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Digital historical reconstruction of the rural landscape of Villa Barbaro in Maser

Keywords: Historical cartography - digital reconstruction - rural landscape - piantata veneta

Summary: The evolution of information technology has profoundly transformed the methods used to study and disseminate the history of a territory. In particular, the use of digital cartography and historical documents now allows for a more in-depth and integrated reading of the past. At the same time, multimedia communication plays a fundamental role in promoting and disseminating cultural and environmental heritage. IT tools, and computer graphics in particular, are not limited to the transmission of information, but also allow the visualisation of three-dimensional models capable of representing the evolution of the landscape and interventions in the territory in a qualitative and quantitative manner. This approach allows for the comparison of different types of data: historical, artistic, geographical, and economic; promoting integration between different scientific disciplines and professional fields. (Balletti 2015). This is the perspective of the present research, which aims to digitally reconstruct the historic rural landscape in which Villa Barbaro in Maser (TV, Italy) is located, a 16th-century Palladian masterpiece now protected by UNESCO. The work has integrated historical cartography, archival documents, direct surveys and advanced spatial technologies (GIS, 3D modelling, rendering and real-time animations) to identify the territorial transformations that have taken place from the 18th century to the present day. Based on these analyses, three evocative landscape scenarios were recreated, capable of visually restoring the agricultural evolution and, in particular, of bringing back the memory of the Venetian plantation cultivation system, which has now disappeared. The result is an immersive interpretative experience that expands the boundaries of traditional research, promotes dissemination to the general public and offers new tools for the protection and enhancement of the landscape and cultural heritage.

1. Introduction

Designed by Andrea Palladio between 1549 and 1558, Villa Barbaro in Maser is a Renaissance masterpiece and has been a UNESCO World Heritage Site since 1996. Representing one of the finest examples of the integration of architecture and rural landscape, it fully embodies the ideal of the Venetian villa as a place of balance between productive function, noble residence, and space for cultured reflection. Situated in the Marca Trevigiana, along the foothills of the Asolo Hills, the villa straddles the hills and plains, a geographical location which has favoured its agricultural vocation. Conceived as a farmhouse, Villa Barbaro was built during a period of significant agricultural expansion by the Venetian aristocracy, who sought to increase their social and economic prestige by acquiring and developing land. The close relationship between the manor house and spaces used for agricultural production gives the villa dual significance: it is both a symbol of the power and culture of the Venetian patricians and the organisational centre of the surrounding rural area. A harmonious synthesis of architecture, painting and sculpture, Villa Barbaro is also a total work of art. Paolo Veronese's frescoes and Alessandro Vittoria's sculptures contribute to the creation of an ideal, cultured space where nature and artifice merge in timeless harmony. As Palladian literature

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states, villas are not only places of delight, but also instruments that connect man to the landscape and culture to work. (Zorzi 1939).



Figure 1: Villa Barbaro a Maser, FAST (TV)

1.1 The research programme

The following research is part of the PNRR programme ‘Programmes to enhance the identity of places: historic parks and gardens’, which involves a series of restoration and enhancement works on the gardens, vegetable gardens and architecture of Villa Barbaro in Maser³. These interventions aim to restore the space to its original splendour, making the deep connection between architecture and nature that has historically characterised the complex perceptible to the public once again. The villa, conceived by Palladio as a place of balance between agricultural function and noble residence, is thus reinterpreted in the context of the landscape that generated and sustained it.

1.2 Research objectives

This research project examines the changes to the rural landscape surrounding Villa Barbaro, with the aim of contextualising and strengthening the relationship between the villa's architecture and its surroundings. By cross-analysing sources, a hypothetical layout of the villa's agricultural landscape and that of the Maser territory has been reconstructed, spanning from the early 18th century to the present day. Particular attention has been paid to the rediscovery of mixed farming, specifically the Venetian plantation system a distinctive agricultural feature that has disappeared from both the local context and collective memory. In order to visually restore the evolution of the landscape, three main phases were identified and translated into photorealistic digital reconstructions in the form of immersive views and videos.

This interdisciplinary research also aims to produce results that can be appreciated by a non-specialist audience through the use of accessible, narrative visualisation tools that promote a greater awareness of the historical, cultural, and environmental value of the landscape. At the same time, the research aims to promote innovative methods for enhancing historical cartography as a heritage to be preserved, interpreted, and communicated in a contemporary manner.

³ <https://pnrr.villadimaser.it/>

2. Materials

To identify and interpret the changes, various types of sources were cross-referenced. These provided an overview of the complex landscape and enabled an interpretation to be made in order to obtain digital outputs.

2.1 Historical cartography

Historical cartography is a fundamental tool for analysing changes in the landscape, territorial organisation and agricultural practices. In addition to physically representing space, historical maps reflect the ways in which past societies perceived and managed their environment, providing valuable data for historical, geographical and environmental research.

To be used effectively, it requires critical analysis that considers the context in which it was produced: each map was created to meet specific administrative, fiscal or military needs, which influenced its structure, scale, symbols and accuracy. Integration with other sources, such as land registers or notarial deeds, allows for a more complete reconstruction of territorial realities.

- *Private land registry 1707*: watercolour maps created by Sebastiano Corradin, showing the properties of Villa Barbaro in Maser and Muliparte with numbered and detailed descriptions of each plot. The soil is characterised by colours, the buildings are represented in axonometric projection and feature many details, also showing the type and number of floors above ground. Elements not visible on other maps include the diamond-shaped paving in the semicircle at the front of the villa and the “stradon”, a now fragmented avenue that led to all the land holdings in the plain. Mixed cultivation is present throughout the estate, with the abbreviations APV and PPV. The cadastre was surveyed photogrammetrically by the CIRCE laboratory at the IUAV University of Venice.



Figure 2: Private land registry, Villa Barbaro and part of the hillside farms, CIRCE Geomatics Laboratory, IUAV University of Venice

- *Design of the Asolo Public Land Registry 1715*: intended for tax purposes, it contains watercolour maps of individual plots and a book of estimates with data on property, use and value of land. The maps, kept in the Municipal Archives of Asolo, show simplified buildings in axonometric projection. The colours of the contours distinguish mixed crops.

An overlay of the private land registry with the Public Estimate has made it possible to contextualise the properties of the Villa in the territory of Maser.



Figure 3: overlay of the private land registry in colour on the Design of the Asolo Public Land Registry in black and white, CIRCE Geomatics Laboratory, Iuav University of Venice.

- *Von Zach military map, 1805*;
- *Napoleonic maps, 1811*: the villa and various buildings used for production are represented with geometric precision and detailed characterisation of the land, such as gardens, vegetable gardens, nymphaeum, orchard, et.;
- *Austrian maps 1840*: update of the Napoleonic maps with greater accuracy and verification;
- *Italian land registry 1942*;
- *Topographical map of Italy from 1890 and 1968*: these provide an overview of the landscape surrounding the villa and its changes over time.

2.2 Aerial photographs

To support historical cartography, the analysis integrated the use of aerial photographs to identify landscape components such as vegetation, agricultural features and water sources. Combining photographs with cadastral and topographical map data enriches our knowledge of the landscape, providing a more accurate picture of the changes that have taken place over time.

- IGM 1945, Str. 09 Photo 128 154, Veneto Region;
- G.A.I. 1945, Str. 23 Photo 1714, USA Army Map Service, Map Library of the CIRCE Iuav Geomatics Laboratory;
- IGM 1967, Str. 68 Photo 288 159, Veneto Region;
- Mountain Series 1967, Str. 45D Photo 128 161, Veneto Region;
- Reven Montagna Veneta 1992, Str. 01 Photo 24 Rossi-Brescia, Veneto Region;
- REVEN Treviso 2008, Veneto Region, st. 02 photo 5091;
- AGEA 2015, Maser-083162 166, Veneto Region.
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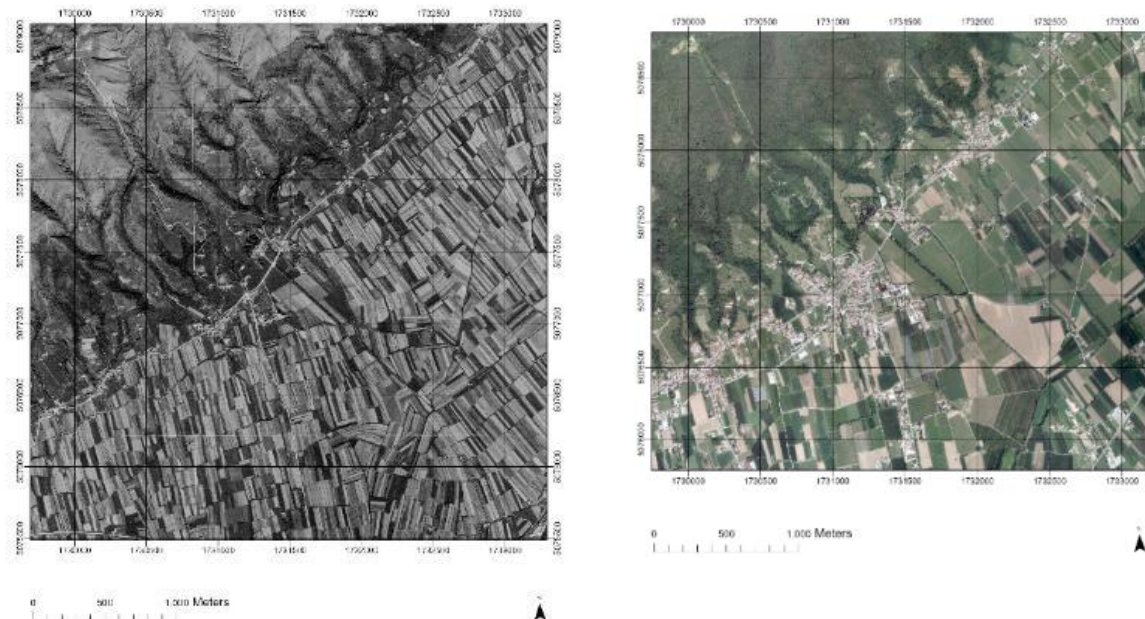


Figure 4: IGM 1945, Str. 09 Photo 128 154, Veneto Region and AGEA 2015, Maser-083162 166, Veneto Region.

2.3 Archival documents

Various types of archival documents were consulted, held in various archives in Veneto, including: the State Archives of Venice, the State Archives of Treviso, the Historical Photographic Archive of Treviso FAST, the Municipal Archives of Asolo, and the Archives of the CIRCE Geomatics Laboratory of the IUAV University of Venice. These documents provided a more complete view of the landscape and allowed us to contextualise and justify certain choices made in the representation of historical maps.

- Polizze d'estimo 1542, Podesteria di Asolo. Archivio Comunale di Asolo;
- Quaderno dei Gelsi 1831, Archivio di Stato di Venezia;
- Annotatorio dei Fabbricati, distretto di Asolo, comune di maser, 1839, Archivio di Stato di Venezia;
- Quaderno dei Gelsi e degli Ulivi, 1831, Archivio di Stato di Venezia;
- Sommarioni, Archivio di Stato di Venezia;
- Registri, Archivio di Stato di Treviso;
- Registri 1714, Archivio Comunale di Asolo;
- Registri agrari, Archivio di Stato di Venezia;
- Atti preparatori del censo stabile 1827, Archivio di Stato di Venezia;

- Inchiesta agraria e sulle condizioni della classe agricola, Jacini 1881-1890, Archivio Comunale di Asolo;
- Catasto agrario 1929, Archivio di Stato di Venezia.

2.4 3D Survey

The survey was made to get an accurate, scaled, and georeferenced 3D model of the villa and its gardens and how they appear today, which is essential for 3D modelling of the landscape and for the consistent insertion of meshes related to complex architecture. To this end, the Iuav Geomatics Laboratory carried out several integrated surveys:

- photogrammetric survey by drone, DJI Mavic, 8192x5460 pixels and 72 dpi;
- ground-based photogrammetric survey, Nikon D800, 7360x4912 pixels, 300 dpi, of the interior and exterior of the villa and the exterior of the Palladian temple, and Sony DSC-RX100M4 with telescopic arm, 5472x3648 pixels, 350 dpi, of some details;
- photogrammetric survey with spherical camera, Ricoh Theta Z1, of the interior of the villa and the Rose Garden;
- survey with SLAM technology, Stonex 120XGO, interior and exterior of the villa;
- survey with laser scanner, Faro Cam 2, greenhouses, nymphaeum, exterior of the villa;
- GNSS survey, Stonex850 GPS.

3. Research method

Historical maps and aerial photographs were georeferenced and compared in order to produce new thematic maps, useful for identifying the main changes in the landscape from 1700 to the present day. Based on the nine maps, three significant historical phases were identified, each of which was digitally reconstructed using three-dimensional territorial models and soil characterisation, with the aim of conveying the most evident landscape transformations. A “typical field” representative of the agricultural configuration of each era was also defined, the characteristics of which were then extended on a territorial scale to digitally reconstruct the rural landscape. Given the importance of vegetation in the perception and structure of the landscape, it was necessary to identify an effective methodology for digitally representing its coverage and distribution. Therefore, software capable of managing complex three-dimensional models, rich in vegetation elements, was chosen to ensure consistent and systematic modelling of the entire territory analysed.

3.1 Georeferencing

In order to compare the different maps and aerial photographs, each document was georeferenced according to a modern reference system. This process allows historical representations to be associated with a modern coordinate system, making it possible to compare them with contemporary maps and identify differences, distortions and territorial changes. To address this complexity, advanced software capable of applying both global and local transformations was used to correct distortions while maintaining a balance between the originality of the document and its compatibility with current data. In this way, historical cartography becomes a dynamic analysis tool, capable of providing a more accurate and detailed image of the past. [Azzari 2010; Balleti and Guerra 2005; Balleti and Guerra 2016] The process of georeferencing a historical map in raster format consists of assigning geographical coordinates to each pixel of the image. This is done

through a series of geometric transformations and resampling operations, based on a set of control points identified in correspondence with characteristic elements present in both historical and modern cartography. The procedure adopted in this research is based on the “Adjust” transformation model, integrated into the Esri ArcGIS Pro software. This method was chosen because it combines a global polynomial transformation with a local transformation, making it particularly suitable for correcting the distortions typical of ancient maps. The reference system used is Gauss-Boaga west fuse.

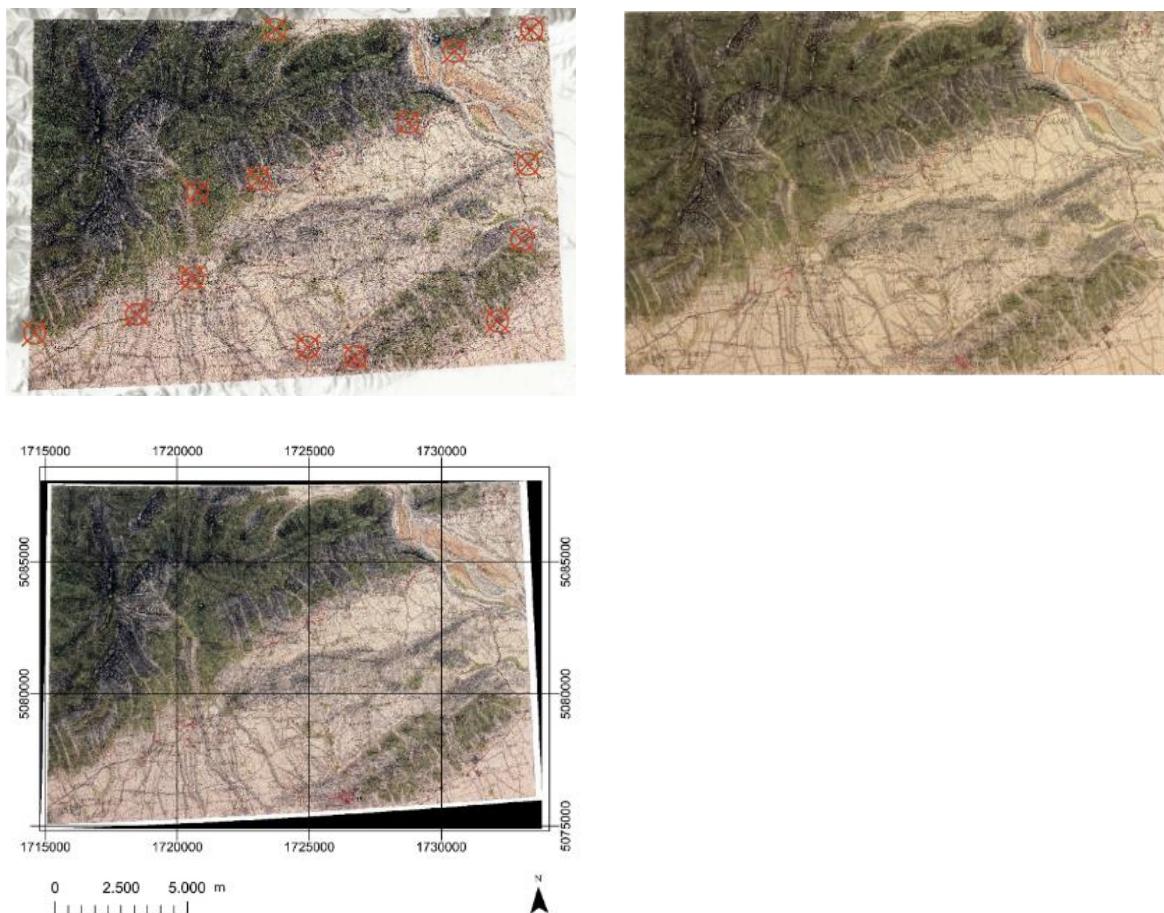


Figure 5: example of ‘Adjust’ georeferencing: original Von Zach map, map with control points, georeferenced map.

3.2 3D mapping

For better interpretation and dynamic visualisation, some historical maps have been rendered in three dimensions. Using ArcGIS Pro software, it was possible to integrate the historical maps with the current Digital Terrain Model (DTM) by applying the DTM's altitude coordinates, in the same reference system, to the pixels of the raster image. The result of applying the historical maps to the DTM was satisfactory, as the presence of the Asolo Hills introduces variations in altitude that give the map greater dynamism and realism. The analysis highlighted how these morphological differences contribute to a more accurate representation of the territory, improving the perception of the area's orographic characteristics.

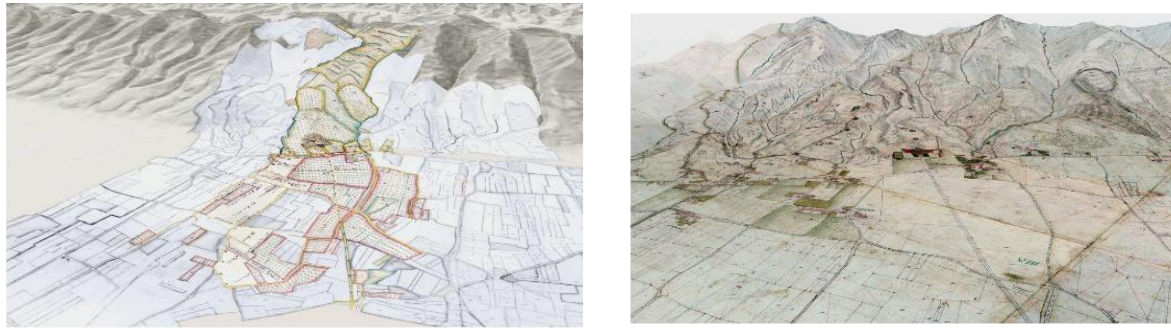


Figure 6: integration of historical cartography with the DTM for 3D visualization.

3.3 New thematic maps

Thanks to the georeferencing of maps and aerial photographs, it was possible to compare the various sources and create new thematic maps with a particular focus on crops and land use. In order to compare and analyse the various historical maps and aerial photographs, considering their different nature and the different periods in which they were created, it was necessary to standardise them.



Figure 7: thematic maps from different periods with Villa Barbaro at the centre.

- *1700*: agricultural landscape dominated by mixed cultivation, associated with grazing in the hills and arable farming in the plains, with few areas devoted solely to forestry, and rural buildings scattered across the hillsides.

- *First half of the 19th century*: rationalised agricultural organisation, expansion of production annexes, presence of orchards and vegetable gardens near buildings, first traces of specialised viticulture in the hills; slight increase in building density along the main road.
- *First half of the 20th century*: mixed farming still present but in decline, development of specialised vineyards and fruit growing, fragmentation of farms, expansion of production buildings on the villa's farms.
- *1960-70*: acceleration of the abandonment of mixed farming, spread of intensive farming (monoculture of vines and cereals), characteristic long and narrow fields still present, increase in urbanisation and industrial areas; comb-like building settlement along the main roads.
- *Current landscape*: consolidation of intensive viticulture and monoculture, progressive unification of agricultural plots to facilitate mechanisation, expansion of woodland on the hills at the expense of pastures, reduction of separating trees, construction growth in the industrial area.

3.4 “campo tipo”

To reconstruct the elements of the landscape, three periods were identified: the first half of the 19th century, the first half of the 20th century and the current landscape. These periods were chosen because they represent the most significant phases of transformation in the rural and agricultural landscape of Maser, highlighting the main changes in land management, cultivation techniques and the layout of agricultural elements. For each era, a “*campo tipo*” was defined, a representative model of a typical agricultural field that helps to understand the spatial relationships between agricultural elements, such as the layout of plants, the distances between rows, the presence of headlands and agricultural hydraulic systems, etc. The rules and relationships of the typical field were then extended and applied to the scale of the entire territorial model. Particular focus was given to the Venetian plantation, a mixed cropping system that has profoundly characterised the agricultural landscape of the Veneto region since the 16th century. Based on the association of vines, support trees and herbaceous crops, this technique responded both to production needs and to the logic of rational land use. Over time, however, changing economic and social conditions led to the gradual abandonment of this system, significantly altering the appearance of the landscape and the memory of its original agricultural practices (Bulian 2001).

- *First half of the nineteenth century*

In the first half of the 19th century, the agricultural landscape around Villa Barbaro was dominated by Venetian plantations. The fields had an orderly geometric structure: rectangular, with headlands for the passage of working animals and drainage ditches along the sides to facilitate drainage. Vines were cultivated in a married form, intertwining with trees such as field maples, elms and fruit trees, planted at regular intervals of about three metres. The most common training system was the festoon system, with shoots suspended between support trees, creating arches of vegetation that were functional for the ripening and harvesting of the grapes, while in the hills they were associated with a tree. Inside the plantation, cereals such as corn and barley were grown, alongside vegetables such as beans and potatoes. Mulberry trees played a fundamental role, both at the head of the rows and scattered throughout the fields, as they were important for silkworm farming and the rural economy of the time.

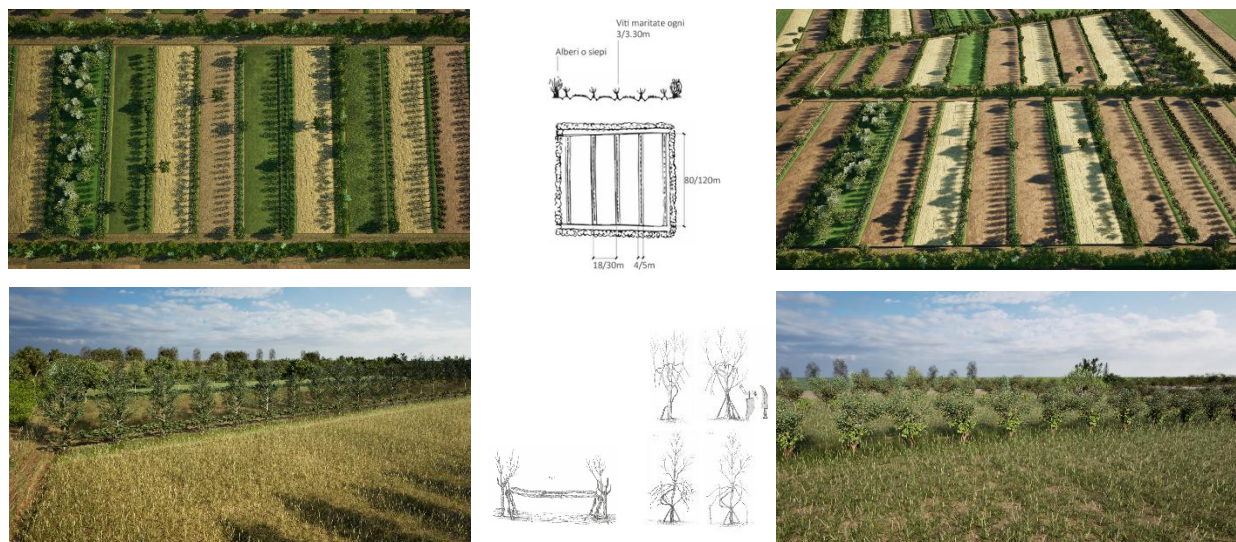


Figure 8: digital reconstruction of a “campo tipo” representative of the first half of the 19th century.

- *First half of the twentieth century*

In the first half of the 20th century, the agricultural landscape underwent a gradual transition: although still present, the plantation began to adapt to new economic requirements. The first specialised vineyards began to spread, where vines were no longer grown only on living supports, but also on dry poles and iron wires, allowing for a more rational and orderly planting system. However, the structure of the plantation was not completely abandoned: in many cases, mulberry trees survived as isolated elements or within the new rows. The traditional distances between the elements were partly preserved. On the one hand, the nineteenth-century agricultural structure persisted, while on the other, more productive cultivation models emerged, heralding the intensive agriculture of the post-war period.



Figure 9: digital reconstruction of a “campo tipo” representative of the first half of the 20th century.

- *Current landscape*

In the current landscape, the Venetian plantation survives only as an agricultural memory in some marginal sectors. The modern field is simplified, dominated by intensive specialised viticulture, with rows spaced between 2.50 and 3.50 metres apart and vines planted about 2 metres apart. The

plants are supported by concrete or aluminium poles connected by iron wires, in a system designed for mechanisation and production efficiency. Agricultural industrialisation, increasing urbanisation and replacement with more profitable crops (first corn, now vines) have made planting inefficient in terms of new economic logic. However, the villa's estate does not engage in intensive production but still preserves an example of specialised vineyards cultivated using ancient techniques, with low-growing vines supported by wooden poles, bearing witness to the area's farming tradition. The “relics” identified to the south of the study area represent a living memory of the historic agricultural landscape and offer an opportunity for conservation and cultural enhancement. Today, the forest dominates large portions of the hilly landscape, replacing historic crops and pastures as a result of the abandonment of agricultural practices and policies that have encouraged reforestation.

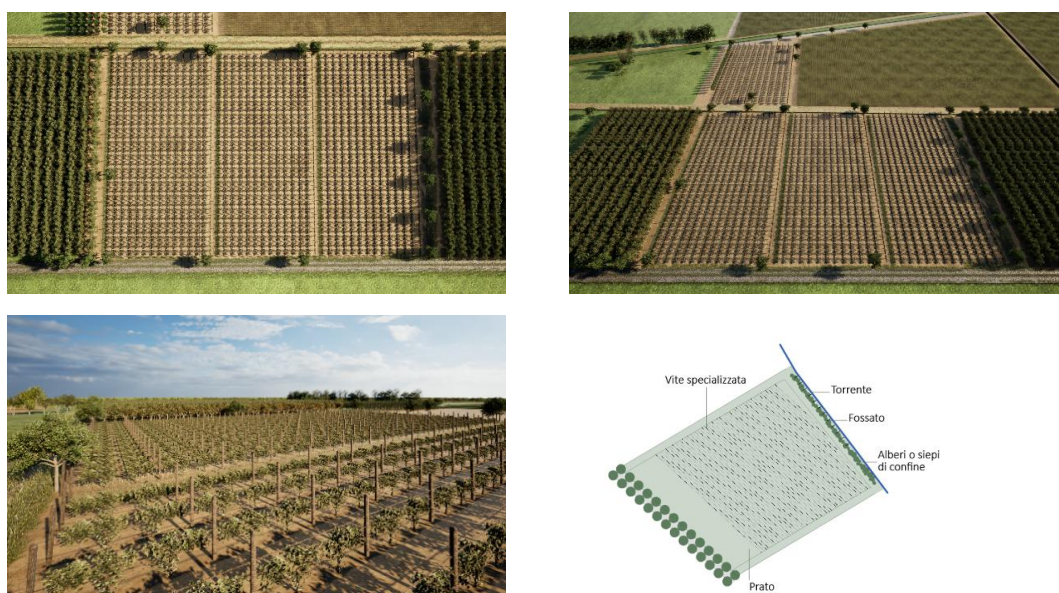


Figure 10: digital reconstruction of a “campo tipo” representative of the current landscape.

4. Reconstruction of the historical landscape

Once the standard fields for each period had been defined, a three-dimensional model of the study area was created, including Villa Barbaro, the farms and part of the town of Maser. The model was initially developed in Rhinoceros, chosen for its precision in managing NURBS surfaces and its versatility in export formats. The terrain model was constructed from the Digital Terrain Model, while informations on roads and buildings were derived from the Regional Technical Map, updated with 2015 orthophotos and data from Google Maps 2025. To reconstruct the landscape back in time, elements that were not consistent with previous eras were progressively eliminated, integrating data from historical sources such as the Italian Land Registry, aerial photographs from 1942, and 19th-century maps and related summaries.

The transition to photorealistic visualisation took place in Twinmotion, in direct connection with Rhinoceros. The software allowed for realistic visual rendering thanks to real-time rendering, smooth management of complex scenes and the use of techniques such as instancing, scattering and spacing, which optimise the distribution of vegetation. The plant assets used feature Level of Detail, automatically reducing geometric complexity based on the distance from the observer and the device used. Lighting and shadows were managed efficiently,

balancing visual realism and performance. The result is an immersive and accessible representation of the evolution of the historic landscape of Villa Barbaro and its territory.



Figure 11: digital reconstruction of Villa Barbaro and its farms, on the right engravings and photographs from the late nineteenth century (FAST).



Figure 12: digital reconstruction of Villa Barbaro and its farms in the first half of the 20th century, with a historical photograph in the upper right corner (FAST).



Figure 13: digital reconstruction of Villa Barbaro and its farms in the current landscape, with reference photographs on the right.

5. Conclusions

Research has demonstrated how the integration of historical sources, cartography and digital technologies represents an effective tool for investigating, interpreting and enhancing the cultural landscape. The analysis of the case of Villa Barbaro in Maser has made it possible to reconstruct, through advanced methodologies, the evolution of the agricultural territory and its relationship with architecture, providing a layered and informed interpretation of the context. The use of digital tools, such as GIS and three-dimensional modelling, has contributed not only to a greater understanding of historical dynamics, but also to a wider dissemination of content, promoting new ways of narrating and communicating heritage. In this sense, digital technologies become an integral part of the research and dissemination processes, helping to make heritage more readable and accessible. The work therefore stands as an example of an integrated and replicable approach, capable of combining scientific rigour and accessibility, with the aim of stimulating more conscious practices of protection, management and enhancement of the historical landscape.

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