HISTORICAL SDI, THEMATIC MAPS AND ANALYSIS OF A COMPLEX NETWORK OF MEDIEVAL TOWERS (13TH-15TH CENTURY) IN THE MOORISH STRIP

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ABSTRACT:

This work is part of an investigation into the use of GIS for the documentation and comprehension of medieval architectural heritage in the ancient Kingdom of Seville. The research was done in the framework of the project "Sustainable guardianship of cultural heritage through digital BIM and GIS models: contribution to knowledge and social innovation", an interdisciplinary project focused on the applications of information technology in architectural heritage in Spain. The study case of this paper is located in the Guadalquivir valley during the period between 13th and 15th centuries. It concerns the Moorish Strip site, fortified by the Christian Kingdom of Castile with the aim of creating a barrier with the Moorish Kingdom. Its deteriorated state has led us to create a historical and spatial database in order to contribute to its conservation management plan. Apart from the historical documentation research and the data gathering, intensive fieldwork was also done to collect information about the buildings. In this paper we present a Historical SDI to investigate the hypothesis that the spatial patterns of the Moorish Band obey rules of "inter-visibility" control. Some analysis has been done on the site scale, such as: i) a thematic map of building material; ii) a spatiotemporal analysis; iii) the density of the distribution of towers over the territory; iv) a simulation of the territory visibility from the towers; v) the inter-visibility among towers; iv) thematic maps using attribute values. These analyses permitted us to highlight the need to create a preservation plan that should consider the network visibility system as an important value for heritage interpretation and knowledge.

1. INTRODUCTION

This project presents the description and analysis of the Moorish Strip, built by the Christian Kingdom of Castile and Leon between the 13th and 15th. centuries, a system of defensive architecture located in the Guadalquivir valley [about 47.2484 ha]. It is part of the R&D&i research project "Sustainable management of cultural heritage through digital BIM and GIS models: contribution to knowledge and social innovation" - HAR2016-78113-R. This project's aim is to explore the application of these digital models, fundamentally based on BIM (Building Information Modelling) and GIS (Geographic Information Systems) to the integral and sustainable management of the heritage guardianship: from an element or set to territorial scale figures. From this integral proposal, we centre our attention on the heritage knowledge area, the origin of other guardianship actions, and on its transfer to the diverse disciplines involved (Pinto Puerto, 2018).

In this context, this work is focused on the application of GIS, and aims to apply them both as a registering tool and for the preservation of heritage information and knowledge of heritage considering its territorial scale and its view of the whole. Particularly, in our study case, the documentation is an important part of the project, as many of the towers are very deteriorated or do not now exist. Thus, documenting them also acquires heritage value, enabling the preservation of their historic and architectural memory. This is useful for their management and their dissemination as a tourist resource as well. In this way, we provide the valuing of their signification in their context with a view to understanding them as a "cultural landscape". On the other hand, the analysis of the data will lead us to a deeper knowledge, as well as contributing to the systemisation and standardisation of the information compiled.

In previous projects, we have been able to model the activities of the agents related with the architectural production in the changeover to the Modern Age, between the middle of the 14th and 15th centuries (Ferreira Lopes and Pinto Puerto, 2018). On a territorial scale, religious, military and civil buildings or quarries, were associated with the DBMS, also considering other attributes and their geolocations (*event-based model*). On the other hand, a historical SDI which contemplates historic data about the administrative divisions, dioceses, roads, production nuclei and the phases of the reconquest was also digitalised and georeferenced (*snapshot model*). This study, in conjunction with the investigation "Defensive architecture on the frontiers of the Kingdom of Seville during the late Middle Ages" (Molina Rozalem, 2016), has enabled the combination and systematisation of a historical SDI subject referring to the defensive architecture and its context.

Apart from the historical documentation research and the data gathering, intensive fieldwork was also done during the last four years in order to collect the information about the buildings. This rich data set led us to connect and visualise this defence system with other constructions built in the same period to carry out thematic maps.

The GIS analysis will permit us to highlight the need to create a preservation plan that should consider the network visibility

system as an important value for heritage interpretation and knowledge.

In general terms, the project has three main objectives:

- To create a historical SDI of the medieval towers in the Moorish Strip.
- To understand the defensive architecture as a system, by analysing and verifying its connections with other entities in its natural, social and political context.
- To provide data and analysis for conservation and management strategies.

At the instrumental level, the specific objectives are:

- To generate an interoperable, reusable and expandable historical SDI.
- To ensure access to the data by publishing them.
- To identify new hypothesis and future research lines.

2. THE MOORISH STRIP DEFENCE SYSTEM

During the 13th century, and especially from the middle of this century, the great military conquests led by Ferdinand III and Alfonso X in the Guadalquivir Valley and their later occupation and incorporation into the Crown of Castile had originated a new historic context, not only due to the creation of a new “frontier framework” with the Kingdoms of Jaén, Córdoba and Seville, but also because of the consolidation of the Nazari Kingdom of Granada. In this way, almost from the beginning, a first frontier was created between both Kingdoms. A frontier, moreover, that surpassed the political area, and which deepened the cultural, religious and political differences. The presence of this living frontier with Granada gave rise to the appearance of a series of typical and specific features of the new lands that would last throughout all the lower Middle Ages and which would constitute the very essence of the history of Andalusia.

This frontier was not only a closed and immutable world, from its formation in the 13th century until its disintegration at the end of the 15th century it was in constant transformation. It was a regional phenomenon with numerous local particularities which determined “small frontier realities that, some more isolated than others, meant nothing at all, but related between them reveals to us the existence of certain lines of behaviour applicable in general to all the frontier of Granada" (García Fernández, 1989: 41).

From the 13th century we see that the documentary and historical sources identify Andalusia as the “Frontier of Castile” (Vázquez Campos, 2003: 515), naming it interchangeably with the terms "Frontier" or "Andalusia". This term is not going to apply generically to the territories of the south peninsula, but to the lands of the Guadalquivir valley. The identification went so far that in times of Alfonso XI all the Major Governors of the region were designated as "Frontier" Majors.

This frontier built up a society organised by and for war, as had been taking place in the different territories submitted to the vicinity of the enemy, only that in this case the war organisation had to be prepared to maintain a frontier for more than two hundred and fifty years. To do so, a complex system of fortification was established, distributed throughout Andalusia, which responded to a previous organisation of territorial defence. These were fortifications which had typical properties that determined and characterised them according to the specific needs of each frontier sector.

The main aim of our study is limited to the strip or sector of this frontier, specifically the western, which will end up being called “The Moorish Strip". Manuel González Jiménez defines this expression well: “Probably, from the conquest of Antequera at the beginning of the 14th century the «Moorish Strip» corresponded to the section of the frontier between the Guadalhorce and Guadalete rivers(...). So, in a more restricted and exact sense, the «Moorish Strip» was the set of frontier territories which depended on the jurisdiction of Seville: Morón, Osuna and Cote, at some time in the 13th century (…), and, during a good part of the 14th and 15th centuries, Matrera and Arcos” (García Fernández et al, 1996: 13).

The birth of this frontier and the relative depopulation of Lower Andalusia and all the frontier strip led Alfonso X to concede to the military orders the main villas and castles of the zone to entrust them with their defence. In this way, the strategic castle of Matrera went to the Order of Calatrava in 1256, the same as the castle of Pruna had done three years before and that of Osuna would do in 1264. The village de Estepa passed to the Order of Santiago in 1267, Morón and Cote to that of Alcántara in 1279, and Alcalá de los Gazules and Medina Sidonia to the Order of Santa María de España in 1272 (García Fernández et al, 1996: 18-23). Later, a line of towers and small castles located in the first frontier line and which would act as outlook points would be added to these fortified villages of relative importance (Valor Piechotta, 2002: 31).

In spite of this accelerated process of isolation and confrontation of both societies, as was to be expected it did not halt the relations between peoples of both camps/margins, given that as well as sharing the same territory, in many cases there was kinship and friendship. The frontier was at the same time a marginal zone full of danger, incursions of looting, "raids" for the Muslims and "cavalcades" for the Christians, local reprisals and also a space for cohabitation between traders, farmers, shepherds, hunters and soldiers. This was also a zone of imprecise limits where danger was latent because violence predominated over the safety that pacts, local in most cases, could offer (Figure 1).

In brief, we are dealing with a strip, a space between two frontiers, or a no man’s land, which frequently was uninhabited or uncultivated but was an open road to pacific or warlike movement in one or the other direction. This extensive unpopulated land, both in the Castilian zone and in the Granada zone, was what we could call “the living and real frontier” of the two Kingdoms.

The exact locations of the Castilian-Nazari frontier during the lower Middle Ages is difficult to locate due to the continuous instability and mobility which characterised it during all its existence. Add to this the fact that the frontier demarcation was not precisely supported by natural features. Although each sector, each frontier enclave knew where the jurisdiction of the land that it controlled began and ended, in practice this demarcation was rarely respected, causing many conflicts.

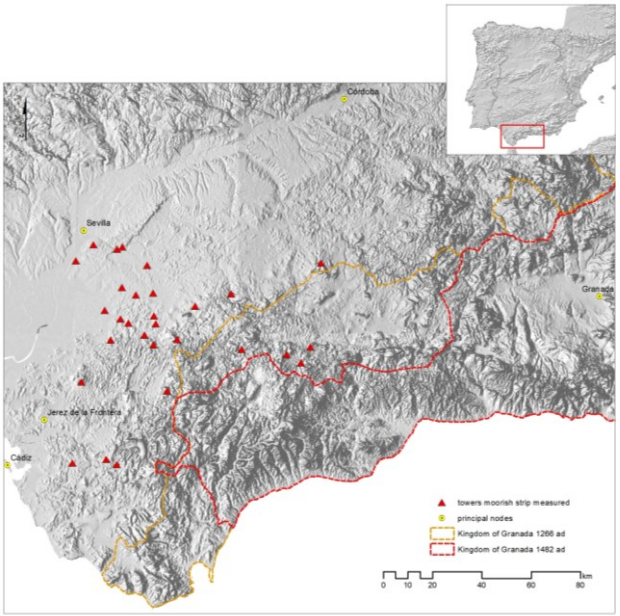

Figure 1: Location of the towers of the Moorish Strip.

2.1 Architectural Models

The analysis of the towers of the Moorish Strip has enabled us to draw important conclusions about their form and function. It is considered that there is a tower model with common construction norms. Though until the beginning of the 14th century the Sevillian outlying areas had based their defence on the pre-existing Muslim fortresses (partially rebuilding them), at the beginning of this century, at least in the sector of the countryside, Seville was involved in a quite notable construction process, in view of the number of fortresses built and their characteristics. This indicates a planned strategy.

The imposition of this building programme is backed by the common characteristics detected. Of the thirty towers which have been measured and for which planimetry has been elaborated, thirteen have the same construction pattern, divided into two groups according to their size. All of them belong to the Council of Seville except the tower of homage of Morón, sponsored by the Crown.

The group of larger council towers is made up of the towers of Gandul, Utrera, el Bao, Alcantarilla, el Águila, Lopera, las Aguzaderas and Morón. Morphologically, they are towers with very nearly square rectangular floor plans, maintaining an almost identical proportion between their sides and with their stairwells on the longest side. There is a sole access, which is on the ground floor, and, almost always, in the centre of the longest side. The stairwell is located to the right of the main access and is separated from the rest of the space by a wall that is narrower than the perimeter wall, a square interior space being left. This leads to an upper chamber and a roof which has a total height of around 15 metres in all the towers analysed. The upper chamber would serve as the main floor, where most of the garrison would be lodged (Figure 2).

The perimeter walls are of a considerable thickness - around two metres - as they are their main defence. These walls have three layers, the exterior ones made in ashlar and which act as formwork, and the interior ones filled with mortar, rubble and earth. The majority of these towers have their corners reinforced with well-carved, inversely overlapping ashlar stones. Furthermore, some of them, such as those of Lopera and el Águila, have an exterior masonry of large and good quality ashlar stones, although in the rest ashlar with generally well cared for joints are more abundant. All the towers have a base constructed with nobler and larger ashlar to strengthen the foundation.

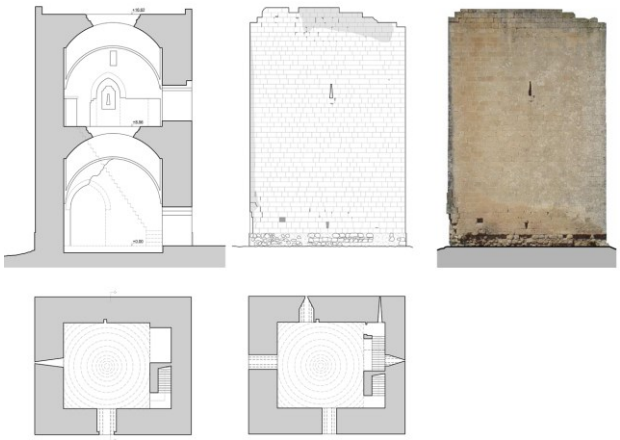

Figure 2: Torre Lopera in Montellano, Seville. Floor plans. Section and photogrammetric elevation.

Regarding the exterior contour, the hermeticism of the fortifications is noted, having only a few arrow-holes, although in most of the towers there is always a side which has a larger window. These windows are located invariably in the upper chamber over the access gate, fulfilling the function of vertical defence. Added to these defences are the machicolations, mainly placed over the windows that are above the access, helping to hinder the entrance into the tower.

The similarities continue being remarkable inside. The square space which is left, excluding the stairwell, is covered in the great majority of cases by a lobbed vault. This also occurs in the upper chamber. When analysed from the point of view of metrology, these interior measures have given us equally interesting results. We have noted that this group of larger council towers are mainly related by their construction measurement unit. This seems to be the Burgos rod, its multiples and submultiples (increased rod, half rod, step, foot and palm).

The similarity in the execution of the lobbed vaults is perhaps one of the factors that is most noteworthy. They are vaults made of well-carved ashlar (in some cases with bricks) over semi-circular arches standing out from the facing of the wall, finishing in an invert strip which transmits the weight to the adjacent walls. The system used is exactly the same in the majority of the council vaults examined. Another common interior feature is the niche that projects from under the stairs, taking advantage of the space which remains to gain height. The dimensions of the niches change but they are always located in the same place, at the back as we enter and to the right of the lower chamber and they have the same form of pointed arches.

In the group of smaller towers - Marchenilla, los Herberos, Membrilla, el Bollo and Quintos – the same patterns are followed, reproducing the same model, but on a smaller scale. This implies that the perimeter walls are narrower (about a metre) and that the total height decreases, remaining below fourteen metres. The characteristics are basically identical: a sole access, stairs on the longest side and separated from the interior space by a narrower wall, few arrow-holes, an interior division into two chambers (both square floor plans and covered by a lobbed vault), and an absence of battlements.

The main divergences of this group of towers with respect to those that are larger is precisely due to their smaller dimension. For example, there is not space for the pointed arch niche under the stairs (except in the tower of Marchenilla). The contrast is also in the lack of defensive elements, such as machicolations, and the use of construction materials of poorer quality, such as brick or rammed earth instead of ashlar stone. This would be justified by the lesser weight that they had to support, their dimension being less and having smaller spans. In most cases, an ashlar base continues being constructed to settle the weight and act as a foundation.

The lack of external defences indicates that the function of these small towers was limited almost exclusively to vigilance. They were surely not devised to shelter the population or livestock in the case of attack. These smaller towers were with good reason located close to the city of Seville, so the likelihood of attacks was much less.

As well as these towers, whose similarity is surprising, there are others which show divergences. These are the towers of homage of el Coronil, of Molares and of la Troya. The former due to its very small size and the renovations undergone in its low zone during the 15th century, the second due to continuous transformations which have made it almost unrecognisable. Finally, that of la Troya has a tower model with a greater floor plan but lower. The upper floor of the el Coronil tower is like a copy in miniature of the towers previously described: a cover of lobbed vault in ashlar, an entrance in the centre of one side and a stairwell to the right, a pointed arch niche below the stairs, a decoration of lateral modillions in the door, etc. For its part, the los Molares tower conserves the interior of the square lower floor plan, whose dimensions are very similar to those of the second group and that is covered by a brick lobbed vault. This room is one of the few vestiges that is conserved of what must have been the original 14th century tower.

3. METHODOLOGY

The preliminary step to building the spatial database of the system of towers was: i) the field work to obtain the data of the towers because their historical documents (cartography, plans, etc.) were not found; ii) the compiling, selecting and structuring of historic data. In this case data related with the promotors and an approximate chronology of the towers were found; iii) the design of the alphanumeric database. In total 30 towers were visited, and their metric data and geolocation were registered. These data were obtained using the following measurement tools: a laser distance measure, a GPS, sketches and high definition photographs. Afterwards we digitalised the floor plans and sections using CAD tools. The historic data and the classification of the towers were organised in the fields of the database designed. In this case, this was a spatial database organised in an *.xls* format. For this study the following fields/information of each tower were selected: name/denomination; X and Y coordinates; height of the tower; typology; model; chronology; promotor; main construction material; state of conservation. Due to the imprecision of the historic documentation, the chronology was registered with data which consider a range of half a century. After designing the attribute table, this was inserted in a GIS setting – in this project we have used the ArcGIS 10.6 set of software – and the WGS 84 coordinates were transformed (obtained by the GPS) for ETRS89 30N, datum used in Spain.

The data of the height of the towers were obtained via laser measurement, applying the triangulation method and verifying/adjusting them through the use of photographs. In most cases, we have achieved a quite precise measurement of the heights, in others, due to the bad state of conservation of the towers and the lack of historic documentation, we adopt the height of 13m based on the heights of floor plans which have survived, the number of these and the heights of analogous towers that have been conserved.

To carry out the GIS analysis, as well as the historic SDI of the defensive towers, of the DBMS and of the SDI (snapshot) of the context (Ferreira Lopes and Pinto Puerto, 2018), we have used the Spatial Reference Data of Andalusia (DERA) for the geophysical information of the territory: Digital Terrain Models (DTM), orography, hydrography, lithography, territorial limits and urban nuclei.

4. SPATIOTEMPORAL ANALYSIS

Having created the geodatabase of the defensive towers, we begin to verify their relations with the physical environment, their attributes/characteristics and the interrelations between them.

One of the relations that we wanted to analyse was their nearness to rivers and streams. Using the tools offered by the ArcMap, we have been able to verify that the maximum distance of these towers from a source of water is approximately 1,7 km, and that, of the 30 towers, the distance between 0.5 – 0.8 km (close to 13 towers) predominates. This is therefore an important factor considered for the construction of the towers.

Regarding the construction material, it can be visualised, via a classification according to the "construction material" field of the attribute table, that those which are in the highest points were constructed with ashlar, while those that are lower used brick and rammed earth (Figure 3). This is due to the towers in high places being in rocky or semi-mountain zones where it tends to be easier to obtain the construction material, unlike the low zones. Added to this is the model of these towers, those of ashlar being mainly larger.

As to the chronology, 50% of the towers measured were built in the first half of the 14th century and are concentrated in the south-west of Seville (Figure 4). Those towers that were constructed in the first half of the 15th century are located close to the frontier with the Kingdom of Granada (frontier of 1492).

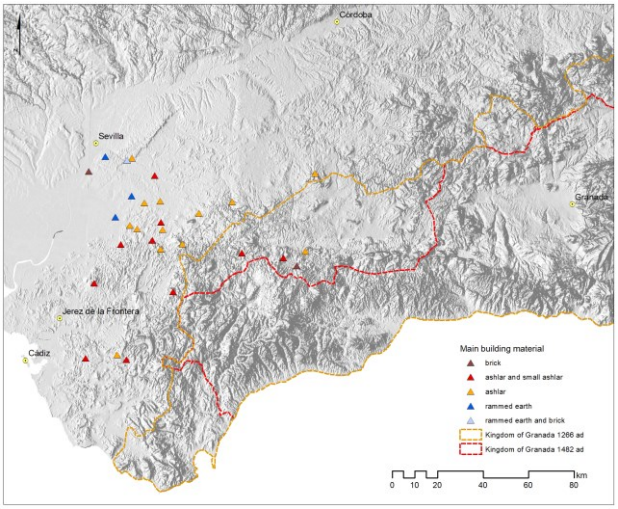

Figure 3: Thematic map of the main building material of the towers.

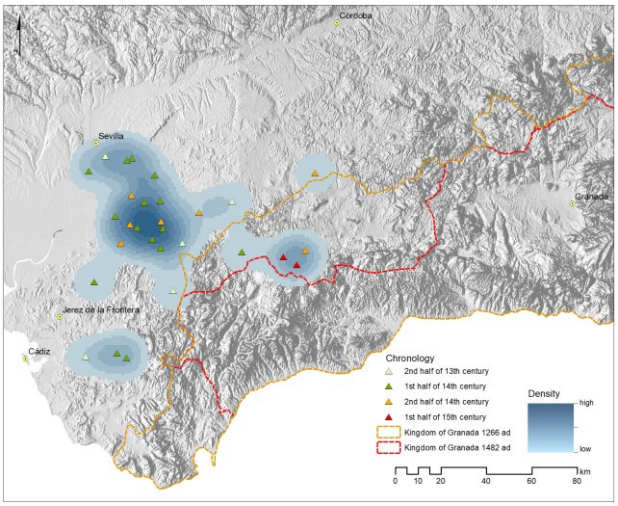

Figure 4: Thematic map showing the chronology of the towers and their location density.

4.1 Visibility

One of the analyses which we implemented was the “Visibility” (Arctoolbox - Military Tools), considering the curve of the Earth, limiting the distance to 20km, which would be approximate to the natural limitations of visual acuity (Kantner, J., Hobgood, R., 2016). We know that there are infinite variables, such as those related with atmospheric data, vegetation, contractions, etc. Nevertheless, those variables have not been able to be considered in this study.

We have used the DTM of the DERA of Andalusia to carry out the visibility analysis. The points with no visibility received value zero (0). The analysis shows the areas visible by 1 tower to 10 towers. A greater visual control is noted in the area towards the south and south-east of Seville, in the zone of the countryside of Utrera, creating a very compact zone which links with the towers close to the Guadalquivir valley whose topographic height is practically null and that would permit warning in the case of attack. On the other hand, the analysis shows a great area between the historic frontiers of 1266 and 1492 with a null value (Figure 5). This latter data leads us to think of the existence of other possible towers in this area which must be in a very advanced state of degradation. Future archaeological works are required for them to be discovered. Implementing this same analysis but including the tower of the Giralda (65 m high during the Almohad Era) – located in Seville - which also fulfilled the function of a vigilance during the 14th and 15th centuries, a greater control of the surroundings of the city of Seville towards the north and north-east is noted. The analysis shows the areas visible from 1 to up to 11 towers (Figure 6).

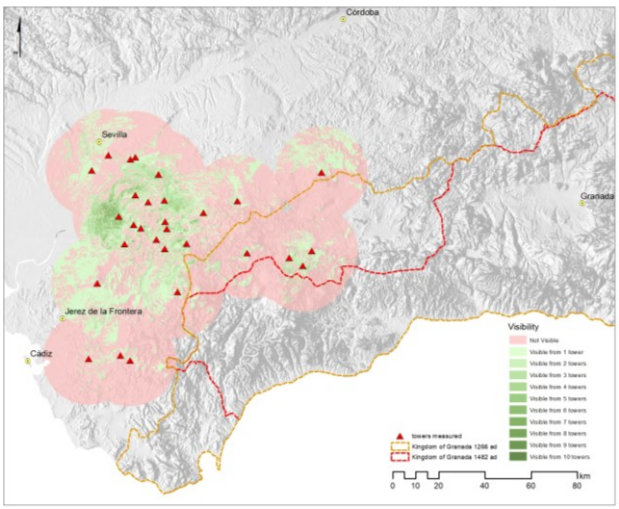

Figure 5: Visibility study from the towers, considering a limited distance of 20km and the earth´s curvature.

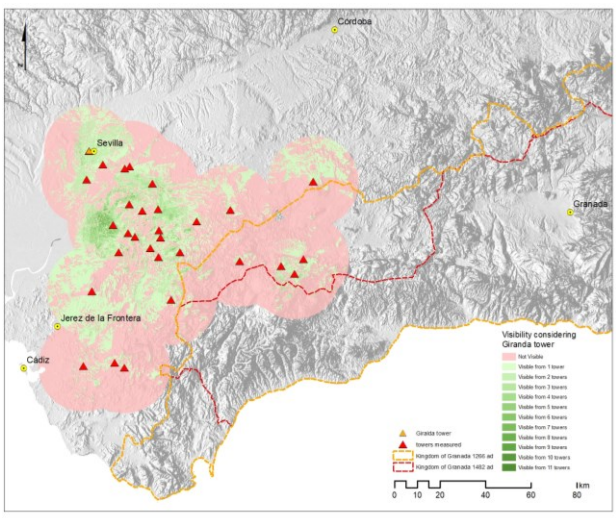

Figure 6: Visibility study from the towers, considering a limited distance of 20km, the earth´s curvature and the Giralda tower.

To check the visual connection between the towers we implemented the “Lines of sight” tool. From this analysis we have been able to perceive the possible network of visual communication between the towers (Figures 7 and 8).

Likewise, we have simulated this analysis considering the limitation of visual acuity to 20km doing a buffer around each tower and analysing the lines which are inserted within this (Figures 9, 10 and 11). We can perceive a greater degree of visual connection in the area to the south-west of Seville.

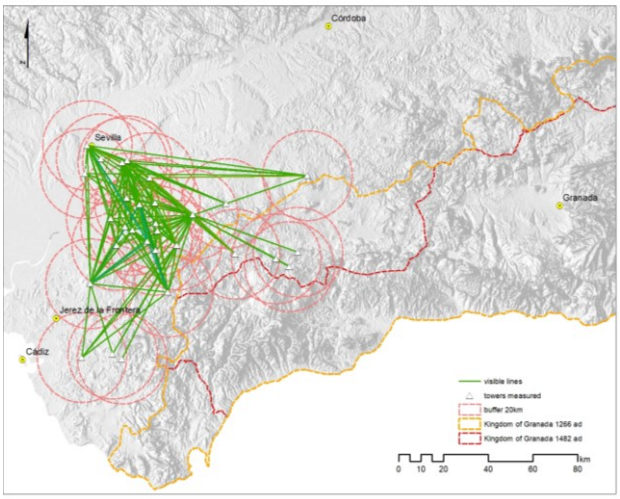

Figure 7. Analysis of visibility. The map shows the network of visual lines between towers.

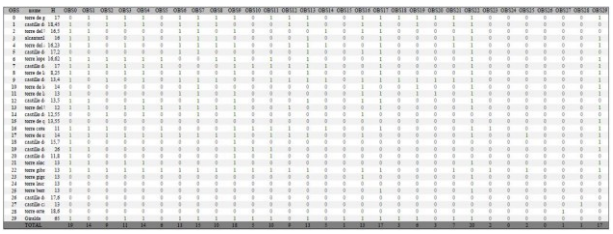

Figure 8. Table showing the visual lines between towers without considering visual acuity. The values “0” and “1” mean without and with visual connection, respectively.

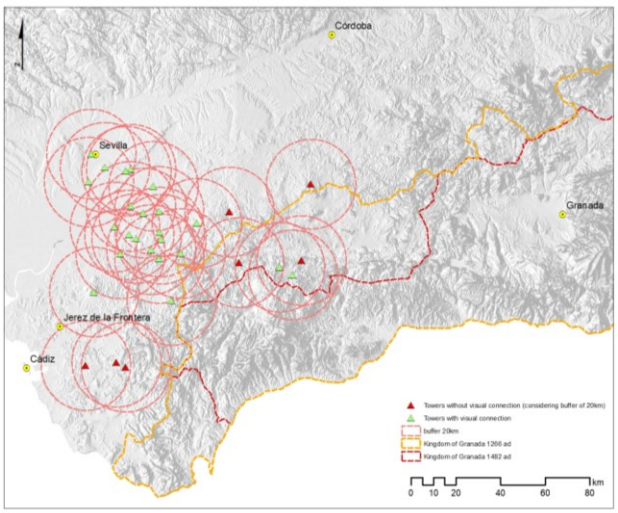

Figure 9. Thematic map in which the towers that have or have not visual connection are noted in the simulation; this considers the 20km buffer.

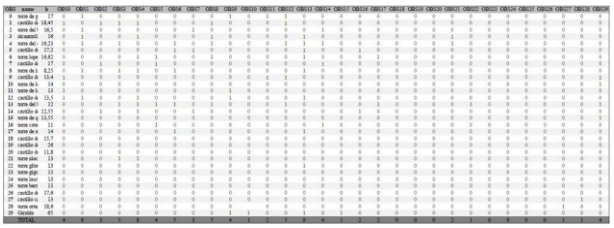

Figure 10. Table showing the visual lines between towers considering the distance of de 20km.

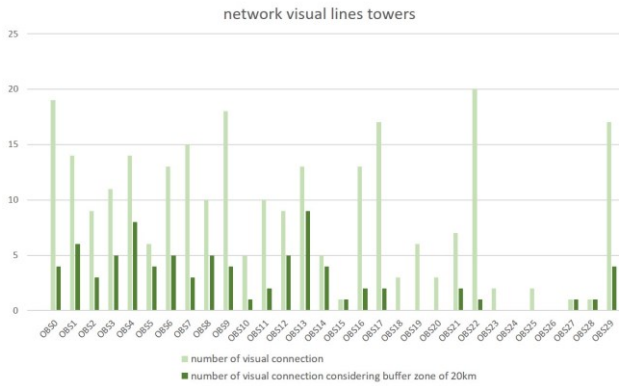

Figure 11. Graph which represents the quantity of visual connections of the towers in both situations - without considering the 20km and considering it.

5. CONCLUSIONS AND PERSPECTIVES

At the beginning of the 14th century the establishing of a frontier of the countryside was achieved, an encirclement of the Kingdom of Granada being again proposed. During the first third of this century, the great majority of the fortifications analysed are built or reinforced. Almost all those in the countryside are edified from scratch by the Seville council following the viewing tower-fort model. Others were reinforced or partially rebuilt. The lack of offensive potential in the Nazari camp made it unnecessary to construct great fortresses, their attacks being limited in most cases to looting, stealing livestock and kidnapping people. This is why these viewing towers frequently included a small walled perimeter to safeguard the livestock and the settlers who populated the zone.

In this sense, the south frontier in the zone of the countryside had a first line of contention made up of the strip conceded to the military orders which were settled in larger fortresses. In the countryside of Utrera, the most feasible zone to be attacked due to its accessible relief and the richness of its pastures and livestock, there was a conglomerate of viewing towers that meant, via a warning, to delay or minimise an attack, as well as giving shelter to the disperse population which lived in the zone. As we have been able to analyse with the GIS, these towers were built at points that enabled visual communication between two or more watchtowers, thus assuring a warning to another stronghold. This did not imply their location in the highest place of the environs, although they were mainly at significantly higher altitudes than the surrounding land, allowing them a visual dominion over it. This study does not pretend to carry out various exhaustive analyses but rather to contribute new knowledge concerning the network of towers of

the Moorish Strip via the application of a digital tool, such as GIS.

The study's principal aim has been to understand the visual communication questions between the towers and to check the zones of most visual control via GIS to verify previous studies mainly carried out by historians. Likewise, the GIS application has made it possible to generate new questions and possible future research lines, such as the zones which, suspiciously, have very little visual control. This may indicate the areas of location of possible towers that have not yet been discovered.

The application of GIS and the analyses carried out show the validity of the use of this tool for the knowledge and understanding of historic, architectural and cultural questions/ topics.

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