Chapter Eight
Roads or Embankments? The Double Function of the Terramare Connective/Hydraulic System in the Valli Grandi Veronesi

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The rise of the Terramare culture was one of the most significant and impactful phenomena in northern Italian prehistory. It involved a large part of the eastern Po Valley that currently corresponds to the regional territories of Emilia-Romagna, part of Lombardia (Provinces of Cremona and Mantova), and part of Veneto (Province of Verona). The contextual demographic increase led to a massive reconfiguration of the settlement system, with important repercussions on the landscape, creating large new spaces dedicated to production and connection infrastructure. The evidence for these ancient settings is one of the main subject matters of our research group (see below), whose work is focused on the area of the southern Valli Grandi Veronesi Meridionali (or Verona Valleys) in Veneto. At the end of Middle Bronze Age (1650–1330 BCE), indeed, more complex power relationships started to emerge in the whole area, fully developing in the Recent Bronze Age (1330–1150 BCE). The entire system acquired the typical traits of a polity (De Guio 1991), with a level of complexity comparable to that of a simple chiefdom (De Guio 1997:155).

One of the main outcomes of this phenomenon was the massive reorganization of the territory. The inhabited areas (the so-called "Terramare," which were characterized by a large surface area, a higher elevation, and a long-lasting occupation) were also highly heterogeneous within a quite distinct and clustered landscape of power that followed a number of hyper-coherent spatial/functional rules, such as decreasing nearest-neighbor distances among a three-tier rank-size distribution of settlements (7–20 ha, 2–6 ha, and less than 2 ha) organized around the central place of Fondo Paviani (Balista and De Guio 1997; De Guio, Balista, et al. 2015). As in the rest of the Terramare universe, the first-rank sites were enclosed by an embankment and a

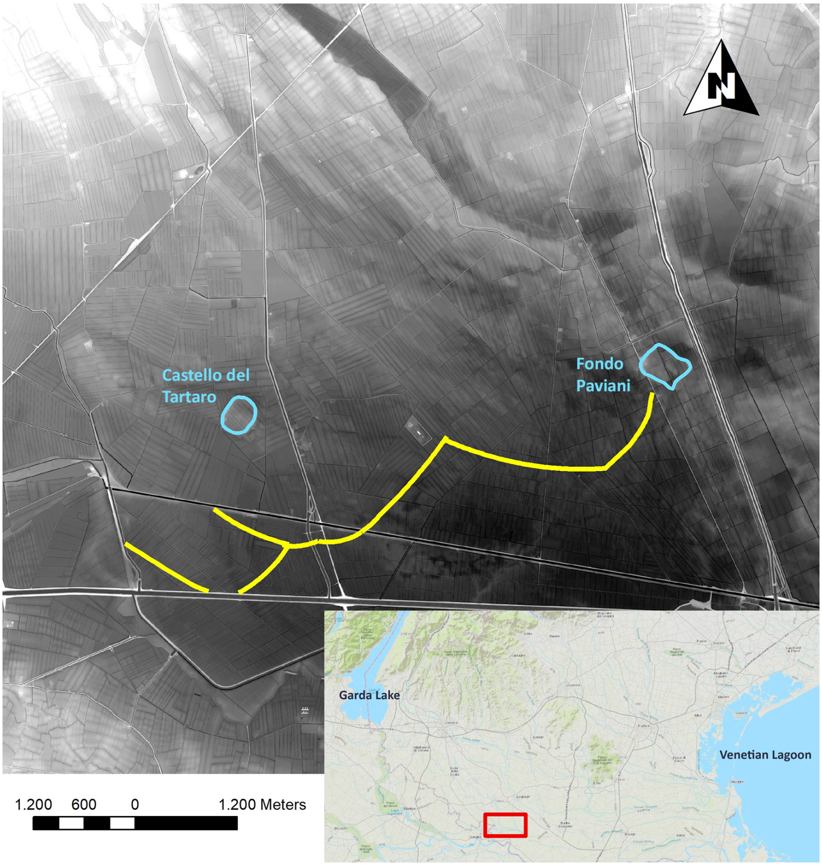

Figure 1. Locations of the path of the SAM (outlined in red), Castello del Tartaro (in blue, on the left), and Fondo Paviani (in blue, on the right) overlaid on a high-resolution digital terrain model (DTM, 2010). DTM courtesy of the Consorzio di Bonifica Veronese.

ditch that, in some cases, have left traces that are still visible, especially in remotely sensed imagery (Balista and De Guio 1997:159). The territorial transformation involved not only the inhabited areas, but also the whole intra-site to inter-site space, for both productive and connective purposes. The best preserved evidence of the ancient agricultural landscape is the area surrounding the site of Castello del Tartaro, where clear traces of an extensive irrigation system can still be remotely detected.

The new Terramare settlement system also led to more frequent exchange relationships that presumably contributed to the development of a dense connective network. The Valli Grandi Veronesi

Figure 2. Aerial view of the traces of the SAM. Image, acquired by aircraft in October 2018, was treated with a saturation stretch enhancing algorithm.

Meridionali, in particular, seems to have been part of short-distance exchange circuits (with sites near Lake Garda and with the Terramare area on the south bank of the Po River), medium-distance circuits (with the entire Po Valley, the Alpine region, and the rest of the Italian peninsula), and long-distance circuits (with the Aegean–Mycenaean and Levantine worlds). Such an increase in complexity most likely required significant labor, managed and controlled by an emerging elite, for both the construction and maintenance of infrastructure (Cardarelli 1997:654).

The southern Valli Grandi Veronesi Meridionali are delimited to the south by the resurgent Tartaro River, which separates the area from the topographically more depressed and less well-drained valleys of the Polesine area (Balista 2009), while the northern geographical boundary is determined by the emerging sediments of the ancient

Adige River conoid (dated to the end of the Pleistocene epoch; Balista and De Guio 1997). The area was spared from the floods generated by the Adige and Po Rivers, turning into a depressed alluvial basin. The morphogenetic processes of the Valli Grandi Veronesi Meridionali include the contribution of sediments from several resurgence rivers that were activated during the ancient Holocene—the Paleo-Tartaro, the Paleo-Tregnone, and the Paleo-Menago—which impacted the area with their passage, thus causing the formation of adjacent terraced plains. During the Subboreal climate period, these watercourses underwent a considerable decrease in flow rates in a sharp alternation of phases of drought and humidity (De Guio et al. 2010:91).

The Alto-Medio Polesine-Basso Veronese project (AMPBV; in English: "High-Middle Polesine and Lower Verona Plain") is an Italian-British project that has been active since the 1980s and is focused on the study of protohistoric evidence in the area of the Valli Grandi Veronesi Meridionali. The favored research methodology relies mostly on non-invasive techniques, limiting the degree of impact caused by archaeological excavation in favor of remote sensing, surface survey, geophysical prospection, and the observation of "stratigraphic windows" exposed by modern land management practices, such as excavation and the maintenance of agrarian ditches. One of the best-preserved connective infrastructures studied during the investigations of the AMPBV project is the so-called "Strada su Argine Meridionale" (SAM; in English: "Road on the Southern Embankment"), which is visible from Case Bellini (southwest of Castello del Tartaro, Municipality of Cerea, Verona) up to the site of Fondo Paviani (Municipality of Legnago, Verona) for a total length of approximately 6 km (Figure 1). Seen from a remote perspective, traces of the SAM look like a lighter band (due to the sandy soil composition of the embankment), flanked by two darker and thinner marks (corresponding to the side ditches, filled by less well-draining and therefore more humid soils; Figure 2). The width of the embankment measures from a maximum of 15 m to a minimum of 11 m; the southern and northern side ditches are large, between 10 and 13 m, and between 9 and 18 m, respectively. In the last investigations of the SAM, presented here, we made use of new imagery from modern sensors and some image-processing techniques, with the aim of better understanding its function in relation to its route and shape and, consequently, its importance as the collective effort of a well-organized society.

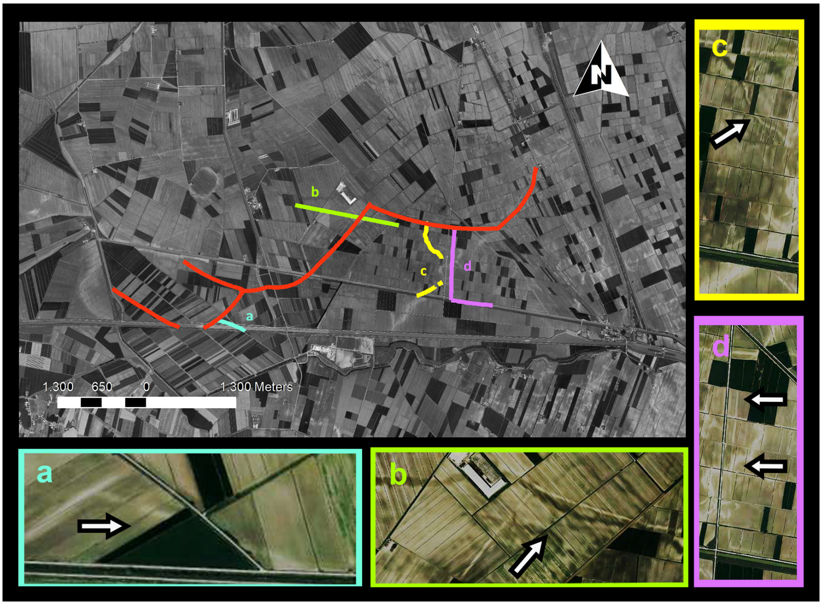

Figure 3. Visualization of the four additional branches of the SAM in aerial orthophotos from 2006. Photographs courtesy of the Consorzio di Bonifica Veronese.

The Route of the SAM

At its starting point about 1.5 km southwest of Castello del Tartaro the SAM has an arched track, which leads northeast toward its connection with the trace of the paleochannel (the Paleo-Tregnone River) that drained the lands around the settlement of Castello del Tartaro. There the road deviates to the east and continues with an almost rectilinear trend following the Paleo-Tregnone up to Ponte Moro, where it begins pointing northeast, arching slightly, and then heads toward Fondo Paviani (Balista et al. 2005:97–98). In its eastern stretch, the embankment is also frequently overlapped by paleochannels coming from the north. The construct has been analyzed and documented in various publications since the 1990s (Balista et al. 2016; Calzolari 1991, 1993, 2001; Tozzi 2009; Tozzi and Harari 1990).

In addition to its main path, recent remote sensing analysis had identified additional branches (Figure 3):

a. The first branch, to the west, has an arched trend very similar to the main route running south, and it crosses another segment with a northwest–southeast orientation.

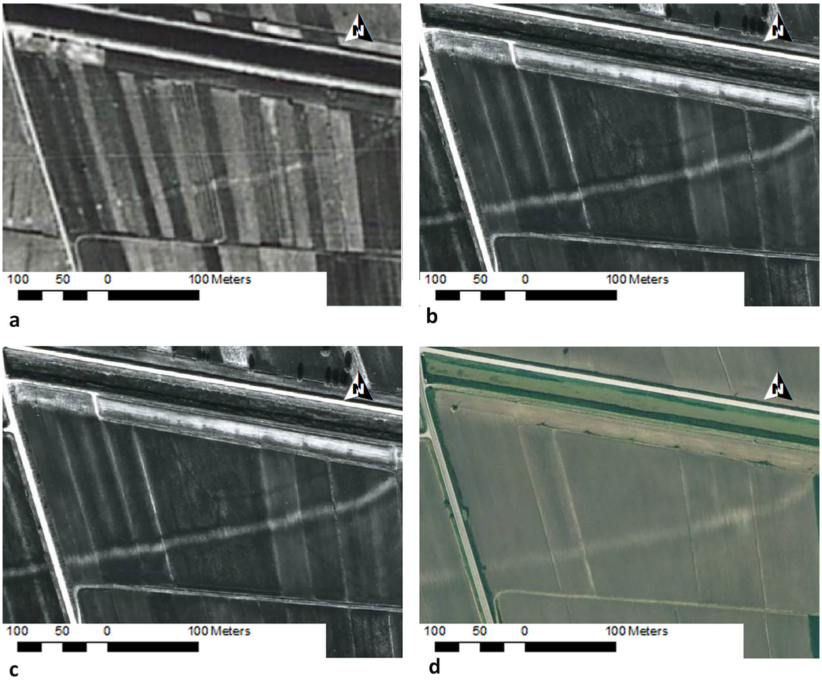

Figure 4. Detail of the SAM (Val Passiva), comparing the trace's visibility in aerial imagery over time (after Betto 2013): (a) 1955 (GAI flight); (b) 1983 (SCAME flight); (c) 1990 (ReVen flight); and (d) 2006 (satellite orthophoto courtesy of the Consorzio di Bonifica Veronese).

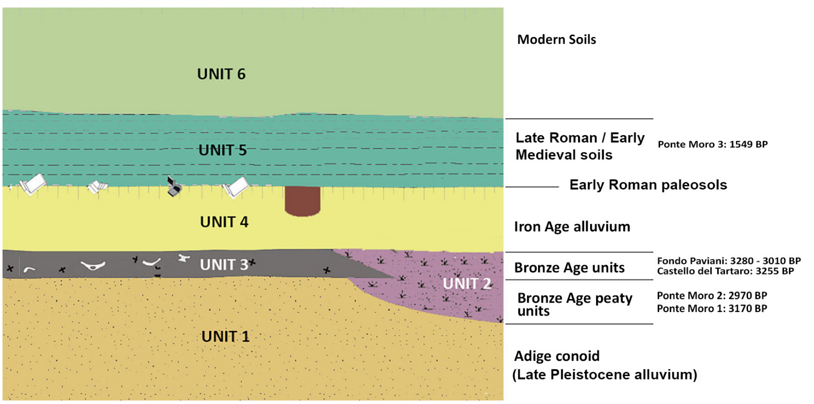

Figure 5. Graphic representation of the stratigraphic Bronze Age units (radiocarbon dates from Balista et al. 2005).

b. About 200 m before crossing the Paleo-Tregnone, another possible branch, with a southeast–northwest orientation and an approximate length of half a kilometer, departs on both sides from the main path and goes toward Castello del Tartaro.
c. The third branch, which can be followed almost up to the Paleo-Tartaro, departs from west of Ponte Moro. It is more irregular, with two wide curves: one facing west and the other facing east.
d. Another branch can be detected from Ponte Moro leading south, almost reaching the town of Torretta; it follows an almost straight line up to Fossa Maestra, where it curves in nearly a right angle.

Field analysis was performed in areas deemed critical for their location or for their information potential regarding stratigraphic relationships and chronological interpretation. Remote sensing investigation included several different and sometimes experimental methodological applications.

Time Series Analysis and Ground Truthing

The analysis by means of remote sensing (time series analysis) of how the features' visibility has evolved has brought particularly interesting results regarding the monitoring and conservation of the traces of the SAM, assessing the rapidity with which modern agriculture relentlessly impacted the archaeological landscape. Between the 1950s and 1980s, the introduction of mechanized agricultural systems at first significantly enhanced the traces' visibility by exposing the buried ancient soils. However, starting in the 1990s, the cyclical and increasingly deeper plowings soon began to erase the ancient deposits, thus mixing and homogenizing the sediments, similar to what happened in many other archaeological areas (see, for example, Cimadomo et al., this volume).

The traces visible above ground in historical aerial photography series were observed, measured, and compared (Figure 4), looking both at the areas that had been previously explored and at ten other sample points that were selected at intervals of about 500 m. Two critical points thus identified were then further investigated through targeted ground checks. The first checkpoint, located in Ponte Moro (Municipalities of Cerea and Legnago), was examined in the fall of 2003, when a stratigraphic section was documented along a modern canal that intercepts the SAM trace almost orthogonally (Betto 2013).

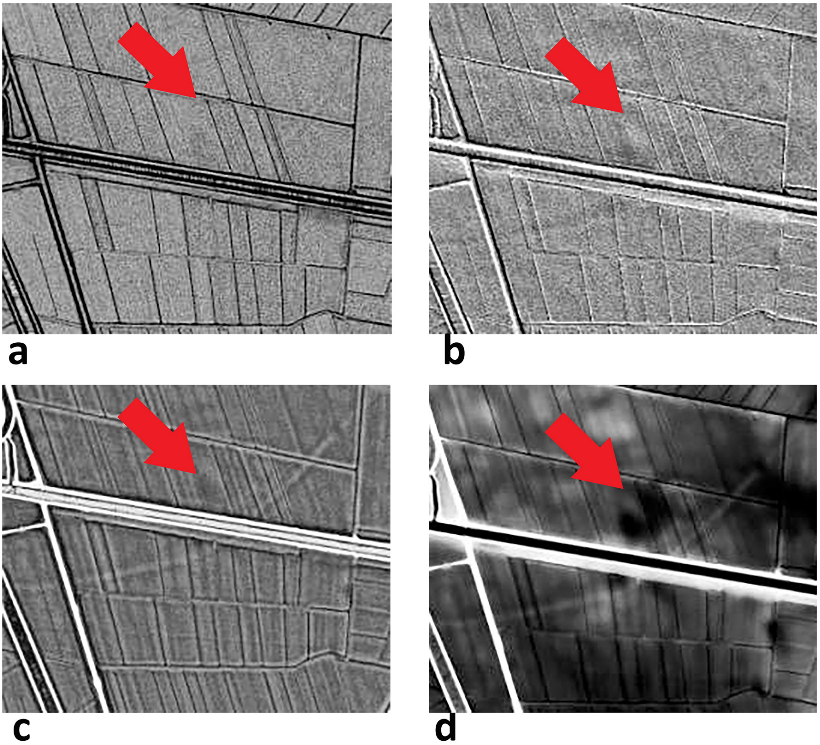

Figure 6. DTM processing in order to enhance the visibility of the SAM (after Burigana and Magnini 2017): (a) sky view factor; (b) hillshade; (c) local relief model; and (d) contrast stretch. DTM courtesy of the Consorzio di Bonifica Veronese.

The exposed section allowed for a detailed analysis of the stratigraphic relationships between the units of the SAM (related to the embankment and the ditches) and the local alluvial deposits. The preserved stratigraphic units are mainly composed of reddish-brown and gray sands, which are now almost entirely remixed with the upper pedological horizons. The ditches, on the other hand, are still quite well preserved, the northern being narrower and deeper than the southern. It also was possible to determine a more precise stratigraphic position of the construction, which covers mid-Holocene soils and underlies the local alluvial Iron Age deposits that partially fill the ditches in their post-abandonment stage. In addition to the frequent discovery of Recent Bronze Age ceramic clusters in close proximity to the SAM, an absolute chronology is given by the Ponte Moro stratigraphic sequence, where a lateral colluvial deposit of the SAM bank is comprised within two peaty strata dated by ^{14}C analysis to 1614–1274 cal BCE (2σ median 1443 cal BCE) and 1371–1051 cal BCE (2σ median 1186 cal BCE), thus providing the *terminus post quem* and *terminus ante quem* for the SAM bank's construction (De Guio, Balista, et al. 2015).

The investigation was successively extended to another nearby section, where the exposed stratigraphic sequence also presented a series of units attributable to Iron Age floods that covered the pedogenetic alterations of more ancient soils; the SAM stratigraphic units are located above these layers (Figure 5). The lateral ditches, of which only the western one could be documented, cut the alluvial deposits and are filled with organic silty colluvial stratigraphic units. This evidence suggested that the ditch could have been reactivated for use in later times (Balista et al. 2005, 2016; Betto 2013).

Image Processing and Analysis of LiDAR Data

Being an already-explored archaeological scene, the SAM also served as a test subject for image processing methodological research. For this purpose, several processing algorithms were tested on different kinds of data, such as radar, LiDAR, and multispectral images. One of the most rewarding strategies turned out to be the LiDAR analysis, for which we had at our disposal a high-resolution (0.5 m) digital terrain model (DTM). Several image-processing algorithms were experimentally applied in order to evaluate their use in the detection and interpretation of archaeological features in the study area (Figure 6):

- Contrast stretch through image histogram manipulation;
- Mono (single-band) and multidirectional (azimuth angle; RGB composite) hillshade, keeping the artificial light source at a height of 30° in order to better enhance the lowest reliefs;
- Principal component analysis (PCA) of different DTM hillshade visualizations, processed as a set of linearly correlated variables (Estornell et al. 2013);
- Sky view factor (SVF), a treatment based on the use of diffuse lighting that indicates the portion of the sky visible from every observation points (Zakšek et al. 2011); and
- Local relief model (LRM), an operational sequence developed with the aim of excluding larger landscape features and highlighting the local small-scale relief (Hesse 2010).

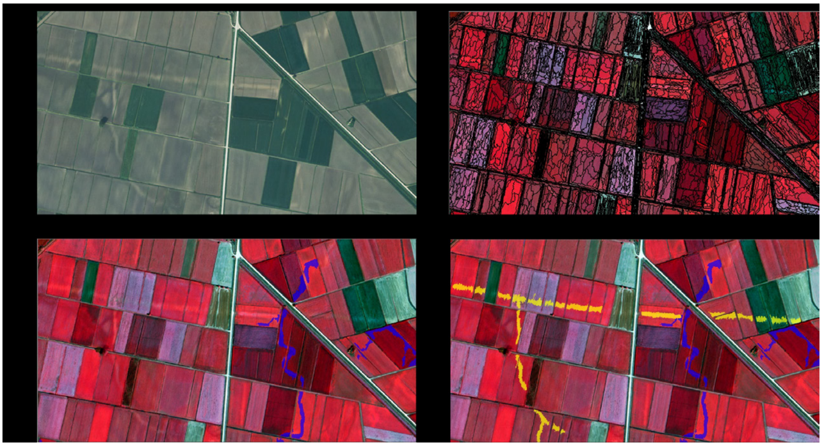

Figure 7. Ponte Moro area (Municipalities of Cerea and Legnago): (a) 2008 orthophoto (courtesy of the Compagnia Generale Ripreseaeree); (b) multi-resolution segmentation of the NIR false-color band combination (NIR, red, green); (c) classification of the paleochannels (in blue); and (d) classification of the paleochannels (in blue) and the SAM (in yellow).

A small-scale visibility comparison was then carried out by means of autoptic analysis for each section of the SAM. The hillshade algorithms and the LRM gave the best results; the latter, in particular, successfully highlighted both the bank trace and the depressed marks of the side channels, proving the efficacy of this processing not only for mountainous areas, but also for level ground with minimal height variations. The hillshade algorithm worked best in multiple image combinations by implementing PCA and simple three-band composition (Burigana and Magnini 2017).

Object-Based Image Analysis and Landform Classification

The issues that arise from the automatic analysis of high-resolution imagery of wide-range areas are still widely discussed in the scientific community, including within the archaeological domain (Casana 2020). Among the most frequently and widely used methodologies in recent years, machine learning techniques—and, in particular, convolutional neural networks (CNN)—have had wide diffusion (Ball et al. 2017; Trier et al. 2018; Verschoof-van der Vaart and Lambers 2019). Looking at the available literature, it seems possible to argue that the success of machine learning applications is especially related to the homogeneity and standardization of the archaeological remains that have been considered. However, when inferences from external agents (i.e. natural and anthropic factors) occur that change the archaeological record along the diachronic dimension, it is very difficult to implement these differences in a single semantic model ready to be used for machine learning (Magnini and Bettineschi 2019). In this perspective, a knowledge-based approach is more flexible and adaptable to the context, with the foresight to not result in overfitting by making the set of classification rules too specific.

For the case study of the Valli Grandi Veronesi Meridionali, we decided to systematically apply an object-based supervised classification technique (object-based image analysis, or OBIA), which was previously established in the field of archaeology for the classification of landforms (Drăgut and Blaschke 2006; Verhagen and Drăgut 2012), for the semi-automatic classification of archaeological traces (Davis 2019; De Laet et al. 2007; Freeland et al. 2016; Sevara et al. 2016), and for the development of predictive models (Magnini and Bettineschi 2021). This method, which can be adopted at any scale, provides for the partitioning of the image into homogeneous objects through segmentation, on which a classification is subsequently applied (for a complete overview of the methodology, see Blaschke 2010).

SAM Semi-Automatic Classification: Ponte Moro (Municipalities of Cerea and Legnago, Verona)

This study focuses on the issues related to the semi-automatic analysis of linear archaeological features and, specifically, on the SAM and the numerous hydrological features that characterize the area (De Guio, Magnini, and Bettineschi 2015). The test was conducted on the fairly limited area of Ponte Moro (less than 1 km^2), where both types of infrastructure are present. Regarding the SAM, there is also a "crossroads" in the surveyed area that allows us to test the methodology even in the presence of a drastic directional change of the road. As starting data, an orthophoto of the area in the visible spectrum (RGB; Figure 7a) and an image in the near-infrared spectrum (NIR; Figure 7b) were selected, allowing us to maximize the chromatic differences of both the soil marks and the crop marks. In fact, if the road is more visible in the RGB orthophoto for areas without vegetation, the NIR layer (and related false-color band compositions) maximizes the variations in vegetative growth (De Guio 2015).

The first step of the work consists in dividing the image (in this case composed of four layers) into image-objects through a segmentation algorithm; the choice fell, as in most archaeological case studies, on

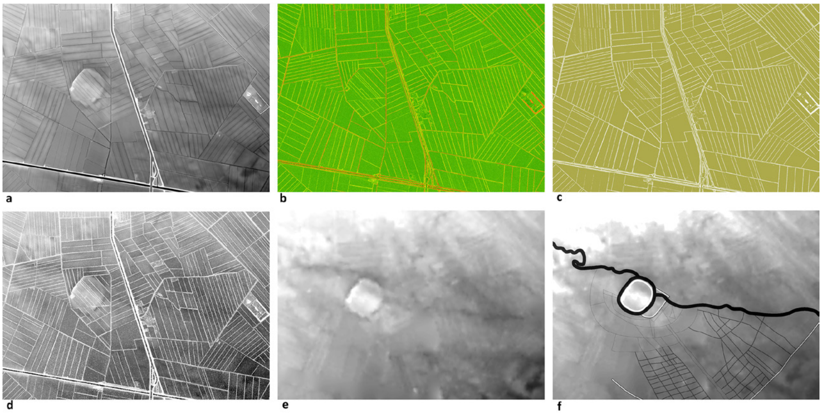

Figure 8. Castello del Tartaro area (Municipality of Cerea). Visualization of the main operational stages in order to create our model: (a) original DTM; (b) slope gradient map; (c) extraction (from slope gradient) of values above the standard deviation; (d) "purged" DTM using the slope extraction map as a mask; (e) interpolation; and (f) final model, including the reconstruction of the SAM and irrigation network.

multiresolution segmentation (for details, see Baatz and Shäpe 2000; Benz et al. 2004), with a trial value of 60 in the scale parameter (Figure 7b). The selection of the segmentation scale parameter largely depends on the data source, the aims of the case study, the geographical context of the investigation, and the internal heterogeneity of the data (Zhang et al. 2018).

The subsequent classification encountered critical issues because of the difference between what is expected considering the knowledge-based semantic model and the real-world archaeological record in its present form. The presence of modern roads and ditches that interrupt the spatial continuity of ancient archaeological traces also modifies the overall geometric structure and how it is perceived in the software environment (Magnini and Bettineschi 2019). Our mind, in fact, is perfectly able to discern ancient evidence from modern structures, and it implements an "automatic interpolation" procedure of the traces even when they lack spatial continuity. For the classification of ancient hydrological features, the use of spectral parameters (especially on the NIR layer) and dimensional parameters was favored (Figure 7c), while for the classification of the roads, geometric parameters such as rectangular fit and length / width ratio were used in addition to the previous parameters (Figure 7d). The application of these parameters was possible because of their relative regularity, even in the absence of spatial continuity (De Guio, Magnini, and Bettineschi 2015). It also should be stressed that the same archaeological evidence can have different outcomes depending on the utse of the land in which it is located at the time of data acquisition (i.e. the seasonality factor of the traces). In fact, looking at Figure 7a, the trace of the SAM appears to be lighter on plowed fields and darker on those with active crops. These differences in outcomes also affect the (semi)automatic recognition of traces. The opportunity offered by OBIA to modify all the classification parameters opens new perspectives in a more robust (semi) automatic recognition, even in the presence of complex archaeological objects and in palimpsestic contexts (Magnini and Bettineschi 2019).

Remote sensing and image processing analysis showed clearly how the SAM connects the sites of Fondo Paviani and Castello del Tartaro as a road. However, the visualization of the SAM path on the DTM suggested further considerations about the function of this infrastructure. Indeed, on its southwest side, in proximity of Castello del Tartaro, the SAM does not cover the shortest possible inter-site distance, but rather turns north in a wide curve, following (according to the contour map) an almost regular isoline of 8.25–8.50 masl; the northern stretch toward Fondo Paviani, whilst being much straighter, maintains the same altitude range. Furthermore, the path never has an altitude below 8 m. Its altitude and trend, as well as some of the additional branches that have been identified, could be related to specific planning in order to preserve the territory from floods and the spreading of marshes.

Starting from these considerations, the AMPBV research group recently developed a simulation of the Castello del Tartaro irrigation system (of which several faint traces are still detectable remotely) in order to better understand its relationship with the SAM and the oscillations of the underground water table.

Creation of the Base Model

The main operations to create the digital support model focused primarily on the reconstruction of the Recent Bronze Age irrigation network. For this purpose, the DTM at our disposal was processed in order to obtain a surface more akin to the protohistoric landscape. The most critical challenge in this phase was filtering out the "background noise" to get rid of the modern facilities and infrastructure features, which would have later compromised the simulation. The following operations were thus executed in a Geographic Information Systems (GIS) environment (Figure 8):

- creation of a slope gradient raster from the z values in each DTM raster cell;
- extraction of all values above the standard deviation calculated from the slope gradient raster;
- combination of all extracted values in a unique feature class;
- buffering of the obtained feature class (with a "safety" value of 2.5 m) to cover any residual anomalous pixels;
- removal of the buffered features from the original data;
- conversion of the treated DTM to a multipoint feature class;
- interpolation of the multipoint file into a triangulated irregular network (TIN) surface model; and
- conversion from the TIN to a new raster image.

The paleochannel recreation was possible thanks to a large number of archaeological and geological data that were collected during both fieldwork (such as core samples and stratigraphic sections) and remote sensing investigations, which helped in locating many related crop-marks and soil marks. The artificial hydrographic network model was based on a reconstruction by Dr. Paolo Cima, which connects all the detected tracks in the study area that are attributable to the so-called "second hydraulic stage" of Castello del Tartaro (De Guio, Balista, et al. 2015), coeval with the site's bank–moat perimeter system. Two additional factors of complexity were also taken into account: the significant dimensional differentiation of the various network components, and the position of some positive reliefs (namely the banks) both on-site and off-site.

The depth and width measurements of the paleochannels and artificial ditches were extracted from field survey data collected since the mid-1980s (for a synthesis, see Bovolato 2012). Based on this information, a hierarchical order was established, according to which the features were classified (each class being represented by an average value). Because of its broader range and variance, we chose width as the discriminating value for the classification into six orders of magnitude:

- 1st order: the settlement moat and its tributary watercourse (width: 45 m, depth: 2.5 m).
- 2nd order: the southeast ditch, which supposedly delimited a livestock area (width: 7.5 m, depth: 1 m; Balista and De Guio 1997).
- 3rd order: the SAM side channels (width: 6 m, depth: 1 m).

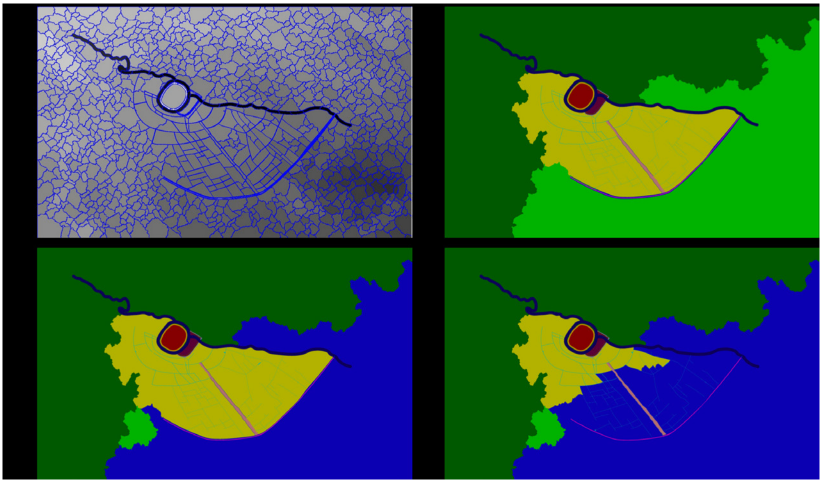

Figure 9. Castello del Tartaro area (Municipality of Cerea): (a) multiresolution segmentation of the modified DTM; (b) semiautomatic classification of the anthropic structures and landforms: the positive anthropic evidence (in red and rose shades), the hydraulic infrastructure (in blue shades), the fields (in yellow), and the natural landforms (in green shades); (c) flood simulation (in blue) on the complete model; the presence of the SAM safeguards the fields from flooding; (d) flood simulation (in blue) excluding the SAM as a dike; in this case, the water height causes the fields to flood.

- 4th order: the side channels of the so-called "Big Road" (De Guio, Balista, et al. 2015), a droveway connecting the settlement with the nearby pastures that ran perpendicular to the SAM (width: 4.5 m, depth: 0.5 m).
- 5th order: the large concentric canals in closer proximity to the settlement, connected to each other by shorter cross-channels and related to a probable horticultural "near-site" area (width: 3.5 m, depth: 1 m).
- 6th order: the smallest canals irrigating the off-site farmland in a narrow closed-field system (width: 0.75 m, depth: 0.5 m).

Three raised elements (for which a height and width were also estimated based on ground-truthed data) were then added to the reconstructed landscape: the site embankment (width: 20 m, height: 5 m), the southeast corral (width: 10 m, height: 2.5 m), and the SAM bank (width: 12 m, height: 1 m).

Since the main goal was to verify tangibly how the agricultural irrigation system may have worked within the local macro-morphology, the analysis required accepting some necessary approximations. Here are reported the most evident:

1. Each vector in our digital model has a flat-bottomed profile, unlike the real hydrography. Consequently, the water flow rate is, in part, overestimated.
2. The current landscape results from repeated territorial restructuring actions (most of which involved land-levelling for agricultural purposes), so that the reconstruction of the smallest reliefs is currently unattainable.
3. Several of the smallest irrigation canals are supposedly no longer detectable by any means now; hence, the reconstructed hydrography may be incomplete.

Landform Classification

The local landforms of Castello del Tartaro were defined in relation to the natural and artificial (i.e. anthropic) characteristics of the site and the near-site; subsequently, the quantitative data were integrated with a qualitative-functional interpretation of the individual classes. As in the previous case study, the multiresolution segmentation algorithm was used, but the scale parameter was increased to 80 in order to obtain medium image-objects in an area of less than 20 km^2 (Figure 9a). The following classification started first with a macroscopic definition of three main landforms: "highlands," "low lands," and "ditches." The selected rule set was based mainly on the absolute altitude of the image-objects, but it also employed morphological and relational features.

The first classified anthropic structures were the embankments and the platform of the site, which, in addition to sharing a higher elevation in relation to the other image-objects, had high values of proximity to the ditches. By linking the morphological characteristics of the embankments to single ditches, it was possible to create three different classes. The same operating practice was also adopted to classify the droveway (Figure 9, in pink).

Secondly, five different functional classes were created for the hydraulic infrastructure (Figure 9b, in shades of blue). With respect to the manual classification carried out during the DTM creation, it was decided to merge the concentric channels (5^{th} order) and distal channels (6^{th} order), because functionally they perform the same task. In this case, the semiautomatic classification took into account the flow rate, directionality, and relationship with other anthropic and natural structures. Once all the anthropic structures were classified, the remaining landforms were merged into three classes, defined as "highlands," "low lands," and "fields" (see Figure 9b, in dark green, light green, and yellow, respectively).

Ultimately, we simulated two different water flooding scenarios (with a general water-level increase of 1.5 m with respect to the lowest area): the first simulation considering the SAM as a dike; the second, without considering the SAM. As can be seen in Figure 9c, the presence of the SAM limited the flooded area in the southeast corner of the model, leaving the fields inside the near-site area completely dry, while the absence of this infrastructure would have led, in the event of the overflow of the Po River, to the rapid flooding of a large part of the fields close to the inhabited area (Figure 9d).

Conclusions

The rise of a complex and articulated territorial system such as the Terramare in the Valli Grandi Veronesi Meridionali must certainly have required an efficient connective network that could favor both long-distance (inter-polity) exchange relationships and a stable connection between its major places, such as Fondo Paviani and Castello del Tartaro, to the benefit of a rapidly growing local population.

The highly visible spatial layout of the SAM confirms the basic function of the infrastructure as a road; some of the branches detected in remote imagery—the chronology of which has not yet been verified in some cases—also suggest a possible reuse in later times, when the connections still in place could have been exploited well after the collapse of the Terramare system. However, the more pronounced curves of the southern portion of the SAM (which appears to delimit the farming area of Castello del Tartaro), its location in relation to the DTM isolines, and the identification of additional branches that are equally adapted to the local land morphology lead to a more complex interpretation.

The location of the Valli Grandi Veronesi Meridionali between the more elevated Adige River conoid (to the north) and the upper limit of the more depressed Polesine area (to the south) during an unstable climatic phase could have made this area vulnerable to waterlogging and consequent crop damage. The experimental simulation on the reconstructive model proves that the massive SAM embankment and its lateral drainage channels could have acted as protection for the most depressed, at-risk areas. Analyzing the remotely sensed images through different processing techniques gave us the opportunity to integrate the information collected in the field and thus create an accurate idea of the SAM and the hydraulic system at Castello del Tartaro. The operational sequence we came up with in order to attain a suitable landscape for the simulation will hopefully be a useful asset in the future, whenever a reconstruction of the current terrain in rural areas will be needed. Finally, the virtual simulation allowed us to run an experiment on the whole system and, thus, to better understand the functionality of the SAM, which proved to work as both an embankment (moreover, its lateral drainage channels could have acted as further protection for the most depressed areas) and a connection. In this perspective, the SAM definitely appears to have been the output of an integrated risk- and uncertainty-management strategy aimed at implementing a locally sensitive double functionality of connectivity (road) and land-use protection (embankment).

As for the wider debate about the social and political implications of similar large-scale connective/hydraulic networks in the past (and in the ethnographic present), the SAM and its related infrastructure at "landscape resolution" seem to have acted as a paradigmatic icon of Scarborough's (2003) neo-Wittfogelian "flow of power" hypothesis. In fact, the proposed scenario appears to be in line with the suggested status of "emergent complexity" with regard to the local polity (De Guio, Balista, et al. 2015) and its expected capability to hierarchically mobilize (from the top down) the huge amount of labor necessary to construct and maintain the highly engineered landscape. This compels us rather sadly to put aside, at least for our case study, the more seductive bottom-up counter-hypothesis so heartily advanced by Erickson (2009) on the basis of his extraordinary ethno-archaeological research and commitment to the noble domain of the archaeology for development. Here, in the Valli Grandi Veronesi Meridionali, a massive infrastructure such as the SAM more likely reflects a top-down power hierarchy typical of Italian protohistory.

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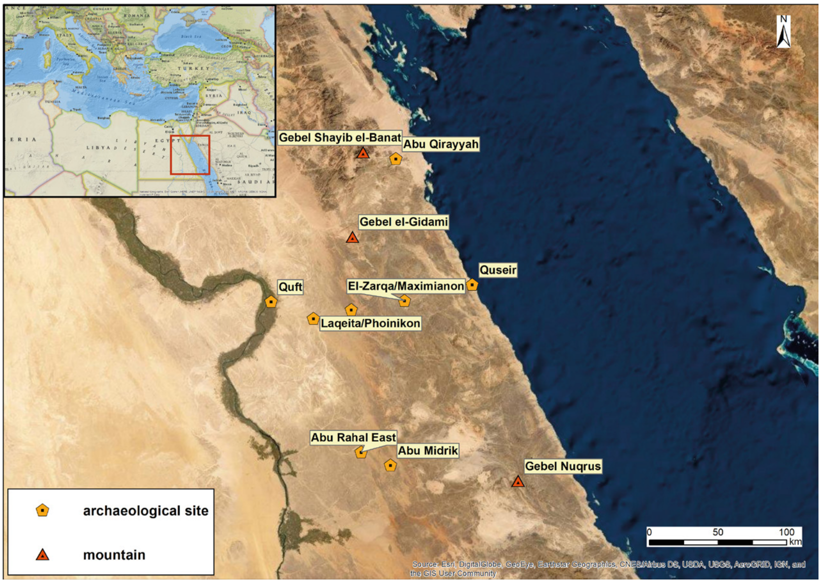

Figure 1. Location of sites in the Eastern Desert mentioned in the text. Imagery courtesy of Esri. © Desert Networks and L. Manière.