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The Impact of Agricultural Practices and Water Management in the Eastern Spanish Coast during the Iron Age and Roman Periods: Methodological Approaches and First Results

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The Impact of Agricultural Practices and Water Management in the Eastern Spanish Coast during the Iron Age and Roman Periods: Methodological Approaches and First Results

GIS hydrological modelling; flooding; landscape; settlement patterns; agriculture; Iberian; Roman.

Introduction

Roman agricultural practices, such as irrigation, drainage, crop rotation, selective manuring and crop selection according to soil type, are well known from several Latin texts, including Columella's *De re rustica*, Varro's *Rerum rusticarum libri III*, Cato the Elder's *De agri cultura*, and Palladius' *Opus agriculturae*. Roman texts on land division and arrangement are also compiled in the *Corpus Agrimensorum Latinorum*. In the field, however, the identification of these Roman practices has been much more problematic. In the almost complete absence of empirical data, Roman land division, referring mainly to centuriation, a land division system in which part of a city's territory was divided into an orthogonal grid of land plots by roads, has been equated with extensive agricultural systems.¹

In contrast to current thinking, previous work on Iron Age and Roman landscapes, incorporating archaeomorphological analyses, survey and excavation data, palaeoenvironmental data, and GIS analyses, has indicated that Roman centuriations were not directly related to agriculture and their landscape impact was much less significant than previously assumed.² These studies further highlighted the significant role of coastal environments, littoral lagoons and water management in Roman agricultural practices.

Overall, a radically different picture of Roman land allotment and exploitation systems can now be put forward and tested using a key case study. The main objectives of this research are to:

- Record the agricultural use and landscape impact of Roman large-scale field division systems;
- Assess the importance of Iron Age and Roman hydrology control and use and
- Establish the differences between the Iron Age and Roman occupation patterns and how these are related to agricultural practices and the first large-scale management of coastal wetlands.

For the following images all rights are reserved, in contrast to eTopoi's Creative Commons licence usage: Fig. 1-2.

1 e.g., Arasa 2003, 157.

2 Orengo, Ejarque, and Albiach 2010; Palet and Orengo 2011; Palet, Orengo, and Riera-Mora 2011.

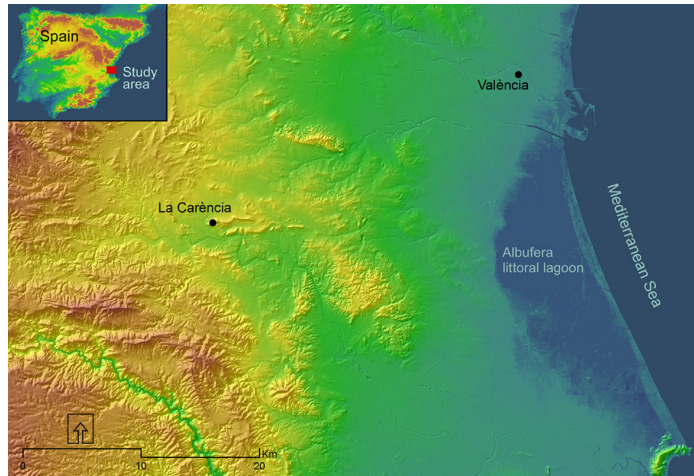


Fig. 1 | The study area (5m/cell DTM provided by the Centro Nacional de Información Geográfica).

1 The Study Area

The study area (Fig. 1) is located on the eastern coast of Spain in the province of Valencia, covering an area of 990km². The easternmost part of the study area includes the Horta Sud region, a floodplain characterised by agricultural practices heavily relying on irrigation, delimited by the Albufera coastal lagoon in the East, a low elevation calcareous range in the West, and the rivers Turia and Jucar in the North and South. The westernmost sector of the study area includes part of the Ribera Alta region, an inner area with a more irregular topography characterised by a dry farming agricultural system. During the last 20 years intensive survey due to urban development and research has resulted in the collection of an impressive amount of data. The two most important *nuclei* in the study area are La Carència, an Ibero-Roman *oppidum* (5th century BC to 4th century AD), and the Roman city of *Valentia* (modern València), a *Colonia* founded in 138 BC, next to the Albufera coastal lagoon and given to the veterans who served under Viriathus.

La Carència has an urban area of about 8ha and it has been identified as the lost Iberian city of *Kili/Gili*, only known by its monetary production. More than 50 settlements have been located during the last few years that can be associated to this *oppidum*.³ Regarding *Valentia*, several studies have identified a centuriated network⁴ and many *villae* and other rural settlements in its territory, many of which border the historic limits of the Albufera lagoon.⁵ The proximity of these two *nuclei* suggests a shared territory, and therefore, an integrated study of the site distribution across the whole area can offer meaningful insights into changing occupation patterns from the Iron Age (Iberian) to the Roman period. The significance of the study area lies in the combination of identified Roman field systems, well-known occupation patterns in both the Iron Age and the Roman period and the presence of the Albufera littoral lagoon, which according to geomorphological and sedimentological data was during the Roman period many times bigger than its current extent.⁶

3 Orengo, Ejarque, and Albiach 2010.

4 e.g., Pingarrón 1981.

5 Orengo (in press).

6 Carmona 2003, 59.

2 Methodology and Sources

This research has incorporated a combination of geospatial technologies applied to the study of occupation patterns and agricultural exploitation but also to the analysis of ancient hydrology control and use by adopting a multidisciplinary approach:

- The introduction of all Iron Age and Roman sites into a GIS geodatabase was core, allowing differentiation between Iberian and Roman settlement patterns.
- Archaeomorphological analysis contributed to the investigation of the Roman communication network and field systems (including the verification of the different centuriation hypotheses around *Valentia*), following previously developed methodological approaches.⁷
- In order to perform hydrological analyses in the study area it was necessary to correct the major modifications of the landscape made with the construction of a new riverbed of the Turia river during the early 1960s. In order to do so, a high-resolution topography of the area transformed by large-scale watershed modifications had to be developed. Thus, several 1956 USAF vertical aerial stereophotographs were used to reconstruct the ancient topography by means of photogrammetrical block triangulation. Ground Control Points were obtained from the Cartographic Institute of Valencia (ICV). The photogrammetrical derived model was transformed into a raster DTM of 20m/cell.
- The 20m/cell DTM developed by photogrammetrical block triangulation representing the area prior to the 1960s landscape modifications, allowed the discrimination of the new riverbed by a Cut and Fill comparison with a LiDAR-derived 1m DTM provided by the ICV. The “filling” of this artificial riverbed in the 1m DTM by employing the photogrammetrical derived DTM allowed a combined model to be obtained in which sedimentological data describing the ancient course of the Turia river⁸ was incorporated. According to Carmona and Riu⁹ the river discharged into the Albufera coastal lagoon during the Roman period. From this combined model a depressionless DTM was produced by a process of sink identification and filling. The depressionless DTM was employed to extract river basins and sub-basins and model the area’s hydrological network using the standard hydrological modelling tools implemented in ArcGIS 9.3.
- The use of advanced hydrological modelling was also necessary, permitting the simulation of flooding areas, water accumulation zones and seasonal water level variations in the Albufera littoral lagoon but also in rivers and flooding zones of the study area. To this end, HEC-RAS 4.1 software, developed by the US Army Corps of Engineers has been employed in combination with HEC-GeoRAS 4.3 and ESRI ArcGIS 9.3. Calibration of the model, in terms of channel roughness coefficient Manning’s ‘n’ values, was derived from the reference tables provided by Chow¹⁰, through field observation, photo interpretation and geological information provided by the Geological Survey of Spain. Cross-sections were extracted from the LiDAR-derived 1m DTM. Finally, information on flood occurrences, their extension, range and frequency in the study area, supplied via WMS by the Regional Council of Environment, Water, Urban Development and Residential Planning was also incorporated. This information complemented the more detailed HEC-RAS hydrological model.

7 Orengo and Palet 2010.

8 Carmona and Riu 2011.

9 Carmona and Riu 2011.

10 Chow 1959.

- Several multiband satellite imagery, such as ASTER and Landsat, were also employed to locate moisture accumulation areas and palaeorelief features, which influenced the settlements, and exploitation dynamics. It also helped to define the historic limits of the Albufera before its medieval drainage. The combination of thermal ASTER data and Landsat TM band 5 provided a good approximation to soil moisture content.
- Written documentation and ancient map analysis was also used to evaluate the extent of areas prone to flooding prior to the first reservoirs in the 18th century and to provide a maximum water input to the reconstruction of the ancient hydrological system. The analysis of ancient maps depicting flooding episodes was particularly useful for this.
- GIS-based geostatistical analyses, in particular the Kolmogorov-Smirnov test, allowed the construction of a hypothesis on the influence of Roman agricultural practices in relation to settling preferences, territory organisation and water management. These analyses allowed the testing of the significance of site distribution along centuriated Roman roads, along the edge of flooding areas and the proximity of sites to water sources.

In a second phase the project will also incorporate a series of techniques which will allow a much more in-depth analysis of the previously obtained data:

- Palaeoenvironmental data and geoarchaeological records, some of them already available for the Albufera, will provide the necessary background palaeoenvironmental data to test the model.
- Ground truth test pit excavation of palaeofeatures of archaeological interest will provide dating material and confirm the preliminary typological assessment made by remote sensing.
- Results obtained in the study area will be compared with other littoral areas for which good datasets incorporating archaeological and palaeoenvironmental data are available, such as *Tarraco* (modern Tarragona), *Barcino* (modern Barcelona) and *Emporiae* (modern Empuries). This will permit assessment of the significance of the data and the local or broader character of the Roman landscape use patterns documented in Valencia.

3 Preliminary Results

The distribution of archaeological sites suggests rather different settlement patterns for Iberian and Roman sites. While Iberian sites are mainly located around the city of la Carència showing a preference for well-drained soils and water springs, Roman settlements are located close to river flooding areas and wetlands. After the foundation of *Valentia* the territory around la Carència is progressively abandoned for the floodplain area around *Valentia*.

The combined DTM provided an approximate picture of the topography of the study area during the Roman period. The conjunction of this data allowed the use of hydrological modelling in the reconstruction of an extensive coastal lagoon with seasonal water variations. Flood modelling was also applied to the simulation of the area's major rivers' flooding catchments.

Preliminary archaeomorphological analysis indicated the absence of any definitive proof of a centuriation in the study area. However, several axes can be related to Roman

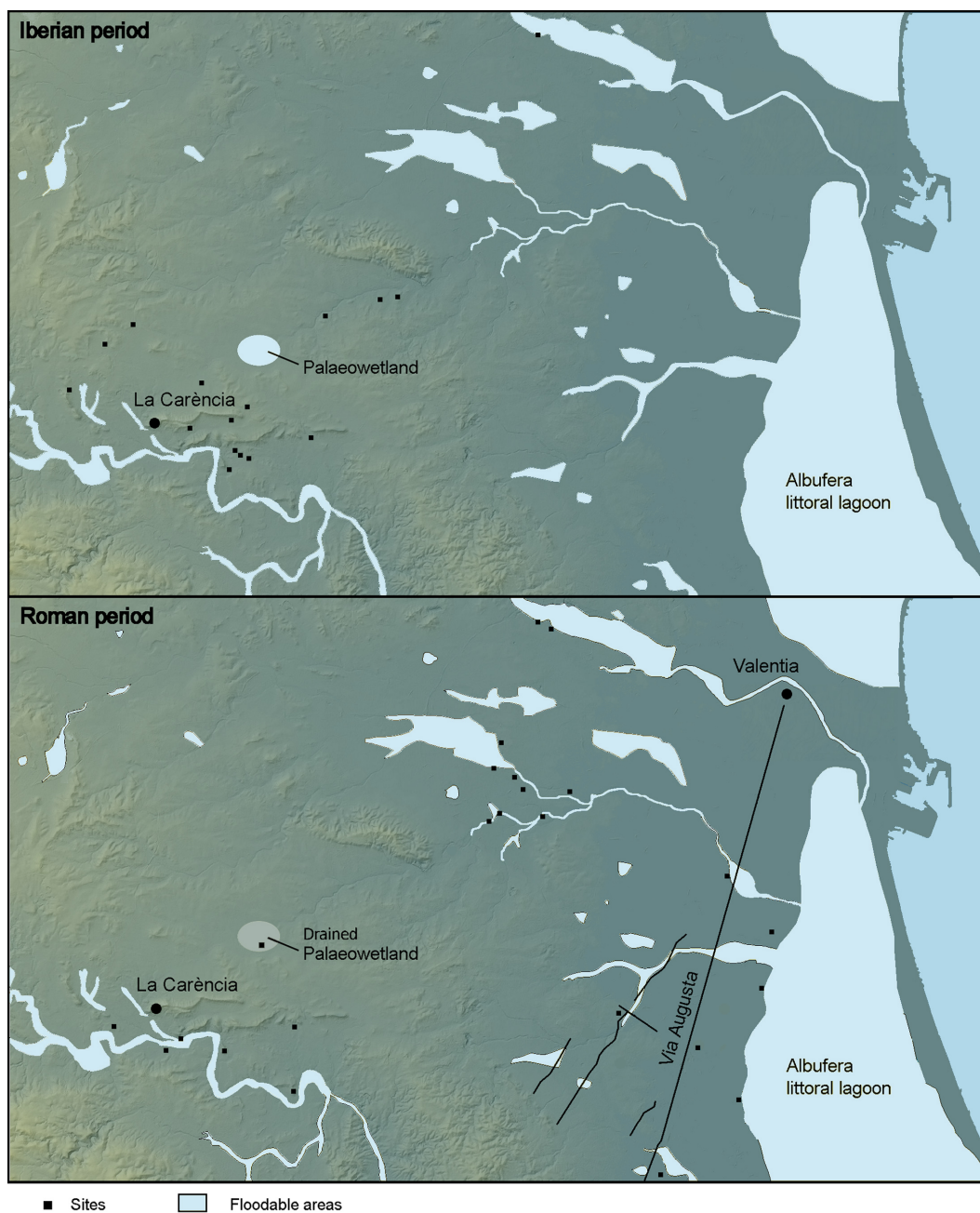


Fig. 2 | Settlement patterns, flooding areas and archaeomorphological traits from the Iberian to the Roman period (5m/cell DTM provided by the Centro Nacional de Información Geográfica).

roads, mainly, the *via Augusta* (Fig. 2). Only three Roman sites can be related to this road while most other settlements are located along the edge of the Albufera lagoon and close to flooding areas (Fig. 2).

4 Discussion

Although definite results cannot be offered at this early stage of the project, some preliminary hypotheses can already be put forward. The location of Roman *villae* and rural settlements along the edge of the Albufera coastal lagoon at its seasonal maximum suggest intensive seasonal agricultural exploitation of the rich organic sediments deposited during

its maximum rather than, as it has been previously suggested, a first drainage of the lagoon during the Roman period. Settlement data around the city of la Carència indicate a similar pattern: while previous Iberian sites are abandoned, newly founded Roman sites in this area are closely associated to seasonal wetlands and river flooding areas (Fig. 2).

The scarcity of traces of Roman land division systems and roads in the study area might not be entirely related to preservation issues. The existence of a Roman centuriation in the area, as was repeatedly suggested during the last 40 years, should not be taken for granted since little evidence exists to support this apart from the *via* Augusta. The few *villae* located along the *via* Augusta do not appear to be dedicated to agricultural exploitation. In-depth study of the area's archaeomorphology in a second stage of this project will provide further data in this context.

These data are in accordance with the evidence found in well studied areas such as *Tarraco* and *Barcino*, where the existence of a centuriation was not related to more extensive agricultural exploitation. These areas show a concentration of agricultural activities in the riverbeds and coastal areas while, in general, human impact on the landscape is scarce.

5 Conclusions

All these data seem to suggest major changes to previously held theories on the agricultural use of large-scale field divisions during the Roman period. Field divisions appear not to have only served the agricultural exploitation of land but they were also a statement of the new Roman status of the territories. Roman agriculture in the eastern littoral of Spain thus, according to current data, thoroughly exploited coastal and river resources to develop an intensive agricultural management rather than an extensive management of the territories in the hinterland.

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