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SCIentific RESearch and Information Technology
Ricerca Scientifica e Tecnologie dell'Informazione
Vol 15, Issue 1 (2025), 193-206
e-ISSN 2239-4303, DOI 10.2423/i22394303v15n1p193

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HERDONIA 3.0. STRATEGIES FOR KNOWLEDGE AND DOCUMENTATION OF AN ARCHAEOLOGICAL AREA

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Abstract

The paper traces the various phases of research on the survey and representation of the archaeological area of Herdonia, which was known as a Roman municipium in the Republican age and lived its greatest splendour in the Augustan age. The use of increasingly up-to-date technologies and software, and the application of survey methodologies and representation techniques adapted to the different aims that the state of research gradually set, has resulted in the digitalization of a large part of the remains of the monuments that are currently visible, with a view to implementing what is now considered an indispensable stage of documentation for the knowledge and protection of the cultural heritage. The aim is to show the degree of complexity in the production of such documentation, both digital and up-to-date, in a site that has been very well studied in archaeological terms in past, but which suffers from the lack of recognition as an archaeological park.

Keywords

Archeological survey, Archeological drawing, Integrated survey, 3D model, Cultural Heritage

1. *Introduction*

The archaeological site of Herdonia, located in a hilly area overlooking the valley of the Carapelle river on the edge of the Tavoliere, is part of the archaeological heritage scattered across the Apulian territory, together with Egnatia, Canne della Battaglia, etc., capable of recounting the most ancient past of the region through places of great historical and cultural value. Although the city of Herdonia contains the greatest evidence of the Roman age in northern Apulia, with a forensic complex of great urban and monumental importance, characterised by architectural remains of which walls of considerable height are preserved, the site is still not valorised in comparison with more well-known contexts and is not the object of attention in regional cultural routes. There are several reasons for this, including the failure to set up a proper archaeological park and the difficulty of managing the site, since the areas on which it stands are subject to different legal regimes and are largely still in private ownership. A contributory factor is certainly the interruption in 2000 of the archaeological investigations, conducted for almost forty years, first by the Belge Centre de Recherches Archéologiques en Italie centrale et méridionale and directed by Prof. Joseph Mertens, and later by the University of Foggia, under the direction of Prof. Giuliano Volpe. The excavation campaigns brought to light only part of the remains of the ancient settlements and, in particular, the Roman city, which spread over three hills, covering an area of approximately 25 hectares. The ancient city, which also preserves traces of an ancient Daunian settlement, is known as a *municipium* from the Republican age, which lived its greatest splendour in the Augustan age, but was still inhabited in later times, up to the Middle Ages. Of the entire city, mostly still hidden under cultivated wheat fields that cover the surface of the hills, only a few important architectural features are visible today (Fig. 1): to the south-east, the remains of the urban variant of the Via Traiana, one of the main road axes that crossed the Apulian territory, and the forum, where the civil basilica, the temple from the Republican age, the Capitoline temple, the *nymphaeum*, the *macellum* and the shops can be seen. In the same area, the *campus* with the *heroon*, the amphitheatre and the north-eastern gate can be seen to the east, and the baths to the west, along the Trajan road. The city was surrounded by walls, the remains of which emerge in parts to the north, north-west and south-west of the hill and were

interrupted by gates, the remains of which are still visible to the north--west and south-west.

Fig. 1: Orthophotoplan of the archaeological area of Herdonia

On the hill to the north-east, on the other hand, is the so-called "*castellum*", a domus by Frederick the 2nd, attested on a triapsidal cult building from the mid-11th century. The excavations, however, did not bring to light the urban fabric, the planimetric configuration of which has been partially defined by geomagnetic prospections carried out by the University of Foggia in recent times (De Felice, & Fratta, 2021), which trace, below the cultivated fields, the layout of the internal road network and the layout of the *insulae*.

2. *Status of the studies and the research genesis*

The history of the studies carried out in almost forty years of archaeological investigations has been collected in scientific publications (Mertens, 1995; Mertens, & Volpe, 1999), conference proceedings and in the "Ordona" series, of which 13 issues have been published up to 2021. There is also a rich historical and iconographic documentation preserved in the Historical Archive of the Herdonia research of the Department of Humanistic Studies of the University of Foggia (De Felice, & Fratta, 2021), which narrates the results of the investigations through excavation documents and survey drawings of individual monuments.

The city, therefore, widely investigated in the archaeological sphere, was, a few years after the last excavation campaign, also the subject of studies in the architectural sphere, with new research conducted with a methodological approach proper to the disciplines of the Representation. Starting with the scientific survey of the existing, the archaeological area was studied in several stages, with the aim of updating the state of knowledge and providing digital documentation capable of describing monuments and places in a complete and objective manner. The use of technologies of different scope between one phase and the next made it possible to expand the amount of data collected, multiplying the possibilities of investigating them and to make the results increasingly accurate.

A first survey campaign was carried out between 2003 and 2005 to describe the *forum* area (Fig. 2) with celerimetric and detailed surveys and to formulate new hypotheses, compared to previous studies, on the original form of the civil *forum* basilica (Castagnolo, 2008).

Fig. 2: Orthophotoplan of the forum area

A new survey campaign was launched several years later, in 2021, as part of a collaboration agreement between the ArCoD Department of the Polytechnic University of Bari, the Secretariat for Apulia of the Ministry of Culture and the Archaeological Superintendence, Fine Arts and

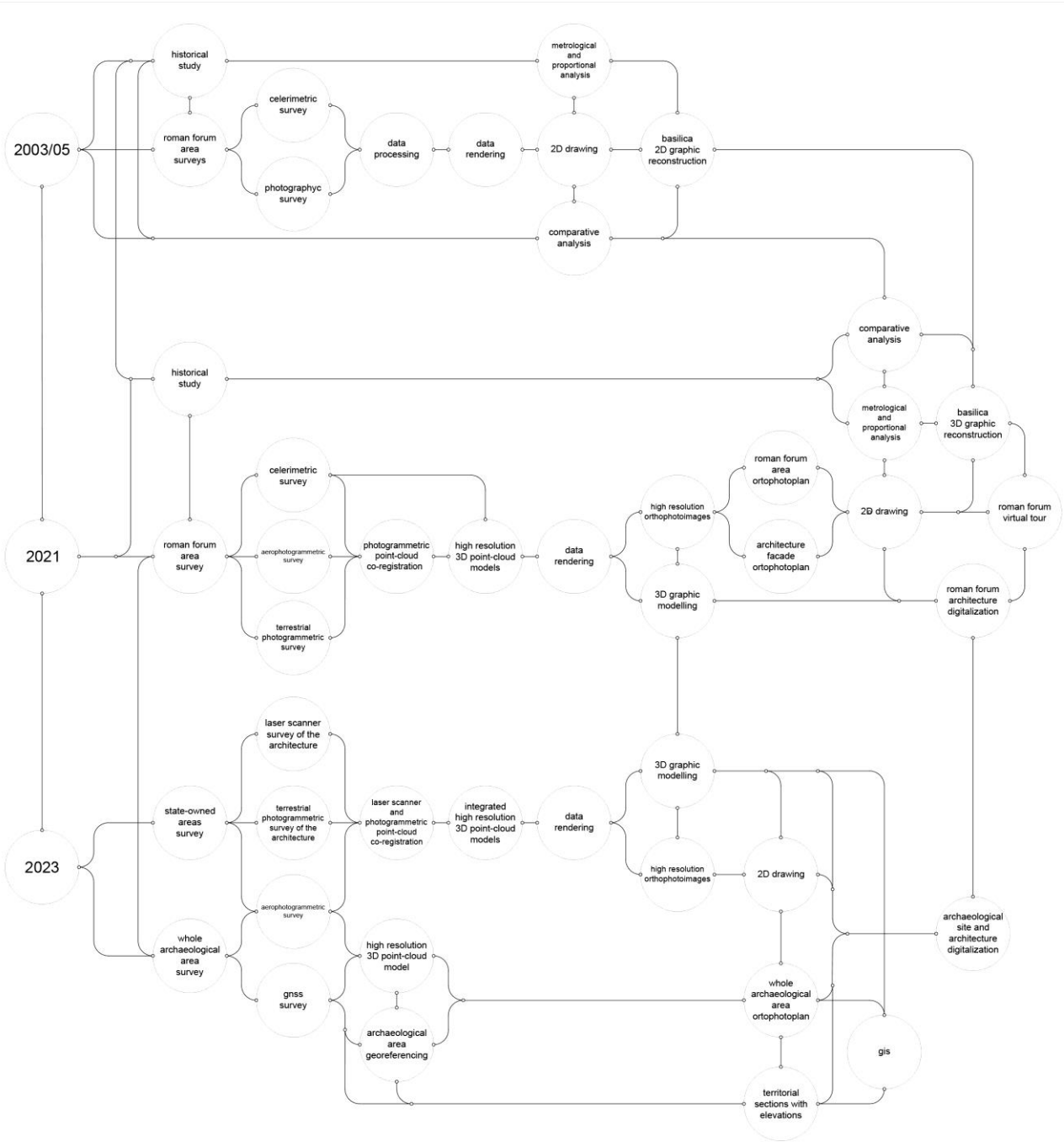

Fig. 3: Visualisation of data interaction system at different stages of research

Landscape for the provinces of BAT and Foggia, and a Memorandum of Understanding with the Ordona Municipality[1]. The. second season of research on the forum area, counting on the renewal of the instrumentation for the architectural and landscape survey, aimed at updating the graphic documentation of the visible structures and the digitalization of the elevated structures.

[1] The research activity led to the Degree Thesis by Giuseppe Alessio Buono, Emanuele Vittorio Cordasco, Antonella Laricchia, Ilaria Lavermicocca, Claudia Milardo, Andrea Nirchio, Cristina Serpenti, entitled Herdonia. Archaeology and restoration, supervisors Prof. Ignazio Carabellese, Prof. Valentina Castagnolo and Prof. Matteo Ieva, and co-supervisors Dr. Daniela Fabiano and Dr Italo Muntoni, Polytechnic University of Bari, 2021.

Following the results achieved, in 2023 the Secretariat for Apulia of the MiC asked the Drawing Group of the ArCoD Department of Bari Polytechnic to extend the digitalization process to the monumental heritage of the entire site and in particular to those state-owned areas, granted by the Superintendency for the cultivation of wheat, with a ban on deep excavation, from which significant elements of the Roman and medieval city emerged, i.e. some sections of the walls, the two gates to the north and north-west, and the area of the *castellum* aggere with moat. The Convention between the two institutions had as its subject "Research activities aimed at the architectural and archaeological study of some areas of the Herdonia site" and was promoted by arch. Maria Piccarreta, Regional Secretary of the MiC[2]. The management of relations between the two institutions was entrusted to Arch. Donatella Campanile, Official of the Secretariat, and the activities were carried out under the Scientific responsibility of Prof. Valentina Castagnolo, who coordinated the work team composed of postgraduate scholarship holders architects Emanuele Vittorio Cordasco, Claudia Milardo, Andrea Nirchio, Remo Pavone, Francesca Strippoli.

3. The workflow and the research goals

The aim of this contribution is to show the degree of complexity in the production of documentation, both digital and up-to-date, in a site that has been very well studied in the archaeological field in the past, but which suffers from the lack of recognition as an archaeological park, through the formulation of a system in which data interact with each other (Fig. 3). The layers of knowledge, as well as the related design and reconstruction proposals and the definition of practices for visualising some of the parts that make up the site, dialogue and enrich each other.

It is taken for granted that before undertaking on any survey, especially in the case of large monumental complexes, it is necessary to prepare a programme of the activities to be carried out in the field, depending on the equipment available and the results to be obtained, as well as the time required and/or the time available. Analysing the workflow of the activities actually carried out during the three phases, certain aspects emerge that define the state of the research: the progress of knowledge during the route, any shortcomings identified and integrated in the subsequent phases, and the need to implement the data collected and the results previously achieved in each step, generate those connections that constitute one of the key aspects that made it possible to carry out a true new knowledge path for the archaeological area of Herdonia. It should be borne in mind that at each stage it was not known that there would be the possibility of resuming and taking the work to a new level of investigation. That is, we started from a survey that intended to study the site in order to formulate hypotheses on the original facies of its architecture and urban space, and we arrived at the digitalization of the entire archaeological area, producing a highly informative visual material that is essential to undertake further knowledge or protection projects. The possibility of accessing more and more advanced methodologies and technologies over time has provided more accurate results, but has made the collection and processing phase more complex (Barbini, Giampiccolo, Maragno, Massari, & Pellegatta, 2024), leading to the need for a visualisation model of the enormous amount of digital and multiscalar data produced, a not secondary aim of the current research, made explicit in the image proposed here. In the diagram, the flow of data is represented by connecting lines between one research phase and the next and between one element (which may represent tools, technologies or methods) and the next. It is apparently represented as enclosed in a circle, thus expressing sense of conclusion in itself, but the connections denounce its apparent temporality and, by opening up new paths, express its perennial possibility of updating over time and project it towards future research scenarios.

4. The research phases

4.1 The first two survey campaigns: the Forum and the Civil Basilica

Already studied by Elisabeth Casteels in 1976, an analysis was carried out again in 2005, by surveying the visible remains of the forum basilica, with the aim of proposing a reconstruction of the

[2] The Convention was financed pursuant to art. 1, c. 1072 of Law no. 205 of 27.12.2017 (Stability Law 2015), with Ministerial Decree rep. 593 of 21.12.2020.

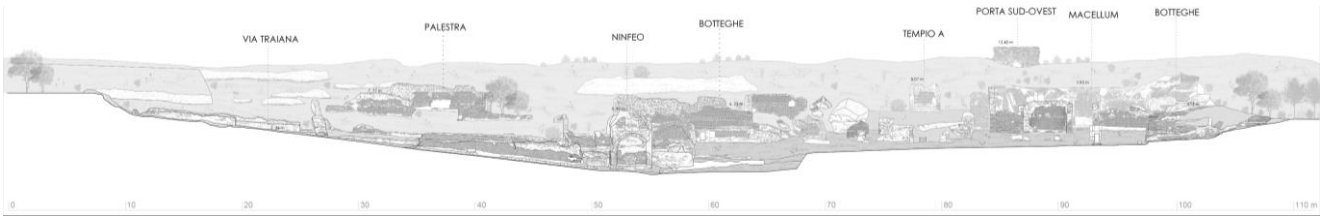

Fig. 4: Cross section of the forum cutting across the Via Traiana and the civil Basilica and looking towards the *nymphaeum* and the forum

Augustan age building (Castagnolo, 2008). The first survey campaign was carried out using tools and techniques that had long since become obsolete, such as photo-rectification on a celerimetric basis, for the representation of the wall textures. The reconstruction itself, although it followed a rigorous hermeneutic path contemplating the interpretation of the architectural remains, comparison with previous studies, metric and proportional analyses of the architectural order, comparison with the Vitruvian text and finally comparative studies with other civil basilicas, had only been carried out on a two-dimensional basis, lacking the constructive verification that the three-dimensional model allows.

In 2023, therefore, it was decided to redo the reconstruction, favoured by the possibility of obtaining more complete and accurate data in the collection phase during the surveys and of being able to manage the reconstruction through the use of modellers that give the possibility of simulating the construction phases of the building and of verifying the technical validity of the hypotheses formulated.

At the same time, a campaign of terrestrial and aerial photogrammetric surveys of the entire area of the forum, including the buildings standing on it, was launched to update the plan and produce overall graphic drawings (Fig. 4). Of each excavated monument, there are drawings drawn up during excavation operations, dated and produced using direct survey techniques and manual restitution (the first excavation campaigns date back to the 1960s). These documents are fundamental because they show the structures as they were brought to light, also describing their state of conservation. Decades later, it was deemed necessary to re-survey the currently visible architectural remains, in order to digitise a heritage of inestimable value, which, moreover, shows signs of slow deterioration, because it is not subject maintenance, with the exception of cleaning it of weeds.

Furthermore, the documentation produced in years of studies lacked overall graphic works showing the building complex in its entirety, such as longitudinal and transversal sections cutting through the forum area, drawings on the scale of architectural detailing capable of documenting the plano-altitude relations between the parts, the location of the different buildings and the elevation and characteristics of the masonry structures. The representation of the spaces in their totality realised with graphic works drawn in mongiana projection constitute an indispensable support for any planning action to be envisaged for the enhancement of the site. In fact, the working group set itself the aim of studying it anew in order to formulate a proposal, still in the form of a didactic exercise, for the use of the archaeological area through the constitution of a park (Buono et al., 2021; Cordasco, Lavermicocca & Milardo, 2023). The project envisaged equipped visitor routes and the preparation of a didactic apparatus *in situ* and on a virtual tour prepared for digital fruition also remotely.

4.2 Tools and Methods

In the second season of research, for the borehole area, techniques based on passive sensors (image-based) were used, i.e. using SfM (Structure from Motion), SIFT (Scale Invariant Feature Transform) matching and CMVS (Clustering Views for Multi-View Stereo) densification algorithms to digitally reconstruct the surveyed scene, and techniques based on active sensors (range-based), using instruments that emit a signal that is recorded to indirectly calculate the coordinates of the collimated point. That is, aerial and terrestrial digital photogrammetry was used to produce high-density 3D point clouds and high-definition orthophotoplans on a celerimetric basis. The

architectural photogrammetric data was metrically calibrated using a Leika TCR805power total station, while the topographical data was metrically calibrated using a GNSS Geomax Zenith 06 station with an Hz accuracy of 2 cm and V accuracy of 3 cm, which also allowed the georeferencing of the surveys.

To connect the data acquired by the different instruments, a series of Ground Control Points were set up, used for georeferencing and aligning the photogrammetric data. The topographic calibration GCPs were placed exclusively on the ground in order to create a planar trigonometric network, evenly distributed over the borehole area. The markers were recorded using the GNSS station as "master points". Their coordinates were acquired with a 2-minute setting, during which the instrument took 900 measurements (epochs) and recorded the average in WGS84 UTM33N co-ordinates with altimetry based on the geoid Italy 2008, with heights referring to sea level.

Fig. 5: Aerophotogrammetric surveys of the Basilica

Aerial photogrammetry was carried out with a DJI Mavic 2 Pro drone, equipped with GNSS navigation systems, and fitted with a 1-inch CMOS sensor, with a resolution of 20 million effective pixels, field of view of approximately 77° and an equivalent format of 28 mm on 35 mm film. The flight operations were differentiated according to architectural and topographical scale, given the need to survey the hole in its entirety and the different architectures at the scale of detail. Both topographical and architectural operations were carried out in manual flight mode (Fig. 5).

For the realisation of the photographic datasets, acquisitions were carried out at a distance of 40 metres for the topography of the entire area, with exclusively nadiral photos, and at a distance of 15 metres for the masonry curtains of the architectural structures, placing the camera in a frontal, nadiral position and with a camera tilt angle of 45°, in order to acquire images of the connection between the different three-dimensional planes of the object (Fig. 6).

Fig. 6: Aerial view of the eastern part of the forum, with the *capitolium* in the centre and the *macellum* to the right

Aerial photogrammetry was supplemented with photographic datasets from terrestrial shots to cover shadow cones generated by physical obstacles. Data from the active instruments were processed and exported using proprietary software. Data from the Geomax Zenith 06 station were exported and post-produced using X-Pad Ultimate Survey and X-Pad Fusion software. The photogrammetric datasets were processed in Metashape, exported as point clouds and orthophotoplans, both in satellite and local coordinates, and interpolated in turn with the data from the active instrumentations in the Cad environment. The orthophotoplans constituted the photorealistic support for the drafting of two-dimensional graphic works in orthogonal projection, returned in a full-scale CAD environment, but with a final output at a scale of 1:50. From the dataset with nadiral photos, the orthophotoplane of the borehole area was returned.

4.3 Some results

The opportunity to handle three-dimensional point clouds enhanced the possibility of exploring new areas of research also in the field of data restitution and its subsequent processing.

The photogrammetric survey of the civil basilica, rendered in the form of a digital model in

Rhinoceros 6, was essential for formulating a new proposal for graphic reconstruction. The quantity and consistency of the information that the three-dimensional model of the remains of the ancient structures provided defined the status of the research, guiding the method to be followed for the reconstruction: on the remains of the perimeter walls, the *tribunal*, the external structures (*porticus* and *calcidica*) and the 16 surviving attic bases and 12 surviving 4-sided ionic capitals, which were part of a colonnade of 8 x 4 ionic columns belonging to the inner *medium spatium*, spatial, morphological, dimensional, constructive and typological considerations were made.

These considerations pointed the way for comparative investigations, the computation of the proportions of the architectural order and between the parts of the building, constructive studies, and the formal definition of the elevated structures, which were completely hypothesised (fig. 7).

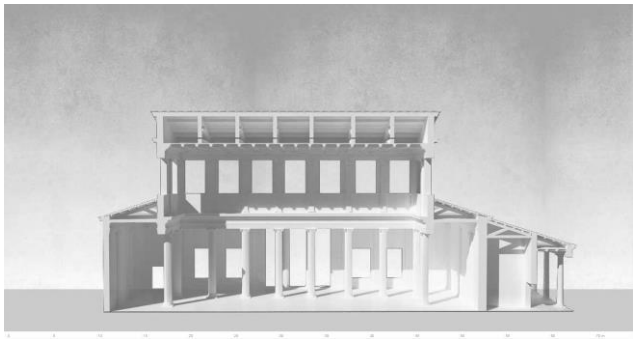

Fig. 7: Reconstructive hypothesis of the Basilica: longitudinal section

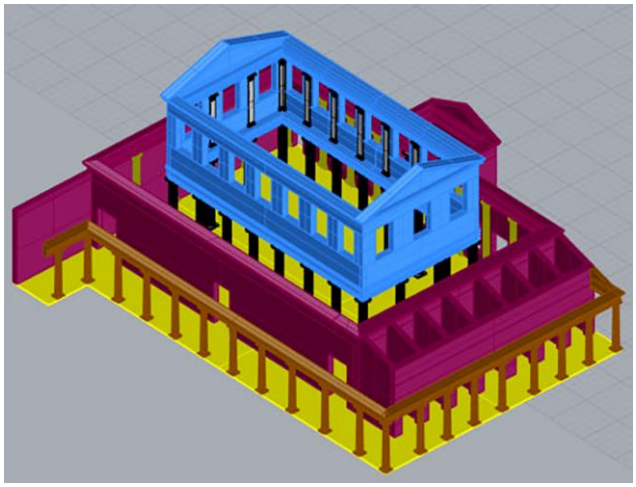

Fig. 8: Reconstructive hypothesis of the Basilica: construction of the 3D model

The hypotheses formulated to reconstruct those parts of the building that no longer exist were based on the results obtained during the first research, including historical and bibliographical references, to which new comparative investigations were added. But certainly contributing to the final outcome was the possibility, through the solid modeller, to simulate the construction act (fig. 8), confirming and denying the hypotheses depending on the construction consistency, materials and stability of the building itself (Leander Touati, Staub, & Forsell, 2021). The most debated issue concerned the dimensioning of the elevated structures, the roof system of both the basilica and the external portico.

This kind of experimentation could not be done with the first reconstruction proposal, but the most recent experience has returned a rather reliable proposal.

The last aim of the research was to construct a virtual tour, realised through a terrestrial photographic beating with an Insta360 One R camera with 18 MP - 4K resolution and 1 inch sensor. The spherical panoramas obtained have composed the skeleton of the composition of the virtual tour that simulates a walk from the remains of the Via Traiana to the interior of the forum and its monuments through the civil basilica. Theasys software was used to compose the tour, within which the different panoramic photos produced views interlaced with each other with bidirectional hyperlinks, offering a fruition according to two opposite directions (forward and backward).

The infographics implemented in the tour allow to interrogate the architecture in the forum area, in the vicinity of which pop-ups have been inserted containing the data emerged from the research and studies conducted by the group, narrated through information panels containing texts and images, drawings and high-resolution photographs (fig. 9).

The tour of the forum also offers the possibility of viewing three-dimensional textured moving models of the bases and capitals of the basilica and forum, obtained from photogrammetric surveys, shown with short video animations or visualised through the use of Sketchfab. Finally, a pop-up inside the basilica allows the user to enter in the three-dimensional model of the reconstruction of the basilica, making it possible to virtually experience the interior space of the building.

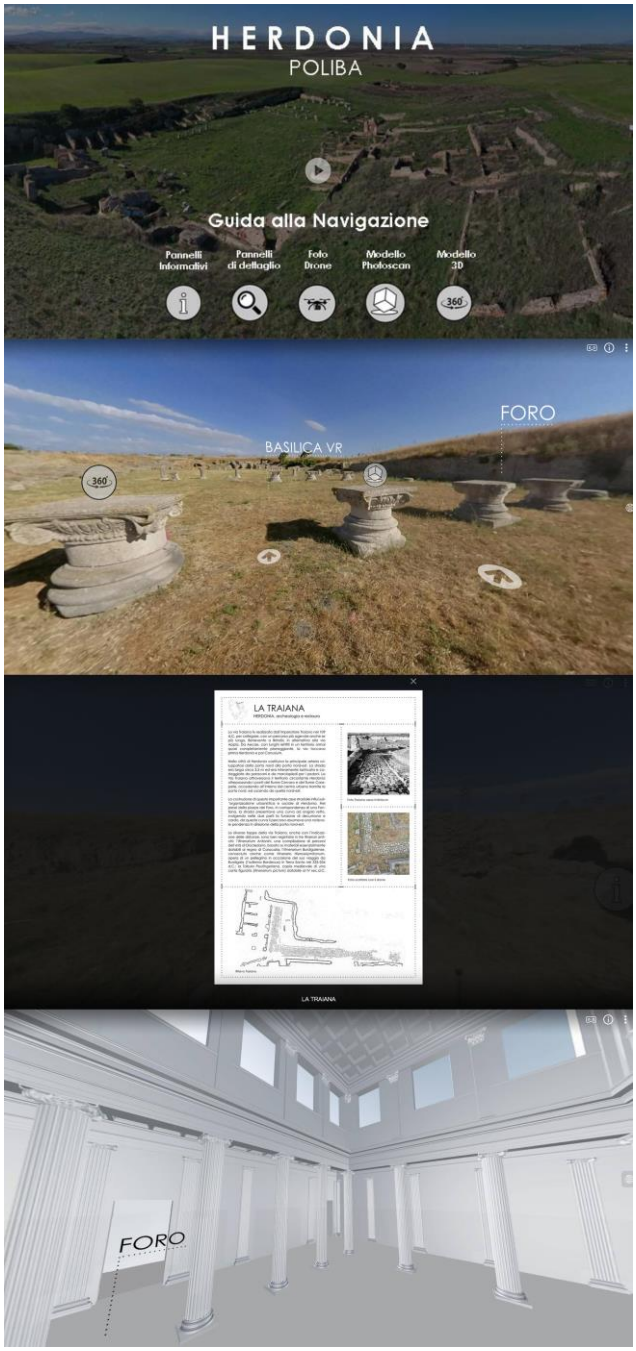

Fig. 9: Virtual tour: home page and some content. Retrieved in https://www.theasys.io/viewer/8Af6uwtNQ7ko6gaT3ozxibbiUAe1gw

4.4 Tools and methods in the third survey campaign: state-owned areas

Image-based techniques, i.e. digital photogrammetry, and range-based techniques, for this phase using a Terrestrial Laser Scanner and GNSS station, were also used for the third-generation surveys, which started shortly after the previous campaign.

Fig. 10: Panoramic map processed with Faro Scene software showing laser scanner station points: south-west gate

The aim was to survey all the emerging buildings present in the state-owned areas, then in the rest of the hill outside the forum. By virtue of the work produced previously, sharing its methodological approach and the validity of the results, the Regional Secretariat of the MiC felt it necessary to involve the research team again to survey the entire archaeological site, with the exception of the areas still under private ownership. Before starting field operations, the areas close to the architectural remains were cleared of the vegetation that partially or completely covered them. The cleaning, aimed at showing the parts to be surveyed in their entirety, is not likely to be repeated any time soon, so it was decided to tackle the new phase of surveys by deploying all the newly acquired tools to document the archaeological remains in their entirety and with the utmost accuracy (Campanile, Castagnolo & Strippoli, 2014; Cianci et al., 2023). Here too, aerial and terrestrial photogrammetry was used for the topographical survey using GNSS, and the Faro Focus S70 laser scanner for the architectural scale surveys, which was also used to metrically calibrate the photogrammetric data (fig. 10). The laser model used is capable of acquiring up to 2 million points per second with an accuracy of 1mm and detecting complex structures up to a distance of 70 metres. As it is equipped with a 165 mpx HDR camera for capturing detailed images,

the point clouds are also equipped with colorimetric data (Leserri, & Rossi, 2023).

A 24.1 Mpixel Nikon D5200 camera was used for the terrestrial photogrammetric survey, with which close-up photographic datasets were made to collect material data and colour information.

Also in this last survey campaign, the flight operations, carried out in manual mode, were differentiated according to architectural and topographical scale (Agnello, & Cannella, 2022).

For the realisation of the datasets for the topography of the entire site, acquisitions were carried out at a distance of 40 metres, with exclusively nadiral photos, while for the remains of the *castellum*, walls and gates, acquisitions were carried out at a distance of 5 metres, with the camera placed in a frontal, nadiral position and at an angle of 45° (fig. 11).

Fig. 11: Aerial views of the *castellum*

The GNSS with which the topographical support for the orthophoto planimetric plans of the site and the georeferencing of the surveys was carried out, was also used to survey the altimetrical elevations of significant areas of the site, with a thickening of the mesh in the area between the north gate and the Maria Cecilia Podere, an early 20th century structure, also affected by the surveys (fig. 12).

The sections cutting across the site covered the following areas:

- the *castellum* hill;
- the first axis defined by the natural slope between two northern heights, which corresponds to the route of the Via Traiana, because it crosses the area near the Maria Cecilia Podere, passes through the northern gate and breaks off to mark the area of the forum;
- the second axis defined by the natural slope between the two southern hills, which runs through the south-west gate and touches the stretch of wall to the south.

The two longitudinal sections are:

- the one from the *castellum* to the south-west gate, to the south-west hillside;
- the one that runs from the forum area along the stretch of wall to the south and reaches the limit of the hill to the south.

As stipulated in the Convention, three-dimensional models of everything that was surveyed were delivered to the Secretariat, as well as the relevant two-dimensional graphics (Cianci & Colaceci, 2022):

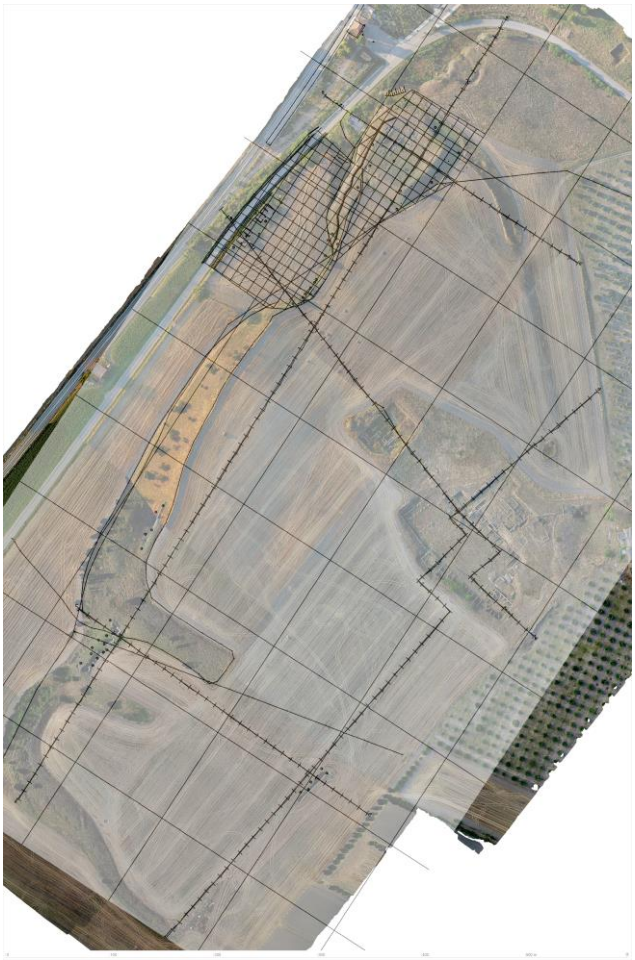

Fig. 12: Elevated sections with GNSS of the archaeological area

Fig. 13: Point clouds from laser scanner and photogrammetric survey: south-west gate, south-east wall, castellum

- the relevant vectorised drawings, on a scale of 1:00 or 1:50, comprising plans, elevations and sections, complete with orthophotos and representation of wall textures;

- the plan of the archaeological area and related sections and orthophotoplan, both in local coordinates and at a scale of 1:1000 and the plan with orthophoto of the hill area superimposed on the topographic survey in local coordinates and related sections at a scale of 1:500;

- instrumental measurement booklets, fiduciary point monograph sheets, photogrammetric processing reports;

- a GIS (on a Q-GIS platform), in the WGS84_UTM33N satellite coordinate system on Geoid Italy2008, with altimetric elevations relative to sea level, containing the georeferenced Data Elevation Models (DEM), the nadiral orthophotoplans of the surveyed architectural structures, the orthophotoplans of the entire area, the georeferenced plan representations of the surveyed structures, the contour lines, the cadastral plans, the geomagnetic prospections carried out by the University of Foggia, provided by the Superintendency.

The GIS was not foreseen in the Convention, but it was considered useful to provide the offices involved with an initial user-friendly tool, containing some of the data collected in the last two survey campaigns (fig. 14). For the same reason, i.e. to facilitate the management of information, two-dimensional representations were provided at the scale of detail of everything surveyed, also containing orthophoto plans (point clouds are still difficult for many operators to consult and use).

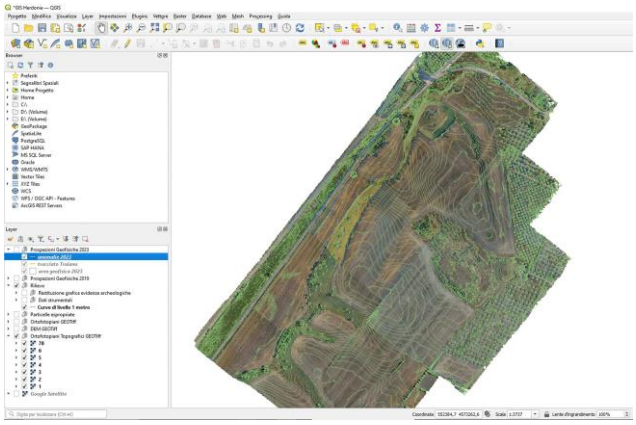

Fig. 14: GIS containing research data

In addition to practical reasons, the motivation that guided the choice towards orthogonal projection drawings is linked to theoretical issues that explicitly concern hermeneutic questions (Gutiérrez-Pérez, & de-Miguel-Sánchez, 2023): the interpretative act underlying the practice of drawing is widely debated and considered essential in the interpretation of architecture, but it becomes even more necessary when dealing with the study of the archaeological remains of ancient structures, for which the understanding of the object is not so obvious. It is therefore considered that the reading of orthophotoplans in an archaeological context, however high in definition and metric and geometric precision, requires the guidance that drawing, the interpretive act par excellence, can provide (figg. 15 and 16).

5. Expected results and future developments

In the survey of archaeological heritage, field acquisition methods with a high degree of accuracy, speed of execution and production of a large amount of complex information of different nature and scale are being consolidated.

The introduction of protocols and tools for their management (from H-BIM to 3D GIS, etc.) allows for great control of the documentation acquisition process (Gaiani, Benedetti, & Apollonio, 2011), both in sites where excavation campaigns are in progress, i.e. where the process is active and continuously updated, and in cases of post-excavation documentation, such as two- and three-dimensional surveys and graphical drawings of the state of the site and documents related to previous investigations (surveys, historical photos, excavation reports, publications) (Bertolini, et al, 2024; Parrinello, & Porcheddu, 2023).

In Herdonia the experience presented here aims to lay the foundations for actions of this type, which have not yet been implemented due to the legal regime to which the various areas of the site are subject, but the Secretariat for Apulia of the Ministry of Culture and the Archaeological Superintendence, Fine Arts and Landscape for the provinces of BAT and Foggia have intended to initiate this process, starting with a series of funding with which the first valorisation projects are being prepared[3] for which the survey campaign was financed.

The methodological process and the model of interaction between the elements (tools, technologies, methods), could serve as a model for a knowledge path applicable to other archaeological sites as well.

[3] Among these is the 'Appia Viarum - Ordona section. Archaeological Area of Herdonia - Broken Bridge on the Cervaro - Roman Bridge on the Carapelle" within the framework of the National Plan for Complementary Investments (PNC) to the National Recovery and Resilience Plan (PNRR).

Monuments and places today tell of the progressive transformation of their state of preservation due to the impossibility of constantly maintaining them. Surveys have shown the changes that have occurred since the ancient structures were brought to light. Evidence of this is the deterioration of the consistency and colouring of the fragments of wall plaster that have now almost completely disappeared from the few walls on which they were found.

The digital documentation produced between 2021 and 2023 certainly photographs the state of

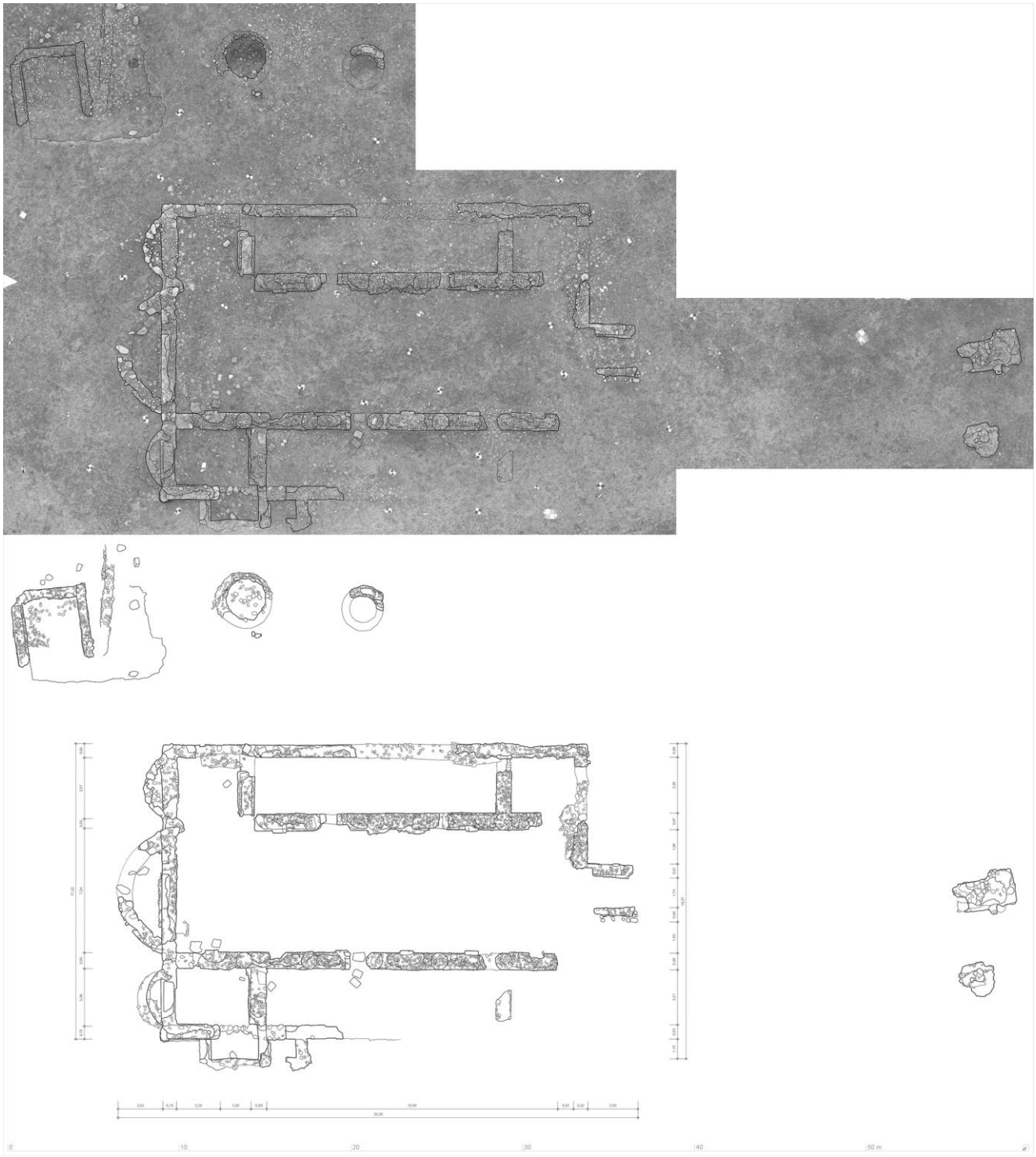

Fig. 15: Elaborati grafici bidimensionali: pianta del *castellum*

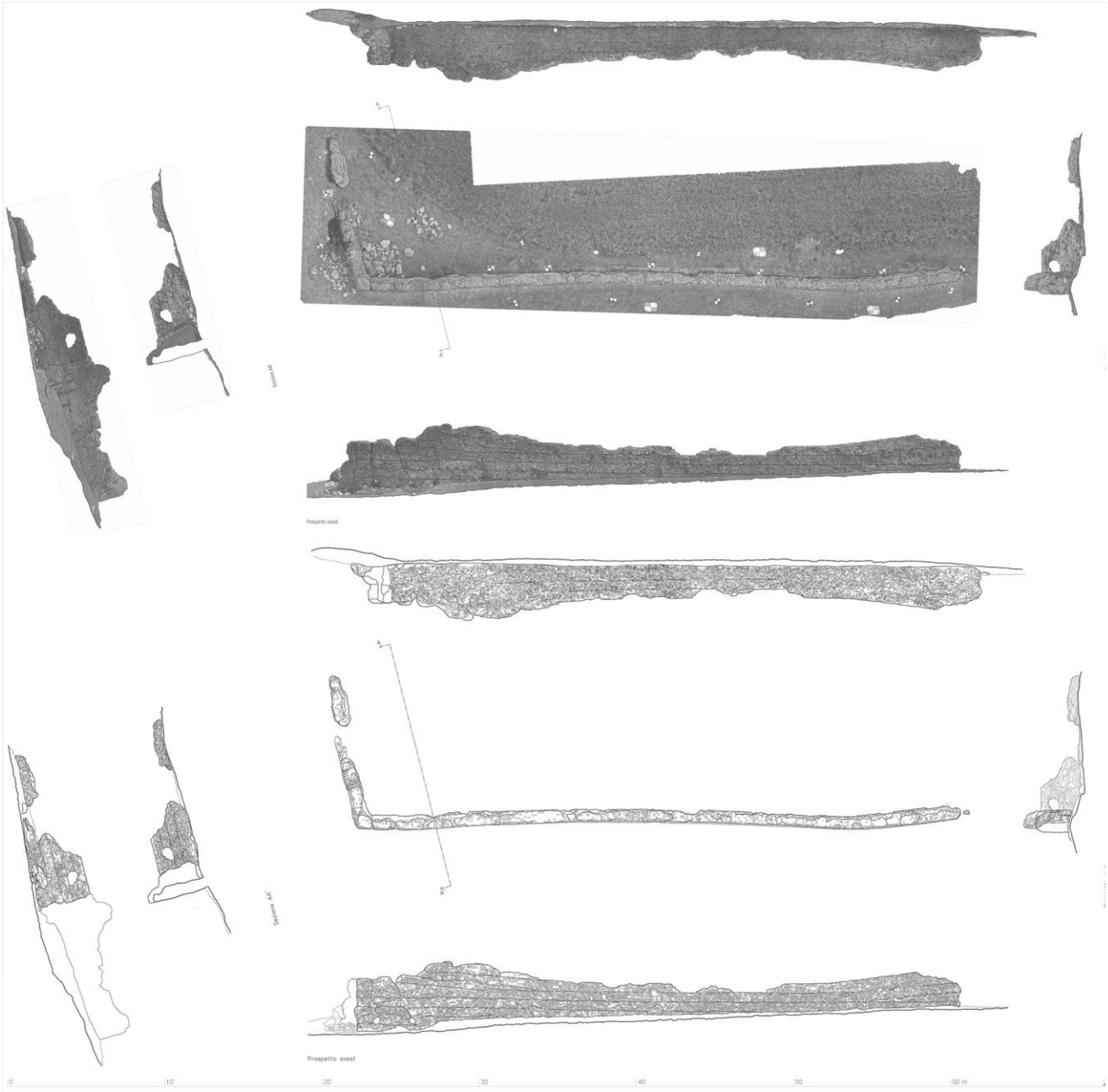

Fig. 16: Bidimensional graphics: plan and sections of the south-east wall

the sites at that exact moment in time, constituting a document for the monitoring of the structures and a fundamental support for future actions, especially in view of the restart of the excavation campaigns, unfortunately not yet scheduled.

Acknowledgements

I would like to thank arch. Maria Piccarreta Regional Secretary of the MiC for Apulia and arch. Campanile, Architectural Officer, now Director of Castel del Monte, for promoting the new research in the archaeological area of Herdonia with a Collaboration Agreement and a Convention with the ArCoD Department of the Polytechnic University of Bari, and arch. Daniela Fabiano and Dr. Italo Muntoni of the Archaeological Superintendence, Fine Arts and Landscape for the provinces of BAT and Foggia, for scientific support.

The graphic outcomes are the result of the research experiences mentioned in the paper, for which the surveys were conducted by the author with the collaboration of all members of the research teams.

REFERENCES

Agnello, F., & Cannella, M. (2022), From aerial survey to representation and visualization: the Temple G of Selinunte, DISEGNARECON, 19 (15), 2.1-2.13.

Barbini, A., Giampiccolo, F., Maragno, A., Massari, G. A., & Pellegatta, C. (2024), Innovation and tradition: integrated practices in the architectural survey of Pretorio palace in Trento, *SCIRES-IT - SCIentific RESearch and Information Technology, 14* (1). 45-62. http://dx.doi.org/10.2423/i22394303v14n1p45

Bertolini, S., Piemonte, A., Caroti, G., Bevilacqua, M.G., Capriuoli, F., Rinaldi, E., Santillo, D., & Muccilli I. (2024), Integrated 3d survey methodologies and digital platforms for the enhancement of archaeological data in the digital transition, *SCIRES-IT - SCIentific RESearch and Information Technology*, *14* (2). 107-124.

Buono, A. G., Cordasco, E. V., Laricchia, A., Lavermicocca, I., Milardo, C., Nirchio, A., & Serpenti, C. (2021), *Herdonia. Archaeology and restoration*. Degree thesis. Bari, Italy: Polytechnic University of Bari, 2021.

Campanile, D., Castagnolo, V., Francesca Strippoli, F. (2024), Heritage digitalisation to preserve memory. Studying the archaeological evidence of Herdonia through the measure and the sign. In *XXII International Forum "Le vie dei Mercanti"* - Proceedings 2024 (pp. 586-594). Roma, Italy: Gangemi.

Castagnolo, V. (2008), La basilica di Herdonia. Esperienze e riflessioni sul rilievo e la rappresentazione del monumento. In G. Volpe & D. Leone (Eds), *Ordona XI. Ricerche archeologiche a Herdonia* (pp. 393-443). Bari, Italy: Edipuglia.

Cianci, M.G., & Colaceci, S. (2022). Laser Scanner and UAV for the 2D and 3D Reconstructions of Cultural Heritage. *SCIRES-IT - SCIentific RESearch and Information Technology*, *12*(2), 43-54.

Cianci, M. G., Calisi, D., Botta S., Colaceci, S., Pontisso, M., Quilici, S., & Spallino, C. (2023), Integrated 3D methodologies for the survey of archeological heritage, *DISEGNARECON*, *30* (16), 4.1-4.12.

Cordasco , E. V., Lavermicocca , I. & Milardo C.,(2023), Herdonia. Architettura e Restauro per un progetto di Parco archeologico. In *II Congress Beni culturali in Puglia* - Proceedings 2023 (pp. 257-262). Bari: Edizioni Fondazione Pasquale Battista.

De Felice, G., & Fratta, A. (2021), *Ordona XIII. Dalla città fantasma alla città virtuale*. Bari, Italy: Edipuglia.

Favia, P. (2018), *Ordona XII. Un casale nel Tavoliere medievale*. Bari, Italy: Edipuglia.

Gutiérrez-Pérez, N., & de-Miguel-Sánchez M. (2023), A scalar approximation to the survey of the architectural, artistic and cultural heritage of the University of Alcalá (Madrid, Spain), *DISEGNARECON*, 30 (16), 5.1-5.13.

Leander Touati, A. M., Staub, T., & Forsell, R. (2021), From 2D and 3D documentation to 4D interpretation. Building archaeological conclusions and workflow strategies gained by remote study of insula V 1, Pompeii, in *OpAthRom*, 14, pp. 181-226.

Leserri, M., & Rossi, G. (2023), The digital documentation of the cultural heritage between public interest versus private property. Survey and research on the Immacolata square in Martina Franca (Apulia, Italy), *SCIRES-IT - SCIentific RESearch and Information Technology*, *13* (2), 28-42.

Mertens, J. (1995), *Herdonia. Scoperta di una città*. Bari, Italy: Edipuglia.

Mertens, J., & Volpe, G. (1999), *Herdonia. Un itinerario storico-archeologico*. Bari, Italy: Edipuglia.

Parrinello, S., & Porcheddu, G. (2023). Sistemi informativi dinamici a supporto della documentazione archeologica per interventi in emergenza. *Restauro Archeologico*, *30*(2), 48-65.