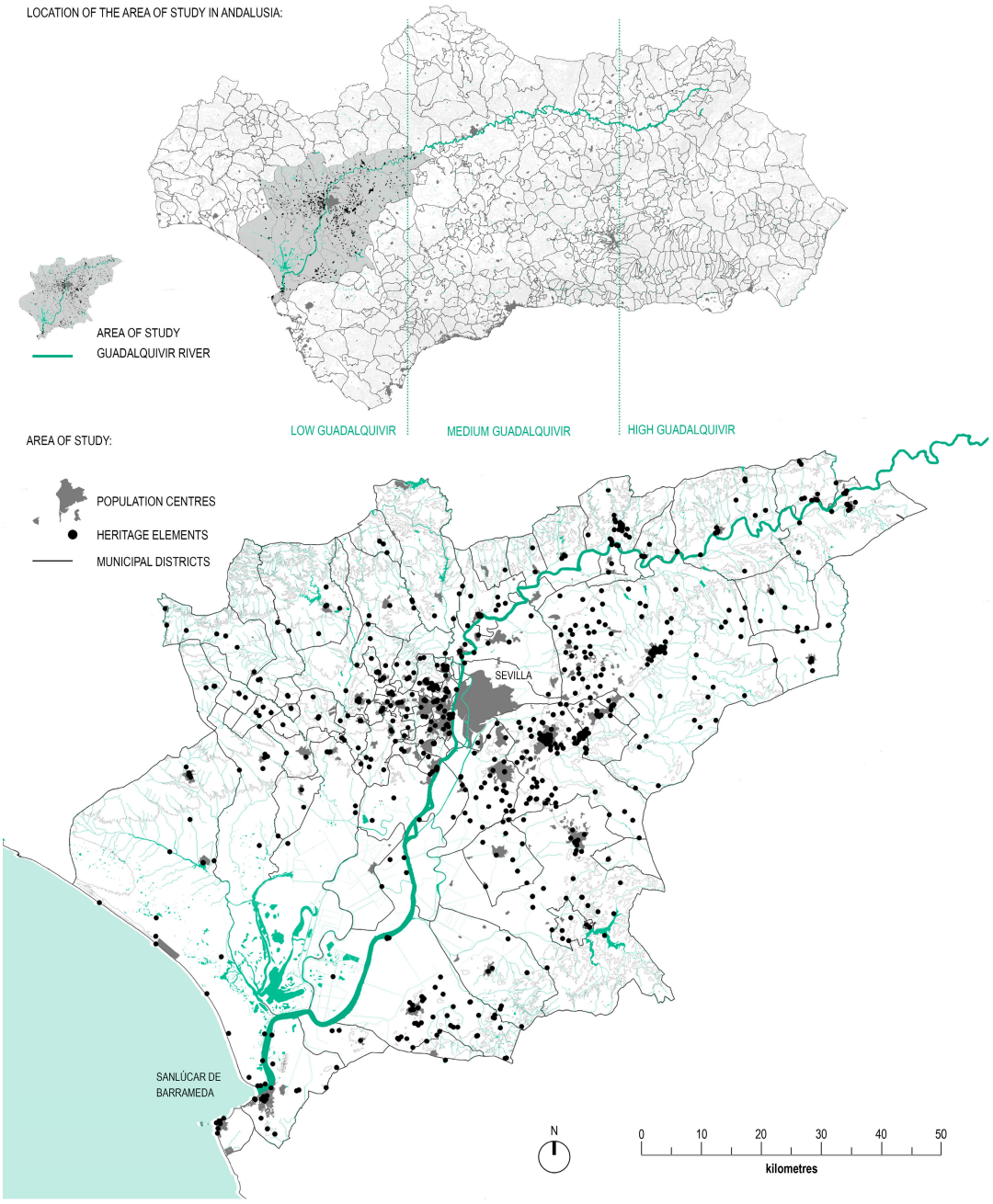

Figure 1. Scope of study. Source: Authorship, 2023.

The Lower Guadalquivir is an area with great landscape diversity and an intense historical depth. The heterogeneity of its cultural landscape and the diversity of its heritage elements in terms of typologies, historical periods, etc., make it an interesting area of study for identifying heritage connections and shared narratives.

3.2. Phase I—Conceptualization and Generation of the Database

The first task of this phase consisted of the recovery of the available information on the immovable heritage of the Lower Guadalquivir. The area is in Andalusia, where the documentation of cultural heritage is carried out by the Andalusian Institute of Historical Heritage (IAPH) [55]. This Institution, in collaboration with other public and private bodies and organizations, has carried out the task of identifying, systematizing, and georeferencing a wide set of data corresponding to the immovable heritage assets of Andalusia [56]. These data can be requested for research purposes from the IAPH Center for Documentation and

Studies. In this way, on 26 January 2022, the shapefiles of the heritage assets inventoried by the IAPH included in the scope of the study were received, together with their data model. The first task consisted of examining these files with the aim of hiding in the new database those heritage elements not currently visible and, therefore, not susceptible to be included in heritage interpretation processes. Most of these assets corresponded to hidden archaeological records, whose location is also approximate due to security and protection criteria. All features were also geometrically matched. The IAPH provided two layers of georeferenced information, one of points and the other polygonal. Although the information on the approximate areas occupied by some heritage elements is very valuable, the specific objectives of this study make it more efficient to reduce all heritage elements to points, which in the case of areas correspond to their centroid. Once these steps were developed, a total of 590 heritage elements were obtained.

Regarding this content, it should be noted that, although the IAPH database is very complete, it understandably presents a greater development in the heritage elements on which there has traditionally been a greater cataloging and documentation effort, such as archaeological records, or in those on which specific research efforts have been carried out. An example is that the IAPH database is very extensive regarding rural agricultural architecture because it integrates the *Catalog of Country Houses, Farms and Vineyards* [57], a study-inventory developed between 1991 and 2002 that addresses an exhaustive record and analysis of the most significant pieces of agricultural architecture dispersed in the Andalusian rural environment. In order to complete and balance the available information, a documentary study has been carried out that includes:

- The review of research papers focused on the study area [58,59].
- The review of archaeological charts, municipal planning, and other regulatory instruments that may contain catalogs and heritage inventories.
- The review of heritage catalogues/registers/atlases such as the *Catalog of Landscapes of Seville* [60], or the *Atlas of the History of the Territory of Andalusia* [61].
- The review of historical cartography of the study area.
- The complementary review of some data published by citizens on the main geolocation digital applications, such as Google Maps.
- The review of local tourist sources using brochures and catalogs, both physical and digital.

Following the review of the information, the number of items in the database increased from 590 to a total of 866 heritage entities.

Subsequently, the classification criteria and the organizational scheme of the IAPH's table of attributes were revised and standardized. The cultural heritage inventoried by this Institution is registered for essentially descriptive purposes, and the information available on each property mainly refers to its historical–patrimonial qualities and its level of protection (Tables 1 and 2).

The new table of attributes includes, similar to the IAPH record, categories that characterize the element from the historical–patrimonial point of view. However, here, a homogenization of the original IAPH terms and classification schemes is produced so that historical, typological, and thematic links can be established more fluidly. The information available in the original table is analyzed and adapted to a new classification scheme with a more simplified thesaurus. So, most of the information gathered regarding historic period, classification, typology, and activity was already present in the IAPH database, and its compilation is therefore the result of the work of this Institution. In the work presented in this paper, what occurs is a revision of classification criteria and simplification of terms. On the other hand, information about the new heritage elements, those that were not included in the IAPH inventory and were located using the aforementioned documentary research, can be found in the same documentation to complete the attribute table. There is also a new section of 'Dynamization', which includes data on the current state of conservation and accessibility of the assets. In this way, the new table offers information on the up-to-date capacity of inventoried properties to be used under social and tourist dynamics (Tables 3 and 4).

Table 1. Table of attributes of the original files provided by the IAPH. Source: Authorship, 2023.

Information on the location of the heritage asset						
SHAPE	CHARACTER	CODE	PROV	MUN	PRMUN	NAME
Point Polygon	Architectural Archaeological Ethnological	Individual numeric code for each entity	Province	Municipality	Zip code	Name of the property
Descriptive information of the heritage asset						
ETHNIC GROUP	G_HIS_PER	S_HIS_PER	G_TYPOL	SP_TYPOL	ACTIVITY	STYLE
Main ethnicity	Recent prehistory Roman Era Middle Ages Modern Age Contemporary Age	Specific historical period	General typology	Specific typology	Main activity	Main style
Information on the level of protection of the heritage asset						
STATUS	FIGURE			LEG_TYPOL		
Registered Initiated	BIC * General Cataloging (Individual)			Legal typology		

* BIC: highest level of heritage protection in Spanish legislation.

Table 2. Example of the IAPH Table of Attributes applied to a heritage asset. Source: Authorship, 2023.

Information on the location of the heritage asset						
SHAPE	CHARACTER	CODE	PROV	MUN	PRMUN	NAME
Polygon	Architectural	410890006	Seville	Santiponce	41089	Old Monastery of San Isidoro del Campo
Descriptive information of the heritage asset						
ETHNIC GROUP	G_HIS_PER	S_HIS_PER	G_TYPOL	SP_TYPOL	ACTIVITY	STYLE
-	Middle Ages	Low Middle Ages	Religious buildings	Monasteries	Christian ceremony	Mudejar
Information on the level of protection of the heritage asset						
STATUS	FIGURE			LEG_TYPOL		
Registered	BIC			Monument		

Table 3. New table of attributes designed in Phase I of the methodology. Source: Authorship, 2023.

Information on the location of the heritage asset						
ID	NAME	MUN	X_COORD	Y_COORD	Area	PROTECTION STATUS
Individual numeric code for each entity	Name of the property	Municipality	X-coordinate	Y-coordinate	Area in m^2	BIC -
Characterization						
PERIOD	G_CLASSIF	G_TYPOLOGY		SP_TYPOLOGY		ACTIVITY STYLE
Prehistory Protohistory Roman Era Middle Ages Modern Age Contemporary Age	Archaeological heritage Architectural heritage Heritage infrastructure	Agricultural heritage Defensive heritage Religious heritage Civil heritage Residential heritage Industrial heritage Mobility infrastructure Water infrastructure		Specific typology		Main activity
Dynamization						
CONSERVATION STATUS		OPEN TO THE PUBLIC		ACCESIBILITY_TYPE		
Good Regular Bad		Yes No		Free In Person Concerted In Person Visual		

Table 4. Example of the new Table of Attributes applied to a heritage asset. Source: Authorship, 2023.

Information on the location of the heritage asset						
ID	NAME	MUN	X_COORD	Y_COORD	Area	HERITAGE_ SIGNIFICANCE
0009	Monastery of San Isidoro del Campo	Santiponce	231298	4147345	-	BIC
Characterization						
PERIOD	G_CLASSIF	G_TYPOLOGY	SP_TYPOLOGY			ACTIVITY
Middle Ages	Architectural heritage	Religious heritage	Monasteries			Devotional Practice
Dynamization						
CONSERVATION STATUS		ACCESSIBILITY	ACCESIBILITY_TYPE			
Regular		Yes	Concerted In Person			

3.3. Phase II—Definition of Heritage Networks

In order to advance in the conceptualization of interpretative narratives that offer new ways of reading and understanding the cultural content and meaning of the landscape, the next phase analyzes the correspondence between the spatial distribution of the heritage elements and the physical characteristics of the territory. The contrast of these results with historical information allows us to define eight heritage networks (Table 5).

Table 5. Defined heritage networks. Source: Authorship, 2023.

Heritage Network	Link	Territorial Reference	Synthetic Description of the Network
1. The historical depth of Los Alcores	Typology: Archaeological heritage	Escarpment of Los Alcores	The escarpment of Los Alcores, occupied by humans since prehistoric times, is the result of the superposition of numerous historical layers that today can be read through a heterogeneous heritage set that highlights the defensive and mining capacity of the place. Likewise, the heritage legacy in this escarpment stands out for concentrating a significant amount of funerary goods.
2. The historical depth of the Aljarafe	Typology: Archaeological heritage	Aljarafe ledge	The strategic position of this enclave gives rise to important archaeological evidence, such as the Chalcolithic funerary complex of Valencina de la Concepción, the protohistoric site of Carambolo, or the Roman site of Itálica. All of them build a very complete reading of the ancient history of the left bank of the Guadalquivir River.
3. The border defensive system of the Moorish Band	Typological and historical: Defensive heritage + Middle Ages	Moorish Band	After the conquest of the Guadalquivir valley in the first half of the thirteenth century and the capture of Seville in 1248 by Fernando III, a border mark was established between the Christian area and the incipient Nasrid kingdom, the so-called Moorish Band. The watchtowers, isolated and far from inhabited centers, integrated into the rural environment of Utrera, are testimonies of the first line of defense of the Band, controlled by the Council of Seville.

Table 5. *Cont.*

Heritage Network	Link	Territorial Reference	Synthetic Description of the Network
4. Coastal surveillance of the Andalusian Atlantic coast	Typology: Defensive heritage	Coastline Between Gibraltar and Ayamonte	In the sixteenth century, King Philip II ordered the construction of a line of defense towers on the Atlantic coast, an obligatory passage for trade between Europe and America. The need to protect the coast is maintained in subsequent confrontations, and today bunkers and other defensive elements that correspond to World War II are also found in the area.
5. The productive infrastructure of the Guadaira River	Typology: Mills and Factories	Guadaira River	On the banks of the Guadaira River, as it passes through the town of Alcalá de Guadaira, there are about twenty Arab mills that were used to grind wheat. This fact facilitated the location of numerous bakeries and flour mills, becoming known as 'Alcalá of the Bakers'. This flour tradition lasted until contemporary times.
6. Groundwater in Lebrija	Typology: Water Wells	Lebrija Aquifer	The Lebrija underground aquifer establishes a close relationship between this area and the water, which functions as a common thread between the agricultural cultural heritage of the wells and the natural heritage of nearby lagoons such as Val de Ojos and Los Tollos.
7. The mining heritage of the Sierra Norte of Seville	Typology: Industrial heritage	Sierra norte of Seville	The Sierra Norte of Sevilla is a geological space where the use of mineral resources dates back to the beginning of the metal age. Since then, this mountain range has been linked to different extractive processes. In the foothills of the Sierra, enclaves such as Villanueva del Río y Minas, Gerena or Aznalcóllar stand out.
8. The paradigm of the Hacienda from Los Alcores to Aljarafe	Typology: Agricultural Heritage and Farms	Escarpment of Los Alcores and Aljarafe ledge	The Hacienda is the most characteristic agricultural typology of the Sevillian landscape, and in the Lower Guadalquivir it has certain architectural and productive particularities that can be explained from the geomorphological characteristics and historical evolution of the environments where they are located.

The first networks that have been defined are those that recognize the primitive anthropic occupations of the territory. Filtering by the typology 'Archaeological heritage' detects a distribution of heritage elements fully consistent with the orographic structure of the environment: the fertile plain of the Guadalquivir River is an essentially flat territory and, in our area of study, the Aljarafe ledge and the escarpment of Los Alcores are the only elevations that stand out in the landscape. These were the first enclaves to be occupied and, therefore, those that today concentrate most of the archaeological evidence in the area. The linking of these archaeological remains in a network allows for a better understanding of the significance that conditions tied to the territory, such as the visibility of the site and its consequent defensive capability, played in prehistoric settlements.

On the other hand, the advanced filters that allow simultaneous combinations show how the heritage typology 'Defensive Heritage', crossed with the historical periods, generates heritage sets that, contrasted with the layers of topographical, altimetric, and orographic information, allow for conceptualizing different heritage networks that highlight the need to control the points of greater visibility of the territory. Thirdly, we focus on detecting heritage structures linked to water. Strong associations are found between heritage sites associated with the specific typology 'Mills' and the bed of the Guadaira River, a tributary of the Guadalquivir River. Research on the origin of these mills recognizes their close link with bread production, which allows for establishing an association between these mills of Islamic origin and the flour-making tradition of the area, which continued until contemporary periods (Figure 2). Continuing with the theme of water, a concentration of water wells in the surroundings of Lebrija is also noticed. When studying the hydrogeology of the area, the presence of an aquifer of Quaternary origin is detected, which allows for linking these extractive operations with other hydrological spaces in the area.

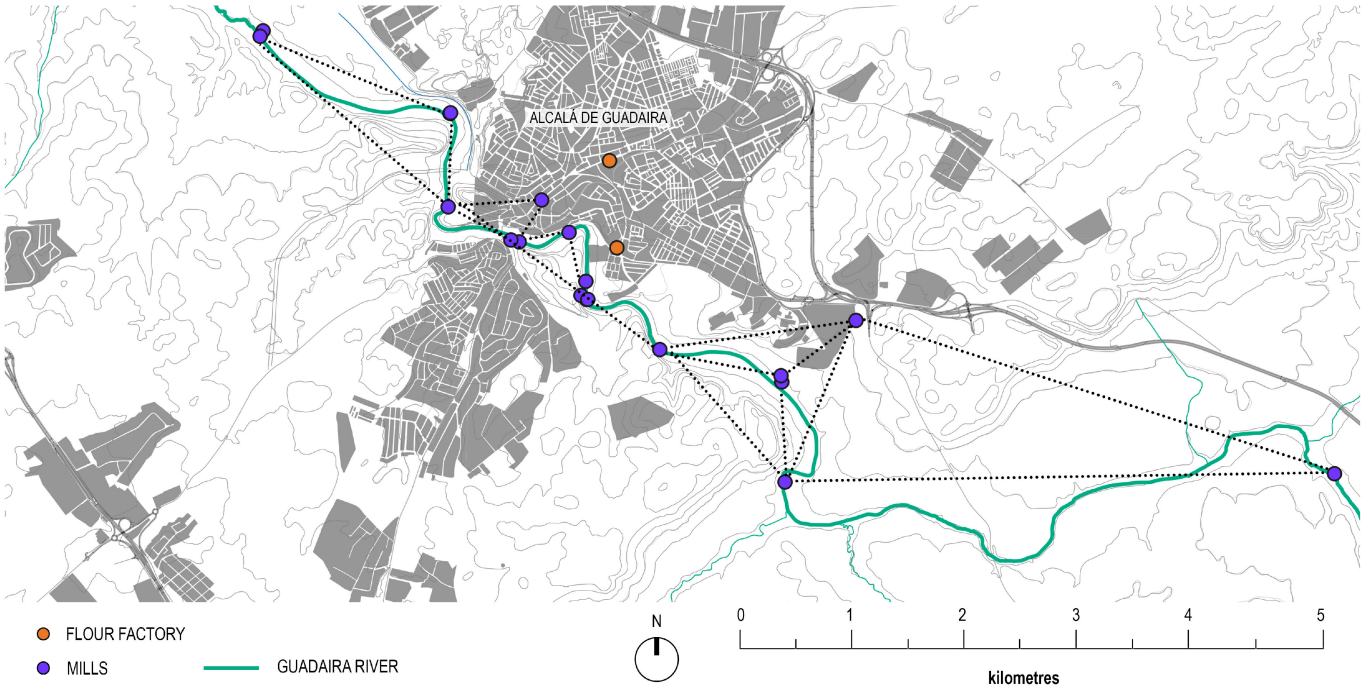

Figure 2. Cartography corresponding to the network 'The productive infrastructure of the Guadaira River' as an example of visual representation of the networks. Source: Authorship, 2023.

Following this work methodology, it is possible to continue locating other heritage networks of interest. Through the analysis of the distribution of the entities corresponding to 'Industrial Heritage' together with the topographic layers, the close relationship between the northern Sevillian mountain range and mining exploitation is identified. Finally, the location of heritage elements under the filters 'Agricultural heritage' and 'Haciendas'—agricultural constructions associated with oil production—recognizes the uniqueness of the two promontories of Los Alcores and Aljarafe, whose soil composition gives rise to very similar agricultural uses, with a marked proliferation of olive groves (Figures 3 and 4).

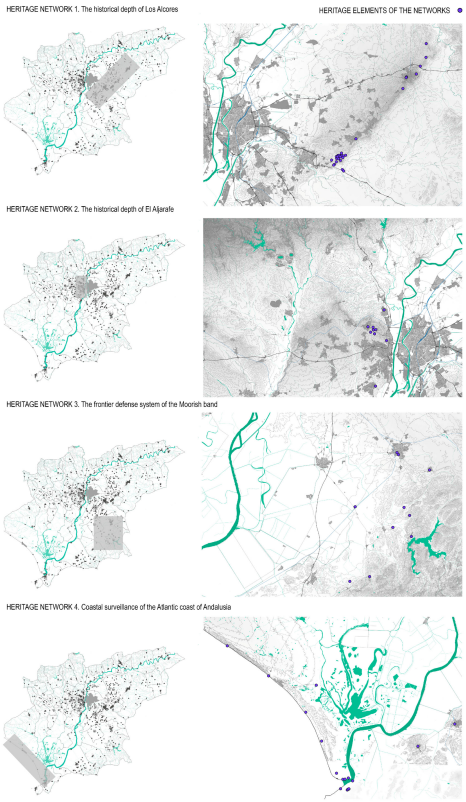

Figure 3. Location diagrams of defined networks (**1**–**4**). Source: Authorship, 2023.

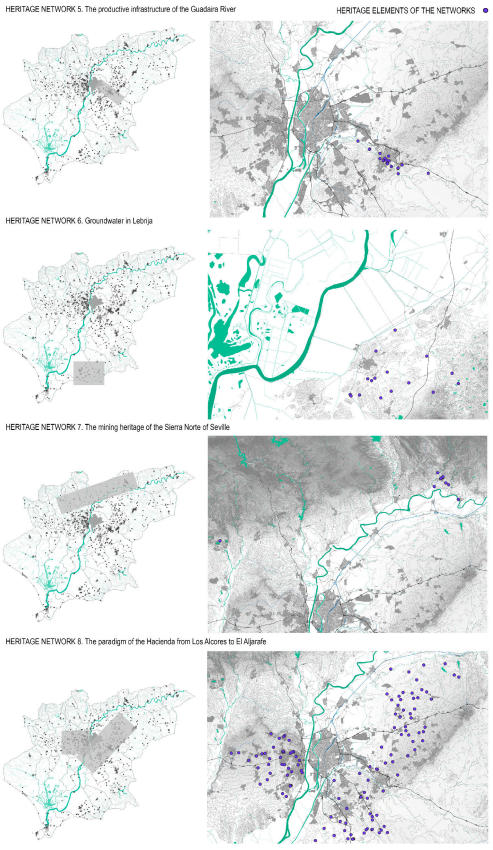

Figure 4. Location diagrams of defined networks (**5**–**8**). Source: Authorship, 2023.

3.4. Phase III—Investigation of Heritage–Territory Relationships in Networks Using Graphs

The objective of this phase is to access an advanced knowledge of the heritage networks defined in the previous phase using the graph theory, for which the free software Gephi in its version v 0.10 has been used. The used information comes from the attribute tables defined in the first phase of the methodology. Data analysis using graphs, together with their associated spatial analysis operations, can help to reveal relational patterns that cannot be detected using the methodology employed in the previous phase. Furthermore, this information is updatable: as new elements or features are added, the graph approach allows for seamlessly updating and continuously re-evaluating the relationships established in the networks.

The methodology is applied in a scalar way on each of the networks. Three sequential graphs are made for each of them, exploring, for each of the scales, the relationships between the elements of the network, as well as between these and the territory. Subsequently, the distances have been grouped into the following sections: less than 500 m, between 500 and 2000 m, and between 2000 and 10,000 m. Upon analyzing the graph, we can observe that certain typologies are concurrently associated with different types of assets, while others are solely linked to a specific range of distances. This observation implies that typologies exclusively tied to a specific distance range from the water only include assets located within that particular distance, indicating a pattern. Conversely, those typologies associated with all three distance groups suggest that they do not adhere to a specific pattern and, as a result, are not related to distance from the water.

Different combinations of thematic information have been studied at each scale, to which different weights have been attributed according to their importance in order to establish hierarchies and coherent groupings between elements. The weights assigned to each group of attributes serve as weighting factors and determine the extent to which each kind of relationship between attributes can influence the formation of groups—or modularity classes—in the network. Therefore, the criterion for assigning these weights is based on thematic relevance. It is important to note that this criterion is quite subjective and may vary depending on the objectives pursued when applying this methodology. Furthermore, these weights may vary at each scale depending on which one is considered to have a greater impact.

The three scales of approach to the networks are described below, using network 5 as an illustrative example.

The first scale (Figure 5) covers all the available information on the heritage assets, including all the data presented in Table 3 (classification, general typology, specific typology and activity). A new attribute is added to these data: the distance of the different elements from the nearest freshwater access point. These data, added in a new column of the attribute table, were previously calculated by means of a geoprocess in QGIS software that calculates the length of the closest axis between the layer of heritage elements and the linear hydrography layer provided by the DERA repository (Spatial Reference Data of Andalusia).

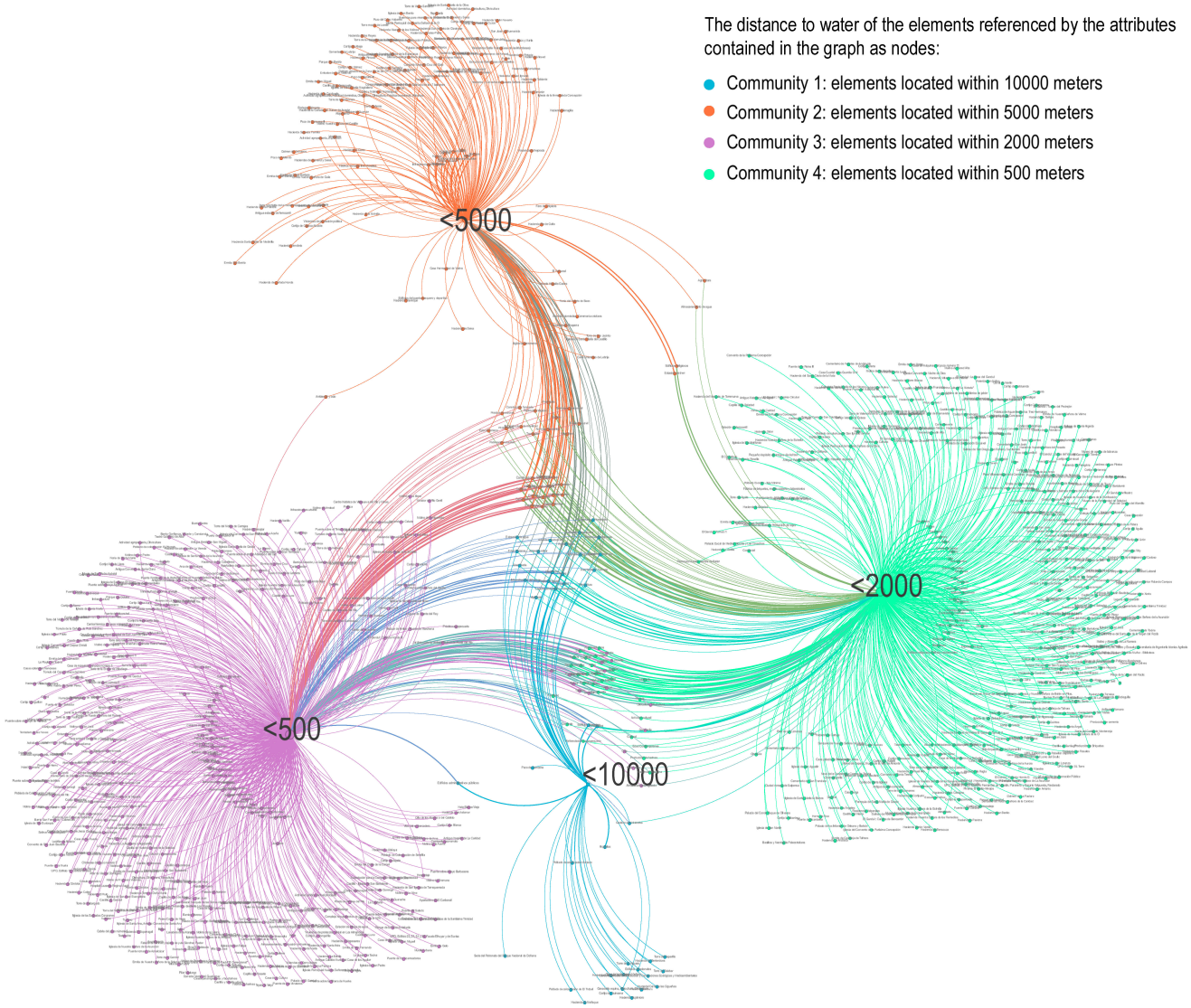

Figure 5. Graph of the relationships established between the heritage elements of the territorial area according to their classification, typology, activity and distance to the nearest hydrographic elements. Scale 1/3. Source: Authorship, 2023.

Relating this geographic information to the characteristics of the heritage assets allows us to study whether the physical territorial structures have supported the territorial relationships between pieces of heritage. In this case (Figure 5), we can quickly identify the amount of data associated with each of the communities (in this case, ranges of distance to water) and which of them are simultaneously related to multiple categories. From this observation, we can conclude that there is a pattern in the sense that many typologies are associated with a single distance to water, suggesting a trend. In the case of those related to multiple distances to water, we can infer that they do not follow a specific pattern, implying that the territorial structure (in this case, the course of water) does not significantly influence the choice of specific locations for assets. On the other hand, for those assets that do use this feature as a criterion, we can affirm that there is a territorial structure that acts as support for their relationships with other assets sharing this characteristic. In the same way, it is possible to study whether they generate additional territorial structures such as settlements, communication routes, land use, etc. The fact that the graph analysis is highly visual facilitates the interpretation of these results in a clear and understandable way since the resulting graphical representations highlight relevant nodes and connections. Each of

the characteristics of the attribute table will function as a node of the network, which will have greater or lesser weight according to their presence in each network.

The network detected four communities that are differentiated by color (1, 2, 3 and 4). The communities—or modularity classes—are defined automatically by the algorithm of Blondel et al. [62], grouping elements that have different combinations of characteristics in common. Each of them corresponds to a distance section of the nearest hydrographic element (in this case, rivers). This visualization makes it easier to associate specific elements with each other that are more closely related to water. On the other hand, the nodes that are associated with several communities at the same time correspond to the characteristics found in the fields of the attribute table, such as typologies, activities, etc. As can be seen, some of them are found exclusively in specific distance sections, which means that they follow patterns that will be investigated in the following graph.

The communities suggested by the software reveal relationships among attributes that, despite having a logical explanation, may not be immediately evident. In this case, Community 1 and 2 primarily groups typologies related to agricultural activity, defense, or religious practices, including predominant types such as farmhouses, castles, and convents. Furthermore, these are associated with a greater distance from water sources. Community 3 predominantly encompasses urban facilities and those related to production or funeral practices, correlating with an intermediate distance to water. Community 4, on the other hand, includes facilities similar to those in Community 3, with mills being a notable and distinguishing element, connected in turn to a closer proximity to water sources. Similar conclusions are provided in graph of Figure 6 with communities 5, 6, 7 and 8. In the case of Figure 7, however, the themes from which the communities are created change, in this instance, being the historical periods to which they belong. We observe that from the Middle Ages (Community 9), only windmills are preserved, in the modern age (Community 10), predominantly windmills but also some estates, and in the Contemporary period (Community 11), windmills are replaced by flour mills and other types of infrastructure.

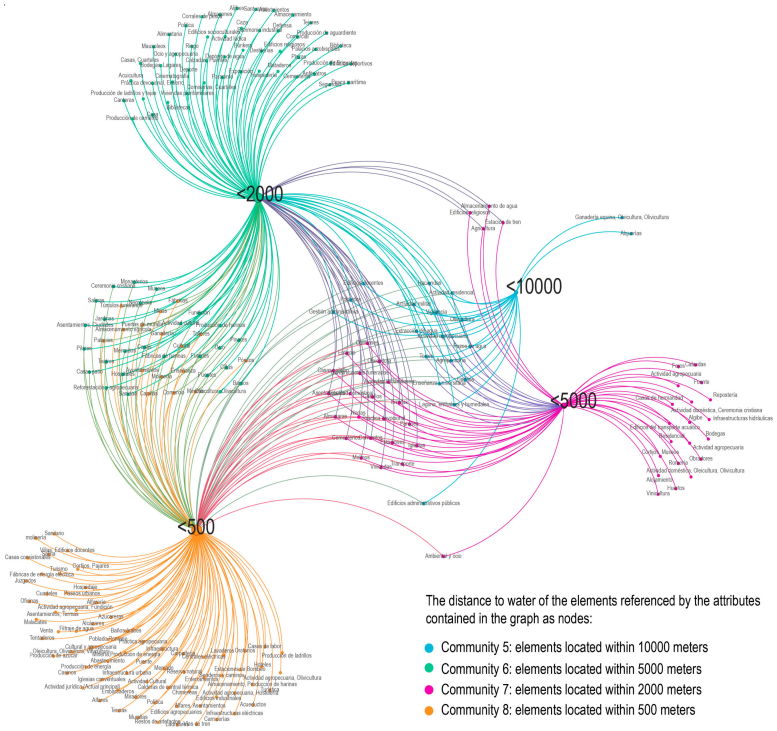

Figure 6. Graph of the relationships established between the most frequent typologies and activities in the territory, according to their distance from the nearest hydrographic element. Scale 2/3. Source: Authorship, 2023.

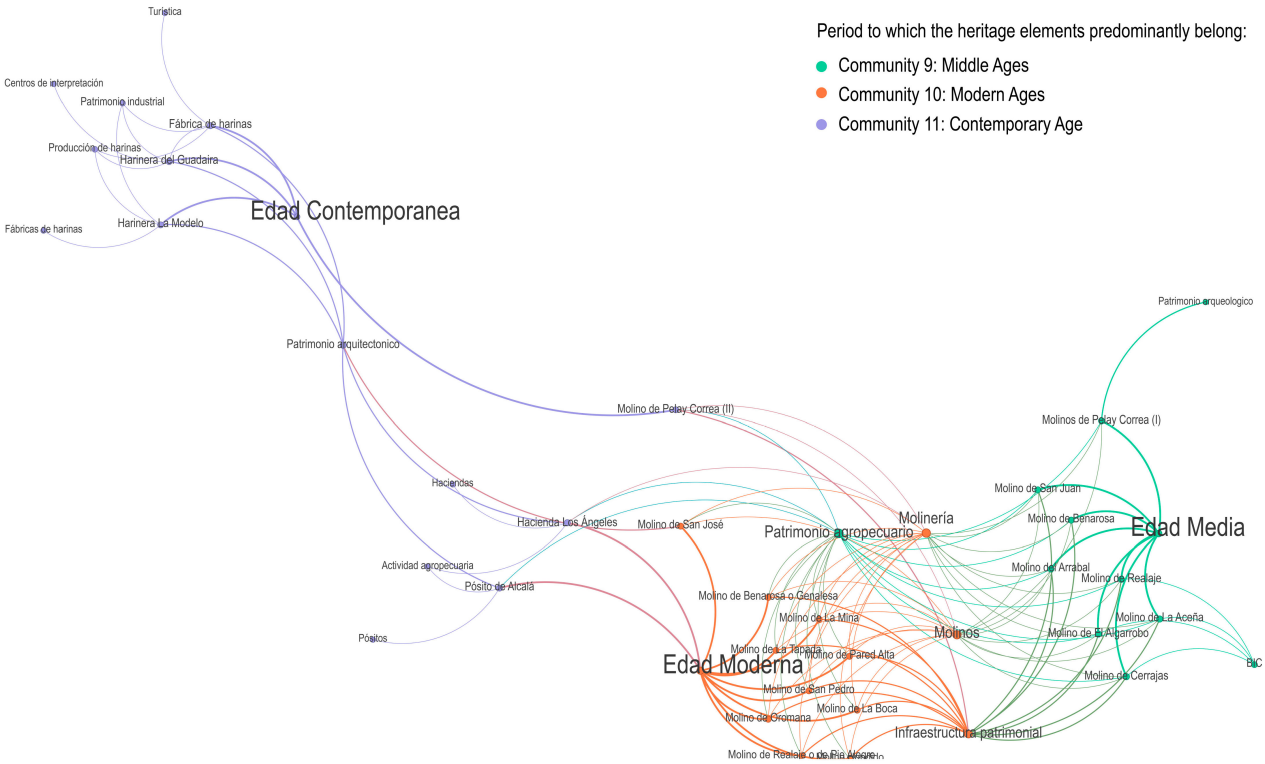

Figure 7. Graph of the relationships established between the heritage elements of network 5. Scale 3/3. Source: Authorship, 2023.

The relationship between water distance and the detected communities underscores the significance of water as a significant territorial factor capable of clustering heritage elements. While it is evident that other determinants can also influence distribution, this observation emphasizes water's role as a unifying element in shaping the heritage landscape. These findings encourage more in-depth and contextualized research that takes into account both the role of water and other factors to gain a more comprehensive understanding of how heritage elements are organized and related within a specific territory. In this regard, the use of graphs proves to be a fundamental tool for addressing this issue in depth.

At the intermediate scale (Figure 6), the specific typology of the heritage elements is connected to the activity and the distance to the water. Again, the graph detects three communities whose main criterion is the distance to the nearest hydrographic element. Observing which elements belong to each community, it is possible to appreciate that the activities and typologies closest to the water are more linked to urban facilities and functions, since most urban settlements have had their origins in places close to a river. Likewise, we find those that require the presence of water currents (mills) and their derived facilities (flour mills, flour storage, etc.). On the other hand, at points farther away from the rivers, we find activities and typologies of elements that do not require the presence of water nearby, such as military installations, funerary facilities, agricultural activities related to orchards, winemaking, etc.

In the third scale (Figure 7), the elements located in the area of Alcalá de Guadaira are related to their characteristics (period, classification, general typology, specific typology and activity, BIC declaration). In this case, the detected communities have historical periods as a common thematic point. It can be observed that those with the most associated elements—mainly mills—are those corresponding to the Middle Ages and the modern period. Those corresponding to the Middle Ages are exclusively mills, some of them declared BIC. In the modern age, we find, in addition to mills, other storage infrastructures such as water tanks. On the other hand, the contemporary heritage mainly includes architecture

for the industrial production of flour. This chronological sequence of architectures and infrastructures linked to grain, revealed through the analysis of the graph, provides us with a vision of its evolution over time, advancing the understanding of the relationship between the historical transformation of the studied area and water.

Finally, it should be noted that the concluding readings of each analyzed case are conditioned by the combinations of information that this research decided to employ. This idea allows access to infinite combinations of thematic information, which enables genuine material to create new narratives on landscape and heritage.

4. Discussion

Heritage must be able to channel new functionalities, whether tourist, leisure, cultural, landscape, or environmental, representing a clear and differentiated role in current territorial structures. Faced with a traditional approach that is practically selective toward heritage in the processes of territorial planning and development—as an obstacle within the limits of whose protection it is not possible to act—we must move toward new processes that value heritage as an active agent of change for the current city and territory, integrating it into social dynamics and ecological processes [63]. In other words, reducing heritage elements to isolated pieces ends up leaving them on the margins of contemporaneity, and therefore heritage must be understood as a component of spatial quality [64]. This means that moving beyond the understanding of heritage as a singular element to perceive it as a territorial or urban system necessitates advancing in heritage management and interpretation models of spatial dimension. As it is not proving easy to find an effective balance between cultural heritage elements and their surroundings, be it in cities or rural areas [65], the historical and current relationships between heritage and its spatial context should be examined since they can reveal keys to its contemporary organization and activation [66].

Regarding this, the current study contributes to the development of the heritage network concept and proposes a structured methodology consisting of three work phases that coordinate the use of commonly used digital tools in the heritage field today (GIS and Gephi) to advance toward heritage management models that are consistent with existing territorial structures. The proposed methodology, which can be applied and explored in other areas of work, not only involves georeferencing heritage elements but also analyses the relationship between their location and the characteristics of the territory to identify heritage connections that can later lead to innovative interpretations of heritage.

That is, the methodology presented in this study addresses physical structures as a first step, but intangible factors such as histories or traditions should be considered in a future second phase. Without the associated interpretive model—the historical narrative—physical forms and patterns progressively lose their meaning.

In this case study of the Lower Guadalquivir, it has been possible to verify how the defined networks, although they correspond to a first approach, generate multidisciplinary work environments to deepen the networked cultural characterization of the Lower Guadalquivir. The graph theory allows us to work on the relationships between heritage assets. These relationships will ultimately be confirmed by the historical study of the landscape, which will shed light on the reciprocal relationship between heritage, population, and territory. The historically oriented landscape analysis will define the spatial framework in which each heritage element has been established, its relationship with other elements, and the dialogue that society has maintained with it over time [67,68]. The methodology described, supported by georeferencing and spatial analysis, is proposed as a tool to support landscape research.

The defined networks should not be understood as already formulated tourism resources but rather as a working basis for promoting tourism-recreation planning strategies that, consistent with research frameworks, will create new scenarios for more flexible and decentralized heritage activation [69]. The study of contemporary social and tourist dynamics is fundamental to derive any of the eight defined networks in a territorial development strategy. Once again, the impossibility of advancing in this type of methodologies

without a multidisciplinary, multisectorial environment and under a multiscale work logic becomes evident.

In addition, the methodology applied offers a new layer of heritage information related to the levels of conservation and tourist accessibility. It is indicated in the new table of attributes if the heritage property is open to the public at certain times (free in-person access), if the visit is only possible by prior request (concerted in-person access), if the visit is not allowed and it is only possible to recognize it from outside (visual access), or if its contemplation is not even possible because it is inside a private enclosed area. This information has made it possible to verify that only 335 of the 866 registered heritage assets can be physically accessed. This confirms the need to build heritage frameworks in the territory that make it possible to extend the interpretative discourses of the heritage pieces that can currently be visited (which are those that nowadays build the tourist identity of the places) toward others that, although not equally significant, reinforce the understanding of heritage in relation to its urban and/or territorial context.

In conclusion, since this working methodology is presented as an opportunity to provide effective connections between heritage management and interpretation processes, it has the potential to serve as an effective bridge between the cultural administration and management sector and the tourism sector. Tourism is considered the primary sector in activating heritage assets and shaping their associated narratives, but it is not the only one worth considering. It is also interesting to explore synergies with the education and research sectors. Ultimately, one of the most promising applications of the methodology is its use as a shared resource among those sectors responsible for heritage administration, research, and preservation, along with those dedicated to strengthening the link between cultural heritage, citizenship, and its contemporary dynamics.

5. Conclusions

It is manifest that the renewal of ideas regarding the synergy between heritage and socio-economic development is required, including here the proclamation of the need to make changes in the current relations between territory, culture, society, heritage, and tourism. The search for harmonious relationships between these variables has a certain utopian dimension that can be only overcome from the field of decisions and practical applications where, however, progress is slower. In this regard, a line of work based on the reading of heritage as a system has been defined in recent years, delving into the relationships between heritage elements and territory because from these it is possible to move toward new models of heritage management with an integrating vocation. The invisible relationships between heritage elements are the support for renewed historical narratives that lead to more complete and balanced heritage interpretation processes. They also constitute the channel to understand heritage as an identity expression that goes beyond those areas or specific assets protected by a preservation figure due to their outstanding cultural or natural values, to be conceived as the territorial structure that, integrated by various material elements and intangible manifestations with different degrees of anthropization, expresses the interaction between natural and human factors that has occurred in a specific place. Under this approach, what is especially relevant is no longer the heritage piece itself but the territory in which it is located, consequently becoming its spatiality and relational character in matters of primary importance.

The current study clarifies the methodology developed for this line of work through its three work phases and shows its application in the Lower Guadalquivir, thus allowing for a visualization of its possibilities and limits. One of the main achievements of this work is the conceptualization of this integrative methodology. Among its limitations is the need to continue advancing, especially in the development of Phases II and III, and to ensure channels for its operability in the aforementioned specialized sectors and environments. This will require funding mechanisms that allow for the formation of different multidisciplinary teams and the development of various follow-up pathways. However, the generation of a georeferenced heritage inventory at a supra-municipal scale—the fun-

damental objective of this work—has been successfully completed within the study area of the Lower Guadalquivir, which represents a key advancement in the implementation of the methodology. Although the deepening of the results through the creation of transversal work environments and teams is a necessary line of development, the study of the Lower Guadalquivir confirms the viability of the methodology and its tools, which in turn ratifies its ability to extrapolate to other case study areas. Studying its application in complex heritage areas such as metropolitan areas of large cities is one of the ways to continue the work.

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