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A methodological approach to settlement location factors. The case of monastic communities in the medieval Penedès (Catalonia)

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Abstract

Settlement location factors could be analysed from an historical perspective using Geographical Information Systems. However, their application is subject to some drawbacks, such as the lack of detailed information about past landscapes and the need for global, interdisciplinary knowledge of the territory under study. Building on the case of monastic communities in the medieval Penedès, this paper illustrates the methodology used both in the data treatment and in the settlement spatial analysis.

Keywords: Landscapes, settlement, monastic communities, location factors, Penedès, medieval.

1. Introduction

Geographical Information Systems (GIS) have become an essential tool in the field of landscape studies. Although there is no well-established research tradition in Spain and Catalonia compared to other countries,[3] several historians and archaeologists have successfully applied GIS in the study of the medieval period in Catalonia (Soler, 2002; Mauri, 2006; Negre, 2013; Bosch, 2017; Costa, 2019; Fernández, 2019).

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3. Without seeking to be exhaustive, some theorical and practical works on GIS and history should be mentioned, such as those by D. J. Bodenhamer, J. Corrigan and T.M. Harris (2010), H. Chapman (2006), I. N. Gregory (2003), A. K. Knowles (2008) and D. Wheatley (1993, 1995).

These previous experiences have been essential to define the main objective of this paper: evaluating the suitability of some medieval settlement locations using Geographical Information Systems (GIS). To achieve this, B. K. Roberts's theoretical proposal has been used as an analytical guideline.

In *The Making of the English Village*, Roberts proposes a diagram with the intrinsic and extrinsic qualities of a site to be occupied (Roberts, 1987, 105). While the former are desirable characteristics of a specific site of settlement, the latter refer to qualities of its environment. Subsequently, archaeologist J. Bolòs (2004, 155) suggested an adaptation of this diagram to the Catalan context, which our present spatial analysis has adopted, albeit with some changes (Fig. 1).

The following text will detail the analytical methodology used to evaluate the suitability of some medieval settlements. The major drawback encountered has been a lack of historical data. Following the recommendations of Open Science (European Commission, 2018; Abadan; Anglada, 2020), this paper outlines the steps followed and the decisions taken throughout the research process.

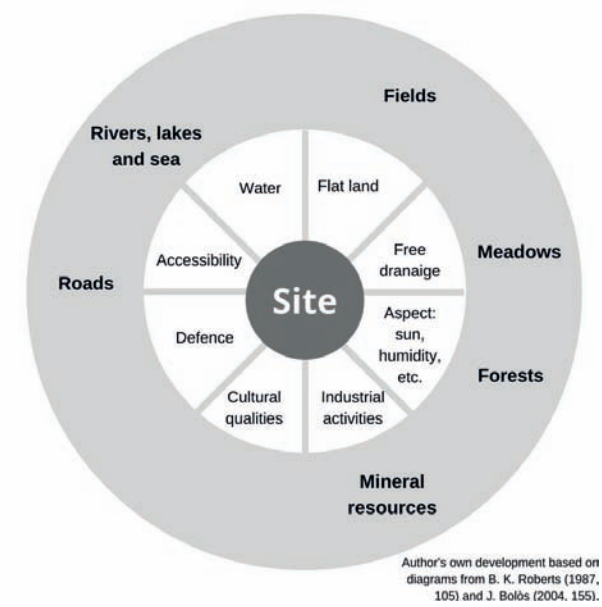

FIGURE 1. Diagram of the extrinsic and intrinsic qualities of a site.

2. THE OBJECT OF STUDY: MONASTIC COMMUNITIES IN THE PENEDÈS REGION

In order to facilitate the analysis, a particular type of settlement has been selected from a specific period of time and geographical area. Archaeological, bibliographical and documentary sources attest to the existence of twenty-three monastic communities between the 10th and 13th centuries in the Penedès region (Fig. 2).[4] This flat territory constitutes an area of transit, as it's located between the Mediterranean Sea and the Catalan pre-coastal range of hills, and also between Barcelona and Tarragona, two cities of great importance in the north-east of the Iberian Peninsula during Ancient History and the Middle Ages.

The Penedès appears documented for the first time in 917 as *Penitense.* The region formed part of Al-Andalus until the 10th century, when the Count of Barcelona occupied it. From the 10th to the 13th century, the nobility created a network of castles and churches and the Count of Barcelona sent a deputy, called the *vicarius*, to control the region. Finally, in the 14th century, the Penedès was recognised as a *vegueria*, one of the new administrative territories into which Catalonia was divided (Arnabat, 2007; 2014).

2.1. The medieval monastic communities documented

In recent years, various research projects have been drawing attention to Catalan monastic communities and revisiting them from a contemporary standpoint. As for the Penedès region, the main bibliographic references are the works of E. Zaragoza (1997) and J. Vigué and A. Pladevall (1992) as well as some websites created by amateur historians. The use of documentary sources, both original and edited, has been crucial to confirm and complete this information. In addition, reports of archaeological campaigns carried out in some monasteries, such as in Granja d'Ancosa (Bolòs; Mallart, 1986) and in Santa Maria de Santa Oliva (Teixell, 2001; Garcia; Teixell, 2009), also provide useful information.

The first references of monastic communities in the Penedès region date back to the 10th century. These are referred to as *cellae* and were dependent on the abbey of Sant Cugat del Vallès, near Barcelona. There are no existing records documenting their organisation or size. The *cella* of Santa Maria and Sant Joan de Monistrol d'Anoia is the most ancient amongst them, documented in 986 (Abadal, 1950, 194). It seems that most *cellae* did not survive for longer than 100 years, with the exception of Santa Maria de Santa Oliva, which lasted beyond the medieval period (Rius, 1945, fol. 382, 1020).

In the 11th century, the Penedès nobility and the Count of Barcelona promoted the creation of four Benedictine priories subordinated to foreign abbeys. A great amount of information about these communities is available and all of them lasted beyond the medieval age. Sant Pere de Riudebitlles, founded in 1011 by the lords of Mediona Guifré and Guisla and linked to Santa Maria and Sant Martino on the island of Gallinara in Italy, is a clear example of such priories (Feliu; Salrcah, 1999, 100).

The 12th century was characterised by the arrival of new orders, such as the Cistercians, Templars and Knights Hospitaller. These orders created five new communities, some of them

4. Among these, the exact location of Sant Salvador de Pinells is still unknown.

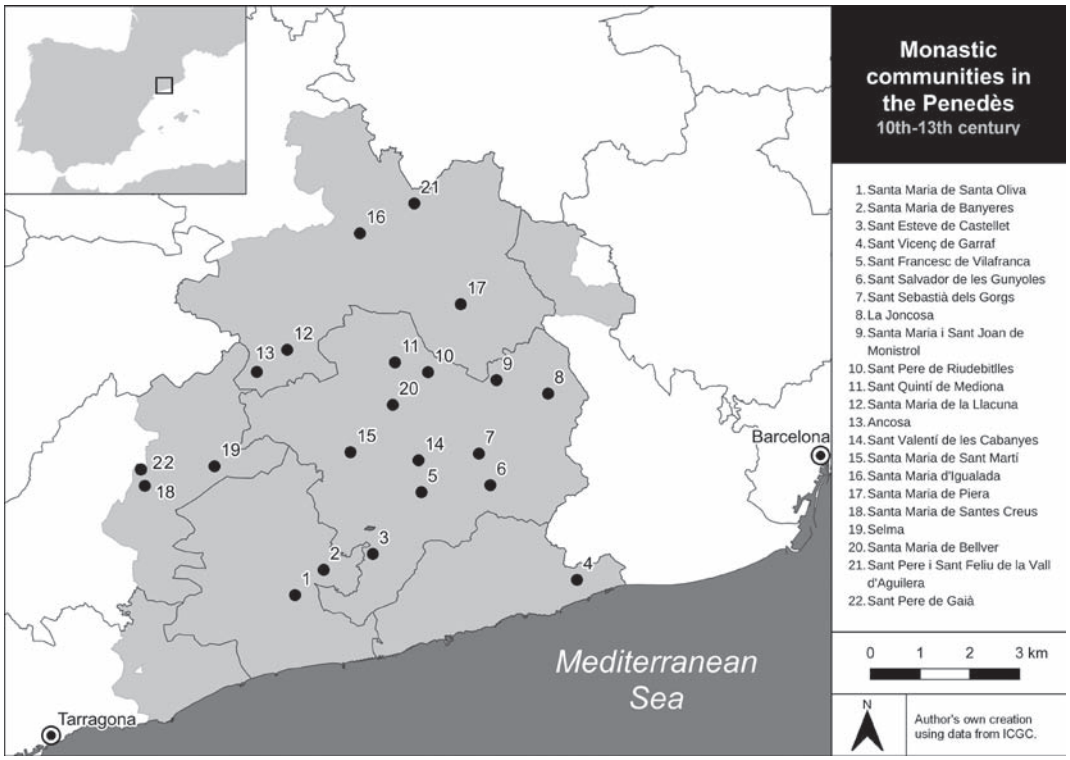

FIGURE 2. Monastic Communities of the Penedès during the 10th-13th century.

developing as delegations of important monasteries, as is the case of Granja d'Ancosa (Bolòs; Mallart, 1986). Santes Creus, located at the border of the Penedès region, stands out as one of the most important Cistercian abbeys in Catalonia.

Finally, historical records corroborate the emergence of two phenomena in the 13th century. Firstly, mendicant orders arrived and founded the first urban convent in Vilafranca del Penedès, the most important city of the region at that time (Miret, 2002). Secondly, historical references attest to the existence of *donati* communities, groups of people that gave their life to the Lord, in different churches. Pastoral visits made by the Bishop of Barcelona, Ponç de Gualba (1303-1334), reported three cases of *donati* but information about them is minimal (Martí et al., 1984).

3. METHOD OF ANALYSIS

According to Roberts's diagram, several analyses were carried out to assess the extrinsic and intrinsic qualities of the locations of monastic communities. Unfortunately, not all these qualities could be analysed due to a lack of historical information. For example, there are no reliable data about forest areas in the Penedès between the 10th and 13th centuries, so the importance of this location factor has been excluded from the analysis.

L. García Sanjúan's work (2005) and M. Fernandez's doctoral thesis (2019) focusing on the region of Baix Montseny have become essential guides to plan this research. Most of the methods detailed in this paper have been adapted from these studies, albeit making the necessary changes.

3.1. Delimitation of extrinsic qualities: Site Catchment Area and friction costs

The first step has been to calculate the Site Catchment Area (SCA) for each community; i.e. the priority territory to obtain different resources. Consequently, the analysis of suggested extrinsic qualities has been restricted to these areas.

The Site Catchment Area (SCA) of a certain territory results from the sum of the radius equivalent to the maximum possible distance to be walked in 60 minutes from a settlement (Fig. 3). The free software QGIS offers an *r.walk* tool that enables this calculation, as Fernandez has widely demonstrated (2019, 57). To do so, a two-raster dataset is required: one with elevation data (DEM) and another with movement costs. These datasets provide information to calculate the walking speed according to the slope and type of terrain.

For the dataset with the elevation data, a Digital Elevation Model (DEM) from the Cartographical and Geological Institute of Catalonia (ICGC) with high resolution (2x2 metres) has been used. However, the dataset with movement or friction costs was built by the researcher as there are no historical models for this (Fig. 4). These costs are affected by several geographical elements, such as forests or rivers, that can hinder or facilitate movement. Due to a lack of historical evidence regarding their exact location in the medieval period, present data must be used.

To establish movement costs resulting from hydrography, cartographical information from the Catalan Water Agency (ACA) has been used with some modifications. Several studies have revealed that, between the 10th and 13th centuries, the Medieval Climatic Anomaly (MCA) affected the north-east of the Iberian Peninsula, leading to a drier climate with low frequency and more extreme episodes of rain (Belmonte et al., 2012; Benito et al., 2019). With some differences, these conditions are similar to the existing ones. Certainly, watercourses often change their route and flow but using present hydrographic data has been considered the best available approach in the absence of any alternative. To establish the proportional friction costs, watercourses have been classified using the works of A. Munné and N. Prat (2002) as well as some historical information (Palau, 1988; Sabaté, 1992; Bolòs; Hurtado, 2018; Díaz-Ros, 2018).

Apart from these data, movement costs related to soil use (forests, fields and meadows) have also been considered. Some studies adopt 20th-century soil use as a method to obtain such data (Fernández, 2019) but this option was rejected for the Penedès. This region has undergone a large number of agricultural changes in the last 300 years (Valls, 1997; Arnabat; Vidal, 2008, 255-270), making this option unreliable. Estimating an agricultural area with low movement costs around each settlement was also rejected. Although this could have been a good solution, it required a detailed study of the medieval Penedès settlement system, which was not available. Instead, low friction costs resulting from the medieval road network have been taken into consideration thanks to the work of M. Vives (2007) and other secondary studies (Bolòs, 2004; Mallart, 2008; Bolòs; Hurtado, 2018).

3.2. Agricultural potential of the Site Catchment Area

Roberts (1987) proposed the proximity of arable fields, forests and pasture as extrinsic qualities of a site. In their spatial analyses, L. García Sanjuan (2005), J. Negre (2013) and M. Fernández (2019) have considered the agricultural potential of land located next to settlements. The classification of slopes is commonly assumed as an accurate method to calculate such potential because of its historical conditioning. Drawing on the slope classification model suggested by Fernández (2019, 68), a slope map of the Penedès area has been created using the same DEM dataset as for the Settlement Catchment Areas. However, due to the strong anthropic modification undergone by the soil over the past few centuries, this information must be considered merely as an approximation of the medieval landscape.

The United States Department of Agriculture (USDA) soil taxonomy draws on several factors to determine their agroecological potential, such as drainage, slope, depth and texture (López-Acevedo et al., 1994). Present-day soil analyses usually borrow heavily from this taxonomy and the Catalan Institute of Cartography and Geology has drawn on it to create its agrological cartography (ICGC, 2010-2019). However, the latter did not include the Penedès area. For this reason, our analysis has used the Catalonia Soils Map based on the Soil Taxonomy System

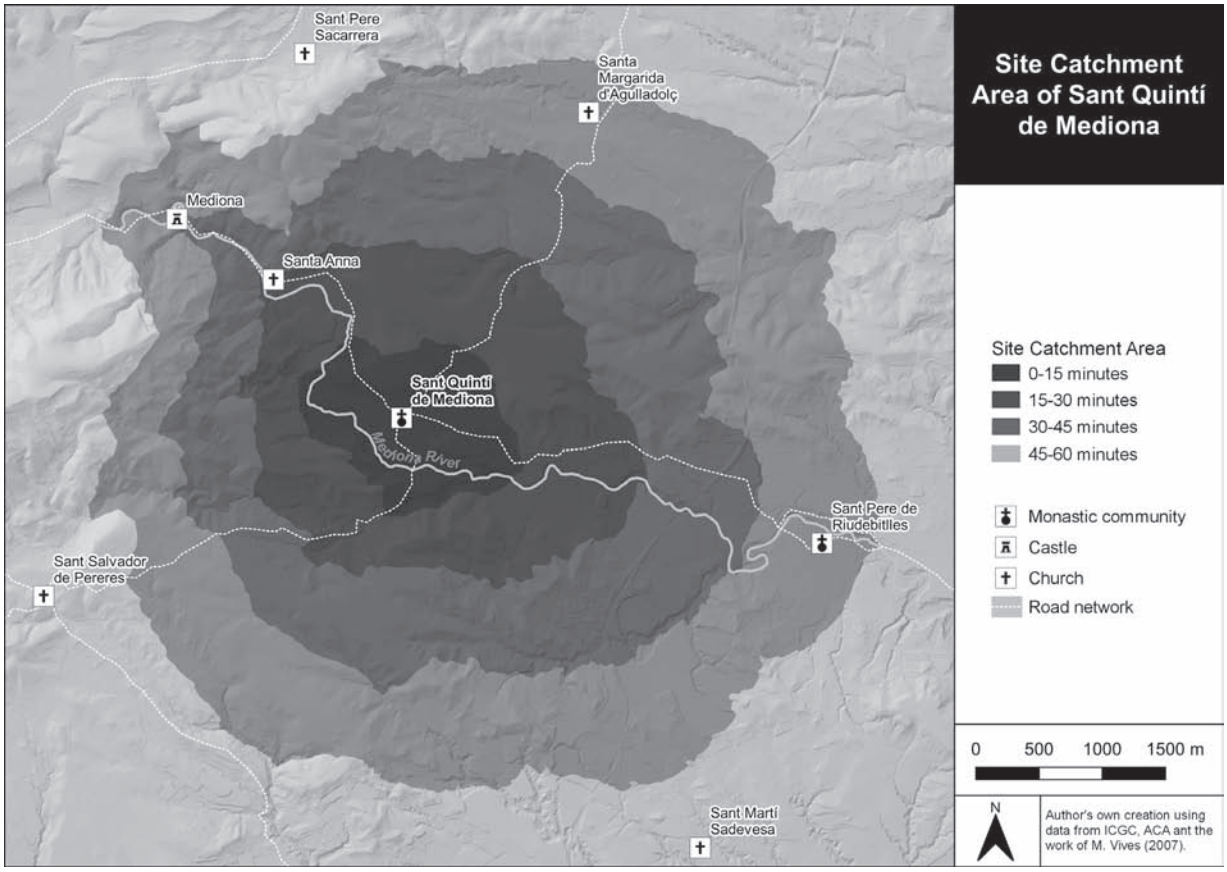

FIGURE 3. Site Catchment Area of Sant Quintí de Mediona.

Name	Characteristics	Width	Walking speed
Permanent	Fast-flowing, permanent rivers at present.	Hydraulic Public Domain according to ACA	3 km/hour
Potentially permanent	Fast-flowing rivers with variable flow which were used used by medieval watermills.	Hydraulic Public Domain according to ACA	3 km/hour
Seasonal flow	Streams with seasonal flow and drainage surface similar to potentially permanent streams, with medieval watermills next to them.	2 metres	3.6 km/hour
Temporary	Present streams with little and seasonal flow.	2 metres	4 km/hour
Road network	Comprising international, interregional and local roads.	2 metres	4.5 km/hour
Non-classified terrains	Comprising fields and forest.	-	4 km/hour

FIGURE 4. Classification of friction costs included in the raster map. (Author's own creation based on information from A. Munné and N. Prats (2002) and the Catalan Water Agency (ACA).

(ICGC, 2019). Despite being less detailed, it offers some approximation of important soil qualities, such as depth and texture.

By cross-referencing two geographical datasets, namely for soils and slopes,[5] a map with three general categories of terrain has been obtained: soils with generally good conditions [A], soils with some disadvantages [B] and generally unsuitable soils [C] (Fig. 5 and 6). This classification has been used to assess the agricultural potential of land next to settlements.

3.3. Accessibility

In order to study the access of communities to certain terrains, two different analyses have been carried out. The first consists of calculating the distance from a specific settlement to the nearest main medieval road using, once again, the *r.walk* tool. In this case, the friction cost dataset was adapted to restrict possible movements to the road network (walking speed for *non-classified soils* has been reduced to nearly 0 km/h, see Fig. 4). In doing so, the travel time from a specific settlement to its nearest main communication route was calculated using only medieval paths, drawing on the work of Vives (2007).

This estimation has been completed with the prominence coefficient, which determines the elevation of the settlement in relation to its surrounding terrain. It has been calculated by dividing the settlement's altitude by the maximum altitude in the SCA. If the result is near 1, this indicates the settlement's elevation is considerable; if it's around 0.5, the elevation is intermediate; and if it's near 0, this indicates a low elevation (Garcia Sanjuán, 2005, 142).

Proximity between monastic communities and market towns has been dismissed as an extrinsic quality related to accessibility. M. Soler (2016) dated most of the Penedès marketplaces existing in the 13th and the 14th centuries, except the cases of La Granada, Vilafranca del Penedès and Martorell. Their origin seems to be later than the foundation of most monastic communities, so they should not be considered as a location factor. However, simple examination of a map with the communities and markets indicates this relationship may have sometimes been in the opposite direction: some monasteries may have encouraged the creation of towns and marketplaces related to them.

3.4. Water supply

Water supply is a basic requirement to ensure the survival of a settlement. Water could be collected via springs, wells, canals or watercourses. Due to a lack of academic research dating springs or wells, it's difficult to determine their antiquity. Documentary sources can provide us with some information but only in certain instances, as is the case of Santa Maria de Piera (Rius, 1945, fol. 382) and Sant Vicenç del Garraf (Pladevall; Vigué, 1992, 64). An analysis of piezometric levels could be a good option to infer the possibility of sinking wells but the Catalan Water Agency does not provide enough detailed information to carry this out.

Consequently, only water available in large quantities so it can be exploited by mills or irrigation systems has been studied. For this purpose, the travel time from each monastic settlement to the nearest main watercourse has been calculated using, again, the *r.walk* tool with movements restricted to the road network (in the same way as in the accessibility analysis, see section 3.3). This analysis has only considered permanent, potentially permanent and seasonally flowing rivers, according to the classification carried out with friction costs maps (Fig. 4).

3.5. Defensive qualities

There are different options to analyse the defensive qualities of a settlement. Firstly, the prominence coefficient (see section 3.3) indicates a site's accessibility, which could be linked to its vulnerability. Moreover, this coefficient has been complemented with an analysis of settlement visibility carried out using QGIS Visibility Analysis plug-in (*r.viewpoint* and *r.viewshed*). This tool offers an approximation of the territory

5. This could take more than 24 hours with QGIS software, so it's recommended to use ArcGIS if possible.

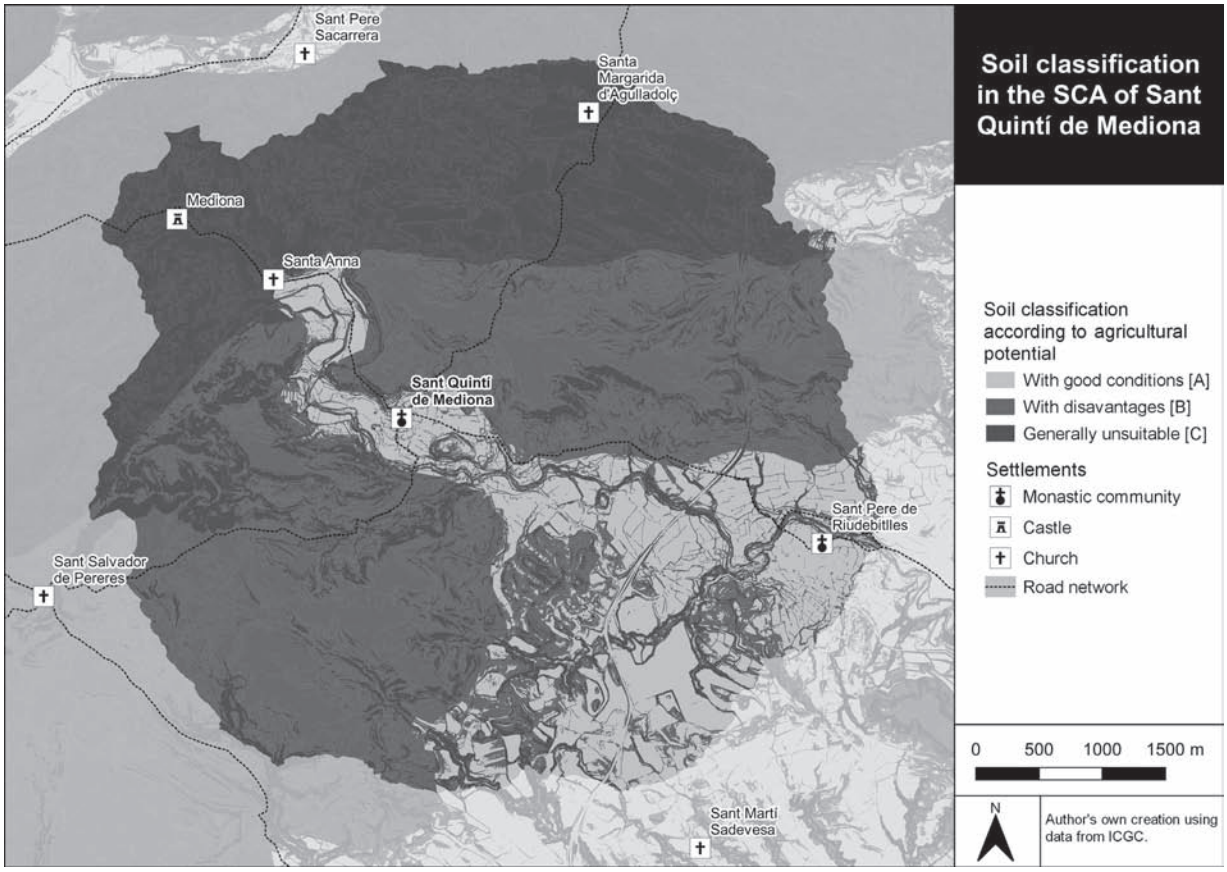

FIGURE 5. Soil classification in the SCA of Sant Quintí de Mediona.

Slope classification	Classification based on the Soil Taxonomy System		
	Deep soils with good drainage and medium textures	Soils with good drainage and medium textures but with variable depth	Superficial soils with good drainage and medium or thick textures
0-7° Suitable for crops	A	B	-
7-15° Suitable for crops using terraces	B	B	C
15-20° Suitable for occasionally crops	B	B	C
20-60° Suitable for livestock or forest	-	C	C
>60° Unsuitable for vegetation	-	C	C

FIGURE 6. Soil classification for the Penedès area (Author's own creation based on information from Leandro López-Acevedo (1994) and the Cartographical and Geological Institute of Catalonia (ICGC, 2010-2019; 2019).

that can be seen from a certain location, taking into consideration the altitude of its terrain. The result should be interpreted cautiously as some factors have not been considered, such as the presence of a forest or frequent fog.

Finally, another way to assess the defensive qualities of a location is by observing the distance between a specific settlement and its nearest castle. A significant number of studies provide information about castles and towers in the medieval Penedès (Pladevall; Vigué, 1992; Batet, 1996; Bosch, 2017). In these studies, fortresses have been divided into two categories: castles with dependent territory (*terme*) and other buildings (castles, towers) subordinate to them. Once more, the *r.walk* tool restricted to the medieval road network (see section 3.3) has been used.

3.6. Aspect: insolation and humidity

Catalan farms (*masies*) are usually located on south-facing slopes to make the most of the sunlight (Bolòs, 2004, 154). Sun is also necessary to ensure crop growth. This quality has been evaluated by the QGIS *r.sun* tool, which calculates the hours of solar irradiation on each part of the territory on a specific day of the year using elevation data (DEM) and an aspect map (previously developed with the QGIS tool *Aspect*). In this analysis, the calculation has been limited to 21 March, during the spring equinox, since on this day the sunniest places receive exactly 12 hours of sun. This facilitates the estimation of insolation for each site.

3.7. Culturally perceived qualities

Roberts (1987, 124) considers several subjective appreciations conditioned by cultural, religious and superstitious beliefs as cultural qualities. Bolòs (2004, 154) proposes settlement continuity as one of these qualities. The existence of remains of occupation could be seen as a proof of a location's suitability to be occupied but also as evidence that it's impossible to live at the site. However, in a pre-industrial society these considerations would probably be of less importance than the reuse of construction materials. A study of the "history of mentalities" could help in determining these factors.

In the case of the Penedès monastic communities, archaeological and documentary sources provide enough information to observe the existence of prior constructions in most of the settlements studied. For this reason, the analysis has been simplified by locating on a map those sites with prior constructions and those without.

4. Conclusions

The results of the different spatial analyses explained above will be used to classify monastic communities in the medieval Penedès according to their location. For now, the experience described above reveals some considerations, mainly related to the methodological approach.

In the first place, global knowledge of the territory analysed and of its main historical and geographical characteristics is necessary. For example, what may seem a simple operation (such as calculating travel time between a settlement and the nearest thoroughfare) requires vast knowledge of the complete medieval road network. This has to be complemented with an interdisciplinary view, since there is a large number of location factors which require being familiar with different scientific disciplines. The methodology used to analyse the Penedès monastic communities has included concepts from edaphology, biology, hydrology and climatology, for example, and advice from colleagues from these disciplines has been essential.

Secondly, two ideas must be considered regarding the use of data for spatial analysis. To start with, the use of current geographical information is the only possible option under present conditions as historical sources are often unable to provide the highly detailed information needed by GIS. Using present data offers us an approximation of certain past realities, which have to be contextualised. Fortunately, studies are gradually improving our knowledge of past landscapes and this could make spatial analyses more precise in the future. Moreover, new data produced by research must be shared with the

scientific community via reliable digital deposits. This will save time for future studies and enhance the quality of the results. The work presented above would not have been possible without some information provided by public institutions.

We are still waiting to be able to present the definitive results of this analysis. However, the methodology detailed in this paper is expected to enable a classification of monastic communities according to their location factors. In doing so, it would be possible to determine which ones exercised most influence and whether some settlements share a location strategy. In certain cases, these strategies can become clear by observing a map, such as the relationship between some monasteries with drovers' routes (Sant Salvador de les Gunyoles) or important rivers (Sant Quintí de Mediona and Sant Pere de Riudebitlles). However, there are other instances where such links are not always evident, especially when the strategy takes more than one spatial factor into account. The combination of this information with historical data would make it possible to examine the success of these strategies and the influence they exercised on the development of the monastic communities.

Moreover, it's expected that the methodology presented here can also be applied to other types of settlements, such as castles or villages. Previously, however, it would be necessary to appraise its effectiveness with regard to the outcome and also to assess a possible overuse of GIS tools for some analyses.[6] In the near future, we hope to present a classification of monastic communities of the medieval Penedès according to their location factors in conjunction with new methodological considerations.

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6. This refers to the ineffectiveness of using computer programs for certain analyses when they are not strictly needed. For example, if a map clearly shows the relationship between mills and rivers, it's not necessary to calculate the distance between them.

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