



# ROMAN VITICULTURE ANALYSIS BASED ON LATIN AGRONOMISTS AND THE APPLICATION OF A GEOGRAPHIC INFORMATION SYSTEM IN LOWER GUADALQUIVIR

ANÁLISIS DE LA VITICULTURA ROMANA A TRAVÉS DE LOS AGRONOMOS LATINOS Y LA APLICACIÓN DE UN SISTEMA DE INFORMACIÓN GEOGRÁFICA EN EL BAJO GUADALQUIVIR

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## Abstract:

The advancement in the historical research of business activities, such as ancient agriculture and specifically Roman viticulture, requires the knowledge of the productive sites. This research will propose a way to interconnect the information contained in Latin agronomic tradition, in order to choose the placement of a production unit, using a geographical information system (GIS). The Latin agronomist information, together with current agricultural knowledge, may lead to a set of measurable, georeferencing criteria for future prospecting, such as land orientation to the winds and insolation, the soil types and the slope. Also, the proximity to terrestrial, fluvial and maritime communication routes, as well as cities and water supply will be assessed. This methodology is applied in the territory of the lower Guadalquivir (southwest Spain) achieving measurable criteria on a georeferenced map, being able to classify the data and create cartography that shows the best places for future archaeological prospecting.

**Key words:** GIS, lower Guadalquivir, viticulture, Columella, Roman agriculture.

## Resumen:

El avance en la investigación histórica de actividades económicas, como era la agricultura antigua y más concretamente la viticultura romana, requiere del conocimiento de los lugares productivos. Este artículo propone una manera de transferir los conocimientos que aportan los agrónomos latinos a la hora de elegir el emplazamiento de una unidad productiva mediante un sistema de información geográfica (SIG). La información agronómica latina, junto con el conocimiento agrícola actual, puede dar lugar a una serie de criterios medibles y georreferenciables para futuras prospecciones, como son la orientación del terreno frente a los vientos y la insolación, el tipo de suelo y la pendiente. También se valorará la cercanía a las vías de comunicación terrestre, fluvial y marítima, así como a las ciudades y al abastecimiento de agua. La metodología que se presenta se aplica en el espacio del bajo Guadalquivir (suroeste de España) consiguiendo medir estos criterios sobre un mapa georreferenciado, pudiendo clasificar los datos y generando una cartografía que muestre los mejores lugares de cara a unas futuras prospecciones arqueológicas.

**Palabras clave:** SIG, bajo Guadalquivir, viticultura, Columela, agricultura romana.

## 1. Introduction

When investigating Roman agriculture, it is necessary to consider the environment and the territory of the chosen site first. It is necessary to carry out some prospecting if we want to know where the most productive places are. Alternatively, nowadays with the use of a geographic information system (GIS) such as ArcGIS, it is possible to simplify this prospecting work. GIS users are able to find the correct georeference for sites and study their environment, as well as to look for potential sites where this kind of exploitation can be carried out (Goodchild, 2013; Van Joolen, 2003).

For this purpose, it is necessary to have the correct agricultural information included in ancient sources. For

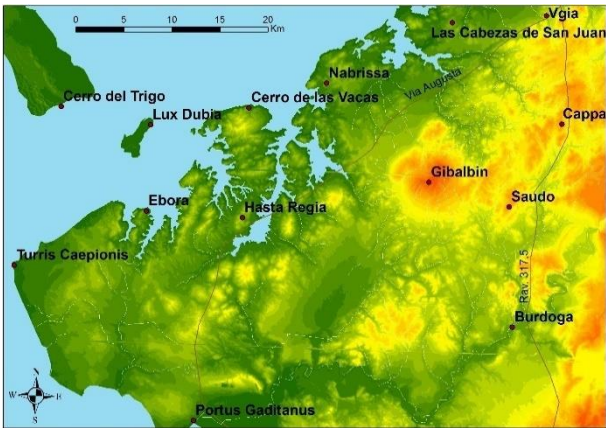
example, in the Latin agronomists, we can find quotes about some environmental factors to consider for an agricultural holding.

The first step is to choose the study area. One of the ideas of this article is to show that this can be applied to any location, and the only thing that would change would be the criterion. The frame chosen for this experiment is the marshland of the Guadalquivir, where in Roman times, there was an estuary. There was also an important Roman colony, *Hasta Regia* (Martín-Arroyo, 2013), in the specific territory of the city of Jerez (Fig. 1). The Seminario Agustín de Horozco, University of Cádiz, has abundant archaeological and geographical information about this area of land.

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**Figure 1:** Spatial study area: *Hasta Regia* colony. *Portus Gaditanus* is located in the Spain's southwest. It corresponds to today's Puerto de Santa María.

There are certain limitations within this study, as the real territoria of *Hasta Regia* is unknown. The land of the ancient Guadalquivir's estuary was called *Lacus Ligustinus* by the Romans. This navigable space allowed them to reach places which nowadays are not even near the coast. For the territory we consider the limits to be the presumed site of *lacus Ligustinus*, i.e. the actual coast and Guadalete River to the east (Lagóstena, 2014).

Columella's quotes set the study area of this territory. He is the most complete Latin agronomist, who was born in *Gades* (Cádiz). With some of his quotes, it is possible to extrapolate this ancient information to a map, especially in the case of vineyards. This type of exploitation could be significant in the territory for supplying Rome or the army, and probably part of the *annonae* system.

The vineyard agriculture in the *Uterior Baetica* province is one of the most important activities, but it is not well studied. Other products such as olives or olive oil are better researched and investigated. In the Betic province, the problem with vineyards and wine is that we do not know the production locations. In the same way, the potteries *figlinae* where the Betic wine amphoras were produced (Carreras, 2001) are unknown, and this historical problem will be a priority in the future research of the colony of *Hasta* (Lagóstena, 2001).

To advance in the know-how of this work, we propose a number of criteria or conditions that Roman farmers considered when choosing a place to farm. It is important to remember that this area was a colony, founded in the times of Caesar. Therefore, land would be distributed and divided into *centuriae*.

The conditions used to know the potential sites must be based on both ancient sources and natural necessities. There are so many criteria that can be considered for this work that we selected the land orientation, soil type, land slope and the proximity, as suggested by Viitanen (2010).

## 2. Land orientation

### 2.1. Winds

Land orientation is one of the most important concerns by Roman agronomists to choose the place for planting

crops, especially vineyards (Cato. *Agri*. 8.2. Varro *R.R.* 1.4.4. Verg. *G.* 2.185., *G.* 2.295.)

*Nobis in universum praecipere optimum visum est ut in locis frigidis meridiano vineta subiciantur, tepidis orienti advertantur; si tamen non infestabuntur Austris Eurisque, velut orae maritimae in Baetica. Sin autem regiones praedictis ventis fuerint obnoxiae, melius Aquiloni vel Favonio committentur.*

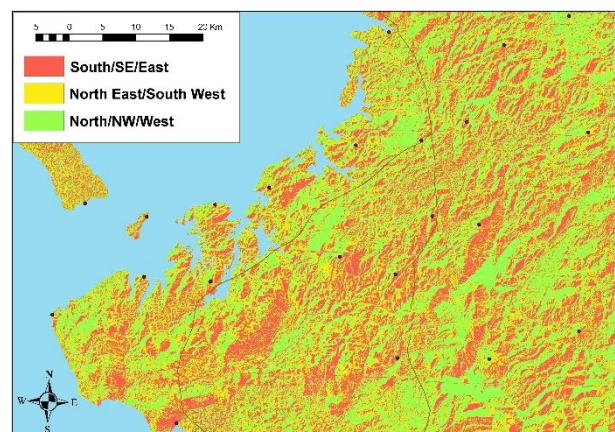
"We believe it best for vineyards to face southwards in cold regions, and in warm regions they suffer from the southerly and south-easterly winds, such as the coastal areas of Baetica. If, however, the land is subject to the aforementioned winds, it will be better for them to face northerly or westerly winds" (Col. 3.12.6.).

Columella in this passage wrote about the bad winds in the area, in the Betic province and more probably near *Gades*. The natural conditions such as winds, frosts or droughts were problems to solve in order to plant vines. In our particular working area, the south winds are hot and dry in summer. The east wind, called 'levanté', is similar to the south wind only stronger, an average of 60-70 km/h and is very common to last for a number of days. It is necessary to counter this condition which is why Columella chose this north-west orientation unlike in the rest of the Roman Empire.

Orientation to protect from winds could be studied using some ArcGIS tools, because the best place to grow a vineyard is a sheltered place, away and protected from the eastern and southerly winds, meaning terrain facing north and west.

For that, it is necessary to create a digital terrain model (DTM) in raster format, using the information in <http://www.juntadeandalucia.es/medioambiente/site/rediam/> we can download a .xyz file, that must be converted into a TIN file with the tool "create a TIN" and transformed to a raster format. With this 3D map of real elevations, ArcGIS allowed us, through the tool in Spatial Analysis Tools/Surface/aspect, to generate an orientation map with regards the compass points.

Then the only condition is to select the options, which, in this case are north and west orientation in green, east and south in red and an intermediate zone in the land orientated to north-east and south-west in yellow (Fig. 2).



**Figure 2:** Terrain orientation.

## 2.2. Insolation

Furthermore, there are other conditions to consider in the case of orientation, the insolation the terrain-ground receives:

*Loci porro vitia sunt, quae fere ad interneconem vineta perducunt, macies et sterilitas terrae, salsa vel amara uligo, praecipua et praerupta positio, nimium opaca et soli aversa vallis...*

“Furthermore, the poor qualities of a place that usually bring destruction to vineyards are harshness and barren soil, salty or bitter marshes, steep, rugged terrain, dark valleys that are not exposed to the sun” (Col. 4.22.8.)

The places affected by shadow or shade are bad for agriculture. This is logical, as we can predict that north facing mountain hillside would be more exposed to darkness than a hillside facing south. The text says that the vineyards that were planted either in areas containing plenty of salty water or in sloping areas would suffer. These are some decisive planting criteria that needed to be taken into account when choosing a location. In our analyses we shall consider these effects for choosing the areas.

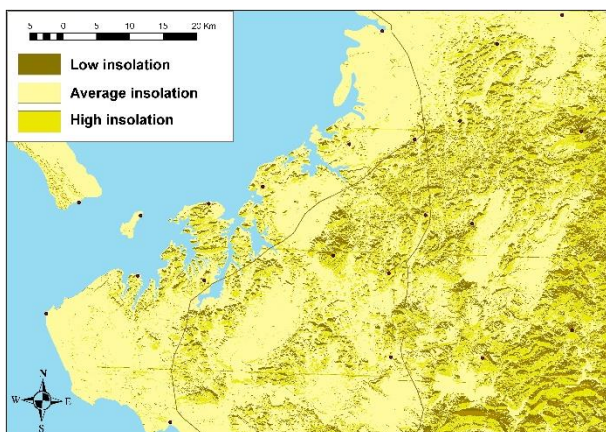


Figure 3: Land insolation study.

In ArcGIS we could use the tool Surface/hillshade with the same raster DTM as before. This tool could show the potential sites that could be in darkness. As results we could consider that the topography is not very steep, and that there are few bad places in darkness. In yellow, there are the locations with better insolation and in dark colour, the worse ones (Fig. 3).

These three criteria of the orientation, winds and insolation, seem to be contradictory at first and in fact they are, because the best exposure to the sun is in the southerly direction, but in this case it could be bad for the winds in the area. This contradiction is only seen in our particular territory due to the special conditions in respect to the land directions referred to in Columella (Fig. 4). He knew this problem and maybe because of that, he quoted his uncle's technique, about covering the vines with palm leaves in order to reduce the effects of the bad wind (Col. 5.5.15.).

## 3. Soil Types

The second criterion to be considered is the soil type, probably the most important one when selecting a place for growing crops. In our study area (Fig. 5), nowadays

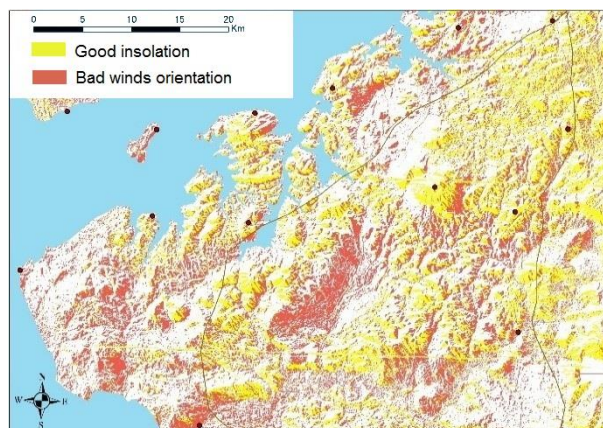


Figure 4: Bad wind orientation and good insolation match in most of the area.

there is large production of wine and a large vine crop as well. The soils are good enough, and in the past this fact was probably the same.

All the agronomists wrote about soils, but without great interest to specify which the better ones are (Cato *Agr. 1.1*. Varro *R.R. 1.6*.). The case of Columella is meaningful, not only because he wrote specifically about our research area, but also because he wrote about his uncle, natural of Gades, providing a lot of information about the matter in Betic province.

*Marcum Columellam patrum meum, doctissimum et diligentissimum agricolam, saepe numero usurperet memoria repeto, ut sabulosis locis cretam ingereret, cretosis ac nimium densis sabulu, atque... ligone succident, vim optimae stereorationis exhibebit. Succidi autem lupinum sabulosis locis oportet, cum secundum florem, lubricosis, eum tertium egerit.*

“Marcus Columella, a very learned and painstaking farmer, frequently employed: that is, to heap clay on gravelly ground, and gravel on ground that was clayey and too stiff, and in this way to grow not only luxuriant crops of grain but also very fine vineyards” (Col. 2.15.4.).

His uncle used these two types of soils, both logical choices, about the exchange of this ground type, in order to improve the quality of the land. Specifically he said that there are two good types of soils in the zone for vineyards, the first one is *ut sabulosis locis cretam ingereret*, sandy land where they add loam. We considered this, better than the translation before, because *sabulosis* is sandy rather than heap clay. The other *cretosis ac nimium densis sabulu*, which means adding sand to loam soil. These two options, sandy and loam soil are in general bad for crops, if they are alone, but good if they are mixed, as was often the case in Roman agriculture (Sáez, 1995).

Those two best soils in the text look similar to two of the common and better soils in the province, (Regosoles) “albarizas” and (Luvisoles) “arenas” (Sáez, 1987). Both have the same characteristics, if you mix them together, the resulting soil would be better for vines, as the previous text mentioned. In a recent archaeological survey, there are some ancient holes that correspond to vines in sand (López and Ruiz, 2007).

The other criterion is Columella's reference to marshland vines:

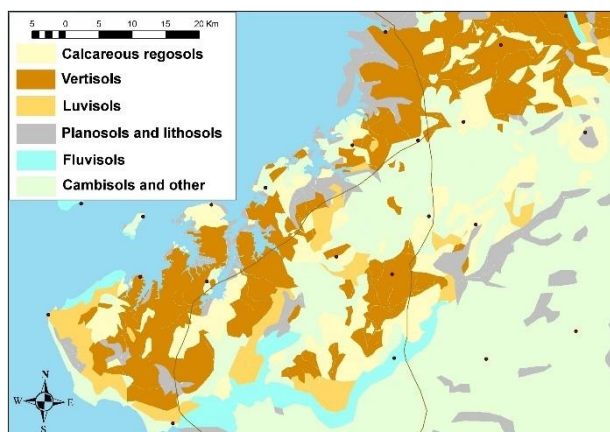


Figure 5: Soil types

*Hac conditura Columella patruus meus, inlustris agricola, uti solitus est in his fundis, in quibus palustres vineas habebat...*

“My paternal uncle Columella, the distinguished agriculturist, used to employ this method of preservation on the farms where he had vineyards on marshy ground...” (Col. 12.21.4.).

The adjective *palustres* in ancient sources are associated with wetlands. Vines do not often want wet soils and for that reason he was probably referring to a soil characteristic, a type of ground that could be flooded in some months of the year, such as the vertisols “bujeo” (De Cara, 2010).

We could consider that because Columella spoke in his book about a practice for vines, it consisted of making a hole for the plant in order to maintain the soil moisture, and that could be done in north Africa but not in a wet or rainy area, because the excess of water could damage the vine (Col. 5.5.4.).

There are other soil types in the working area. The fluvisols are common soils near a river, formed by alluvial deposits that could also be used to plant vines, as long as the vines were not covered by water for some months of the year.

Some soils are not suitable for vines such as litosols, typically in the mountains or planosols which are common in marshland soils; both used for livestock farming and other uses. The information on these kinds of soils and their characteristics can be found in the classification system proposed by the [FAO Soils Portal \(2016\)](#).

The last type of soils are cambisols and other similar types, that are good enough for every type of crop and therefore we cannot discern whether Romans used them for vines or not.

The analysis of this information by ArcGIS could be done using the server Spatial Data Infrastructure of Andalusia (IDEAndalusia, 2016), where it is possible to view the soil characteristics of the land. Then the only step is to georeference the data into a polygon layer and reclassify the new shape in numbers, ranging from 10 if the soil is good down to 0 if it is bad.

#### 4. Land Slopes

Another criterion to consider is the land slope. The terrain slope is present in Varro (Var. R.R. 1.6.5.):

*Propter haec tria fastigia formae discrimina quaedam fiunt sationum, quod segetes meliores existimantur esse campestris, vineae collinae, silvae montanae*

“Owing to these three types of configuration different crops are planted, grain being considered best adapted to the plains, vines to the hills, and forests to the mountains”.

This summarises the main idea that Columella had already written (Col. 3.1.8.).

A medium slope is appropriate for planting vineyards, and even today it is the same. We can assign the plain soil to other crops such as wheat. A steep slope would be more useful for livestock farming or other activities, **as the soil is fairly shallow and stony.**

The study of this criterion could be done by the use of the surface/slope tool (Fig. 7). It is challenging to know the value of an average slope, because by researching the sources we do not have the measuring values of large and small slopes. The slope tool shows where the terrain makes an abrupt change, even if it is in a depression. In the study, we could see that the territory is generally flat, with elevations in the Cádiz mountain range and all the territory has plenty of small changes which are shown in green. There are occasional high slopes in the area (Fig. 6).

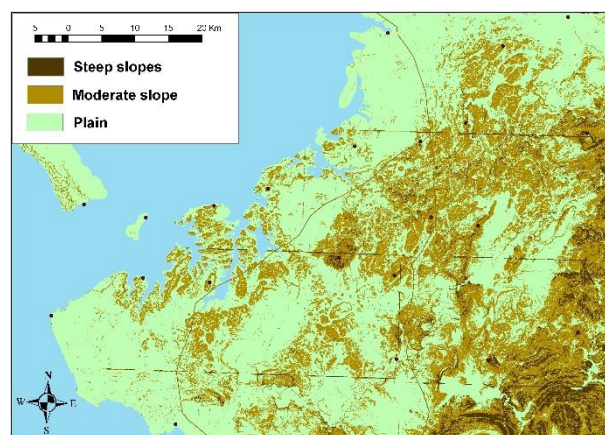


Figure 6: Slope of the study area.

We have reviewed the natural characteristics of the terrain, despite the fact there could be others. Nevertheless, these are the most important for Columella. In the same way, it is obvious that Columella is representative and the best source to learn where the potential places for Roman vineyards were.

#### 5. Proximity

From now on the criteria will be more historical, based on human factors rather than natural criteria. The factors we consider in this section are summarised by Cato (Cato Agri. 1.3.):

*Si poteris, sub radice montis siet, in meridiem spectet, loco salubri; operariorum copia siet, bonumque aquarium, oppidum ualidum prope siet aut mare aut amnisqua n̄aues ambulat, aut uia bona celebrique...*

“Take care to choose a good climate, not subject to destructive storms, and a soil that is naturally strong. If possible, your farm should be at the foot of a mountain, facing South, in a healthy situation, where labour and cattle can be had, well watered, near a good sized town, and either on the sea or a navigable river, or else on a good and much frequented road”.

When the Romans chose a place to build a villa it was important to locate it near to a city, road or a fluvial point, such as rivers and seas. Also the text refers to the need of a water supply and the proximity of workers. These two last conditions are less important in our study, because the water supply for unirrigated farmland is not necessary for vines and the manpower criterion is related with the proximity to a city.

It is possible to know the proximity using ArcGIS. The first thing is to make some changes in the DTM. By reclassifying the raster we could show classification about topography information, and by using the tool cost/cost distance, it is possible to calculate the distance to a previously chosen point (Lagostena, 2011; Mignone, 2013).

### 5.1. Location

The first proximity criterion is the case of being located near to a city or other settlement. It is relevant in this case to know where the cities or settlements are. We can locate some large cities in the territory; the most important one is *Hasta Regia* colony. There are other points nearby that could be cities corresponding to findings of complex archaeological sites, such as “Cerro de las Vacas” or “Gibalbin” (González, 2014). Others such as *Turris Caepionis* or *Lux Dubia* are not cities, but are relevant to our study, because they are cores, for example a tower and a religious sanctuary (García et al., 2008).

Anyway the knowledge of these kinds of locations is necessary as far as being near a village or city is concerned. In this case Columella told us:

*Censeo igitur in propinquo agrum mercari, quo et frequenter dominus veniat et frequentius venturum se...*

“I am of the opinion, therefore, that land should be purchased nearby, so that the owner may visit it often and announce that his visits will be more frequent than he really intends them to be...” (Col. 1.2.1)

It is something significant to be near a city, not only for the market opportunities provided there, but also for good management by an owner. This last point can be a little controversial because of the aim of Columella’s books. He aims to teach contemporaries how to be a good farmer (Col. *Praef.*) For that reason, we could consider whether the owner needed to be near a city or if that was the idea that Columella tried to teach, but was not fulfilled by the majority (Martín, 1971).

Anyway, the proximity of a city is an important criterion to place a plantation, because of the vicinity of the market. This would not be especially necessary for vines

but for the sale of fresh grapes and other fresh produce to be sold.

Fig. 7 shows the cost distance to settlements. In particular, the areas painted in green are the closer ones to settlements. This method does not only consider the straight-line distance but also the difficulty of movement in the topography of the terrain.

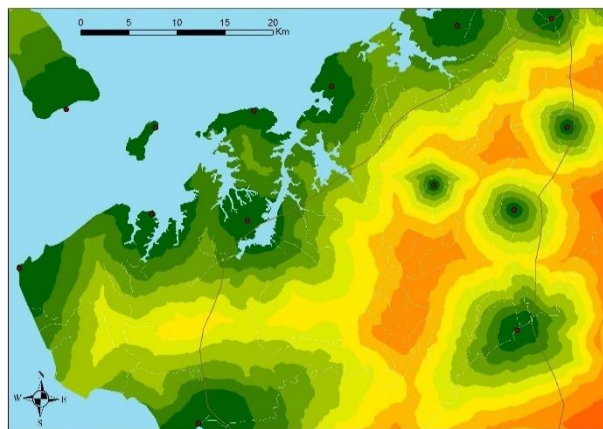


Figure 7: Cost distance to settlements.

### 5.2. Sea and river

In the same way, the proximity of either a road or a waterway is an important criterion because transportation was one of the activities that would most affect the price of the final product, which would be cheaper over shorter distances:

*Quod si voto fortuna subscribit, agrum habebimus salubri caelo, uberi glaeba, parte campestri, parte alia collibus vel ad orientem vel ad meridiem molliter devexis; terrenisque aliis atque aliis silvestribus et asperis, nec procul a mari vel navigabili flumine, quo deportari fructus et per quod merces invehí possint.*

“But if fortune attends our prayer, we shall have a farm in a healthy climate, with fertile soil, partly level, partly hilly with a gentle eastern or southern slope; with some parts of the land cultivated, and other parts wooded and rough; not far from the sea or a waterway, by which its products may be carried off and supplies brought in” (Col. 1.2.3.)

Navigable communications seem to be significant, particularly for exporting these products to other provinces. Fluvial and maritime communications could be affected by the *Lacus Ligustinus*, the actual coast and the Guadalete River (Fig 8).

The implemented methodology is the same as reported above and will be considered for the following ones (Sillieres, 2001).

To know the potential of navigable places, in the analysis we used the reconstructed estuary of the Guadalquivir and the Guadalete layer. The first was done by contour lines for Doñana and the river by georeferencing the hydrography (Gavala, 1959).

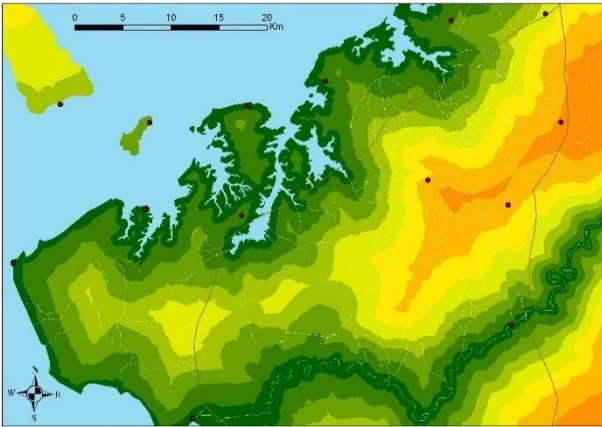


Figure 8: Cost distance to sea and river.

### 5.3. Roads

Regarding overland communications, Columella advises not to be near an important roadway due to the problem of criminals and passers-by. He said not to be too close to the road, but close enough for product transportation (Fig 9):

*Haec autem praetereuntem viatorum populationibus et adsiduis devertentium hospitiis infestat rem familiarem. Propter quae censeo eius modi vitare incommoda villamque nec in via nec a via procul editiore situ condere, sic ut frons eius ad orientem aequinoctialem directa sit.*

"Moreover, the highway, impairs an estate through the depredations by passing travellers and the constant entertainment of those who turn in for lodging. For these reasons my advice is to avoid the disadvantages of this sort and to place the villa neither on a highway nor far from a highway, heigher, and to build in such a way that it faces the point where the sun rises at the time of the equinox." (Col. 1.5.7.)

In the spatial area, two important roadways are known; the first one is the *Via Augusta* and the second is mentioned by *Ravenna Cosmography* (Rav. 317.5) a road that went from *Hispalis* to *Baessipo* (Sillieres, 1977).

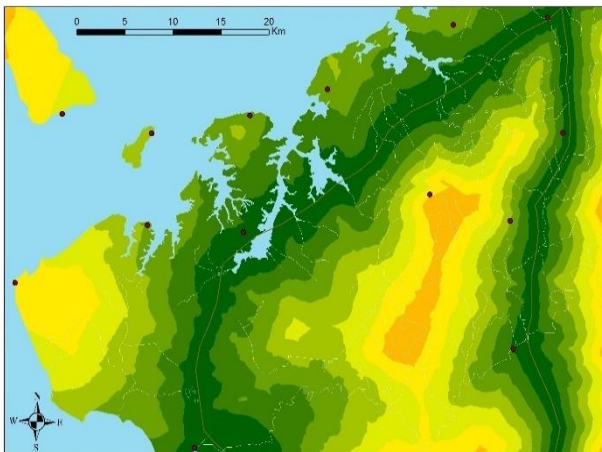


Figure 9: Cost distance to roads.

### 5.4. Water supply

The last factor to consider is the proximity of water, not specifically for consumption or livestock farming, but also for farming some crops, plants like cane, osier and rushes which are related to the crop of vineyards. They are necessary for this kind of cultivation and if they do not have them, it could increase the price of the final product.

*Quoniam constituendis colendisque vineis, quae videbantur utiliter praecipere posse, disseruimus, pedaminum iugorumque et viminum prospiciendorum tradenda ratio est. Haec enim quasi quaedam dotes vineis ante praeparantur. Quibus si deficitur agricola, causam faciendi vineta non habet, cum omnia, quae sunt necessaria, extra fundum quaerenda sint; nec emptionis tantum.*

"In as much as we have discussed those matters which seemed that could be taught to take advantage of for establishing and cultivating vineyards, a method must be set down for the provision of props, frames, and withes. For these are prepared beforehand, as dowries, so to speak, for the vineyards. And if the farmer is destitute of these, he has no reason for making vineyards, since everything that is needed will have to be sought outside the farm; and, just as Atticus says, not only does the cost of purchase put a burden upon the accounts of the overseer, but also the procuring of them is a very great annoyance." (Col. 4.30.1.)

It is focussed on vineyards because of the material required to cultivate them. As already mentioned, Romans had various types of vines that all needed wooden materials to support them. Most of the wood-producing plants were needed for supporting sticks and were found in flooded areas, such as rivers, lakes, streams and marshland. A coastal area could have supplied those kinds of needed materials. Therefore, the convenient area for siting a vineyard would be near to a coastline.

For this map we use the hydrographical information of Andalusia to create a layer with streams, lakes, rivers and the presumption of the ancient estuary of Guadalquivir.

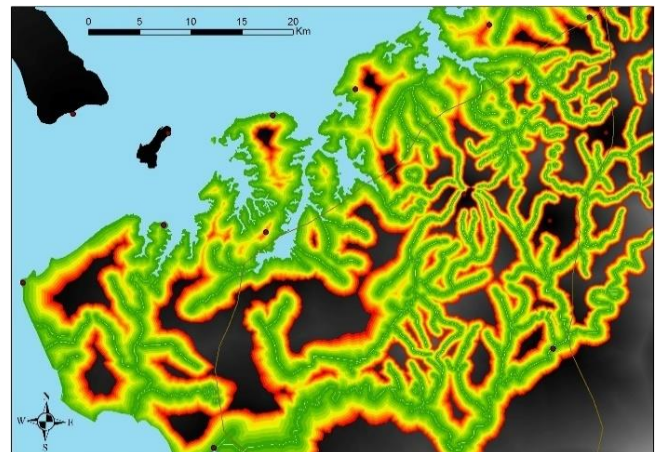


Figure 10: Proximity of streams, rivers and sea.

## 6. Discussion

The conditions we are discussing here, are not the only ones that could be considered, but they are the most important ones for this study. Unifying the conditions on a map could help to locate and visualize the potential places susceptible to be sufficiently suitable for vineyards.

There are eight conditions (criteria) that we have considered, with the associated geographical map. Using the tool weighted overlay can combine all into a single map that shows the best and worst places for vineyards (Fig. 11).

These results could help to locate a villa, not only on the main larger map, but also in a particular place. If this model were used in a smaller area, it could contribute to providing reliable results. This model tries to be predictive, looking for potential places to be prosperous.

The eight criteria of the study are weighted with the same value, 12.5%, adding up to a total of 100%. We gave them the same importance because none of them are completely determined. We use the same weighting for each criterion, because the most efficient way is to balance their values in order to discriminate none of them and because the information of ancient sources do not give us the importance that agronomists consider to every case. That could be the subject of a future study.

The results shown indicate some areas that were bad for vineyards. It is worth noticing that the study could be carried out with other parameters, such as water consumption necessary for the *villae* (but not specifically for the vineyard).

If we compare the results with the current agricultural land use, the brown color on the map is the current crop of vines and the green areas denote the best places according to the research (Fig. 12).

We can observe that there are some areas where the conditions are in the same locations as crops today whereas others are not. In the latter case we must

consider why. Firstly, most of the brown areas for current vineyards are in a light green or yellow, which are not bad for cultivation with the parameters of the Roman agronomists. The second is that the logic of the locations are not the same, because today the importance of viticulture is in Jerez and the majority of the cultivation is near this city. The other points are near Sanlúcar, Puerto de Santa María and Trebujena, these cities having a significant vineyard culture too.

## 7. Conclusion

The use of this historical information for creating a map using a GIS, allows us to estimate the potential places for vineyards. However, it could be undertaken not only for vines, but also for additional economic activities such as livestock farming, olive oil production and maybe mining and fishing.

With other parameters, it is possible to reconstruct cartography using conditions adapted to the study area designed for research and investigation. For example, in other places, wind problems should be different.

The main idea of this work was not to reach a formal conclusion that closes this issue, but to find where the areas would be located. The main purpose was to show the application of GIS to estimate land location in order to carry out future prospection.

The nearest region of *Hasta Regia*, actually north of Jerez, in the weighted map was a good result, probably because in ancient times wine production would be closer to the water, where the products might have been exported, due to cheaper waterway transportation and the proximity of a big city such as the *Hasta Regia* colony, or *Gades* (Martín-Arroyo, 2013).

The ideal study areas (highlighted in green in Fig. 9) are located in the Jerez area called "Marco del Jerez", which is currently an important wine-growing region. As it is demonstrated herein, it seems to be that cultivating vineyards was also important in the Roman age.

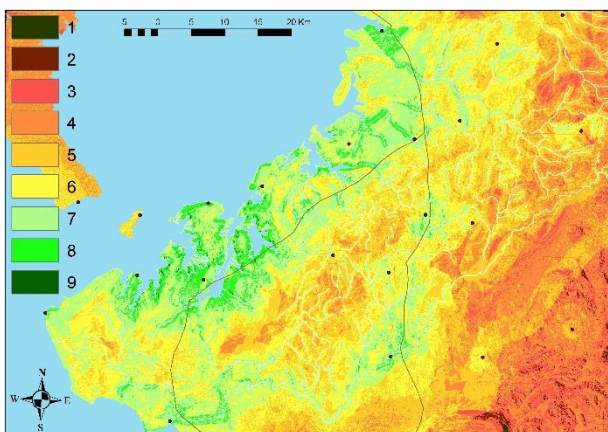


Figure 11: Final weighted map. Green: better places for vineyards.

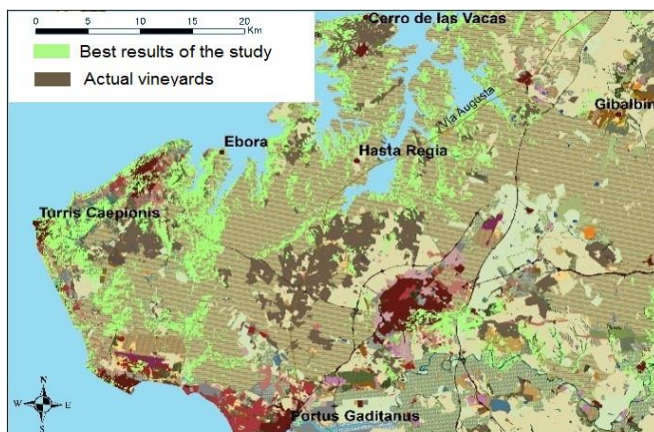


Figure 12: Results in the current land use.

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