From micro-regional to intra-site analysis: the GIS of the Italian Archaeological Expedition in the Erbil Plain (Kurdistan Region of Iraq)

Valentina Oselini[1]*, Michael Campeggi[1], Luca Forti[2], Elisa Ginoli[1], Andrea Pezzotta[2], Agnese Vacca[1] and Luca Peyronel[1]

[1] Department of Literary Studies, Philology and Linguistics, University of Milan, Milan, Italy;
[2]Department of Earth Sciences "Ardito Desio", University of Milan, Milan, Italy;
*Correspondence: valentina.oselini@unimi.it

Presented at ARCHEO.FOSS XV 2021: Open software, hardware, processes, data, and format in archaeological research; on-line; November 23rd-26th 2021

Abstract:

The Italian Archaeological Expedition in the Erbil Plain (MAIPE https://orienteantico.unimi.it/it/maipe/) of the University of Milan is experimenting with a GIS project based on the QGIS system. The project aims to combine data from survey, excavation, and geomorphological investigations carried out at the two sites of Helawa and Aliawa and their surrounding landscape. The MAIPE GIS is intended as a valuable tool for predictive, distributive and cross-data analyses considering the complex diachronic development of the area and the results of paleoenvironmental studies at a micro-regional and intra-site scale.

Keywords: QGIS, cross-data analyses, fieldwork, archaeology, geomorphology

FOSS software used and licence: QGIS (*GNU General Public License*), QField (*GNU General Public License v2.0*), GRASS GIS (*GNU General Public License*)

Introduction (LP, AV)

Since 2013, the Italian Archaeological Expedition in the Erbil Plain (MAIPE, University of Milan), directed by L. Peyronel with A. Vacca as deputy director, has been carrying out archaeological investigations at Helawa and Aliawa, two sites located ca. 27 km SW of the city of Erbil, in the Kurdistan Region of Iraq. The investigated area (ca. 20 km^2) lies in a strategic position of the plain, just north of the Awena Dagh, a range of low hills parallel to the Qara Chuq mountains, the latter representing the border with the Makhmour Plain. The sites are also situated on two tributaries of the Kordara, one of the rivers forming the Erbil drainage system with the Siwasor and the Bastora Chai, south of the Greater Zab (Peyronel *et al.*, 2019, 1-3, figs 1-2). The two settlements, located just 3 km apart, have a typical Mesopotamian site morphology. They feature a central mound resulting from the superimposition of earlier strata created by the decomposition of previous mudbrick structures, and an occupation of the surrounding area close to favourable natural resources. These represent ideal conditions for a micro-scale regional case study and the analysis of the local cultural and historical development.

MAIPE agreed with the Directorate of Antiquities of Erbil to investigate the two sites following a well-defined research program that aims at building a site-based chronology constructed on stratigraphy, pottery seriation and C14 dating. Moreover, it strives to frame the Helawa-Aliawa occupational history in the broader regional context and to reconstruct the human-environment interaction in the micro-region through time by applying a multidisciplinary approach combining archaeological excavations, micro-stratigraphy, bio-archaeological analyses, and geo-archaeological investigations.

As a result of this integrated approach, during seven years of actual fieldwork (2013, 2015-2019, 2021), MAIPE collected a large amount of data that documents the long-standing occupation of the area, spanning from the Late Neolithic to the Islamic period. All data have been organised to be stored in a GIS environment which is continuously updated, named the MAIPE GIS, based on the open-source QGIS which is increasingly used as an effective medium for managing archaeological and paleoenvironmental data in projects in Western Asia (Ardissone *et al.* 2008; D'Andrea 2003; Frigeri 2012; Kolinski 2019, 12; Pescarin 2006).

The present contribution shows how information from an ongoing research project is processed using a QGIS system and illustrates how this tool helps combine various types of data and carry out multi-scalar and cross-correlated analyses (Orengo 2015).

A Multidisciplinary Approach: Data Management (MC, VO, AV)

The use of GIS for the management and analysis of archaeological data allows the integration of information at different scales within a single spatial framework (Boyd *et al*. 2021; Scianna and Villa 2011; Dell'Unto and Landeschi 2022, 5-17). Thus, MAIPE's choice of an open system (QGIS) is intended to improve data accessibility, encourage result sharing and foster collaboration between the project teams, thanks to the elimination of licence constraints and to the reduction of software costs, all without affecting the work quality (Marchetti *et al*. 2018). QGIS is, in fact, available for all popular operating systems, and layers in shapefile format are compatible with other paid-for software, facilitating the exchange of data between different projects (Casagrande *et al.* 2012).

The MAIPE GIS was initially developed in 2013 through the collection of spatial data on the field, the realisation of a 3D model – a digital elevation model (DEM) of Helawa–, and the digitalisation of the general features of this site and its surroundings. Moreover, an orthorectified WorldView2 satellite image acquired in 2011 was used as a base-map for the 5x5 km area, including Helawa, Aliawa and the surrounding territory (Peyronel, Bursich and Di Giacomo 2016). The first DEM of Aliawa, used as a base map for the survey, was provided in 2016 by the Erbil Plain Archaeological Survey (EPAS), (Ur *et al.* 2021). Further Digital Surface Models (DSM) of the main mound at Helawa and Aliawa were realised by the MAIPE team in 2021.

A correlated table system elaborated in a .XLSX format was designed to organise the information collected by the project's research teams. The choice of using .XLSX spreadsheets instead of a .DB server system was initially determined by the need to work remotely from several devices, even without an internet connection.

These tables are linked through shared fields and, together with the spatial data, constitute the MAIPE GIS' relational geodatabase which is built as a Geopackage (.GPKG format). Data collected during the excavation activities conducted from 2016 at Helawa and 2019 at Aliawa have been progressively georeferenced in the GIS and digitalised as shapefile layers.

This system allows an effective workflow that enables team members to record their data in a standardised format compatible with a GIS environment (see also Ardissone *et al.* 2008).

The data processing is organised in various phases and is structured as showin in fig. 1:

1. Collection of base cartography, satellite and historical images of the investigated area;

2. Acquisition and processing of the topographical information by using Unmanned Aerial Vehicle (UAV) imagery;

3. Manual recording of features in the field through Stratigraphical Units (SUs) sheets, Loci sheets, and sample lists, and in the laboratory through pottery and small finds records, photographs and drawings;

4. Digitalisation of the data into the Survey Database, Excavation Database, and Geoarchaeological Database. These databases are organised as spreadsheets and then saved as .CSV files which are uploaded into the MAIPE GIS as attribute tables linked to their respective shapefiles within the Geopackage;

5. Performance of spatial and cross-correlated analysis through the GIS according to specific research questions.

Data Processing: The GIS for Geomorphological and Archaeological Research

Geomorphological Mapping and Preservation of the Archaeological Landscape (LF, AP)

Geomorphological analysis and mapping are fundamental tools to understand the interplay between natural and anthropogenic landscape shaping processes. In this setting, comparisons between satellite and historical imagery through remote sensing and GIS-based analysis are necessary to discriminate between old and recent modifications of anthropogenic and natural landforms (Hritz 2014; Grabowski and Gurnell 2016). In the Kurdistan Region of Iraq, the interplay between tectonics, climate and human agency shaped the landscape during the Late Quaternary, influencing the evolution of geomorphological processes and landforms (Fouad 2015; Abdulnaby 2018; Zebari *et al.* 2019; Forti *et al.* 2021). The area between Helawa and Aliawa is the subject of a detailed geomorphological mapping, conducted both with remote sensing and field survey, to outline the environmental landscape surrounding the sites. The fieldwork was carried out during the 2019 and 2021 excavation campaigns.

Remote sensing was performed through QGIS and GRASS GIS software to process the elaboration and comparison of Google Earth™, Landsat, WorldView2 satellite data and historical imagery derived from the Corona Atlas of the University of Arkansas 1967-1968

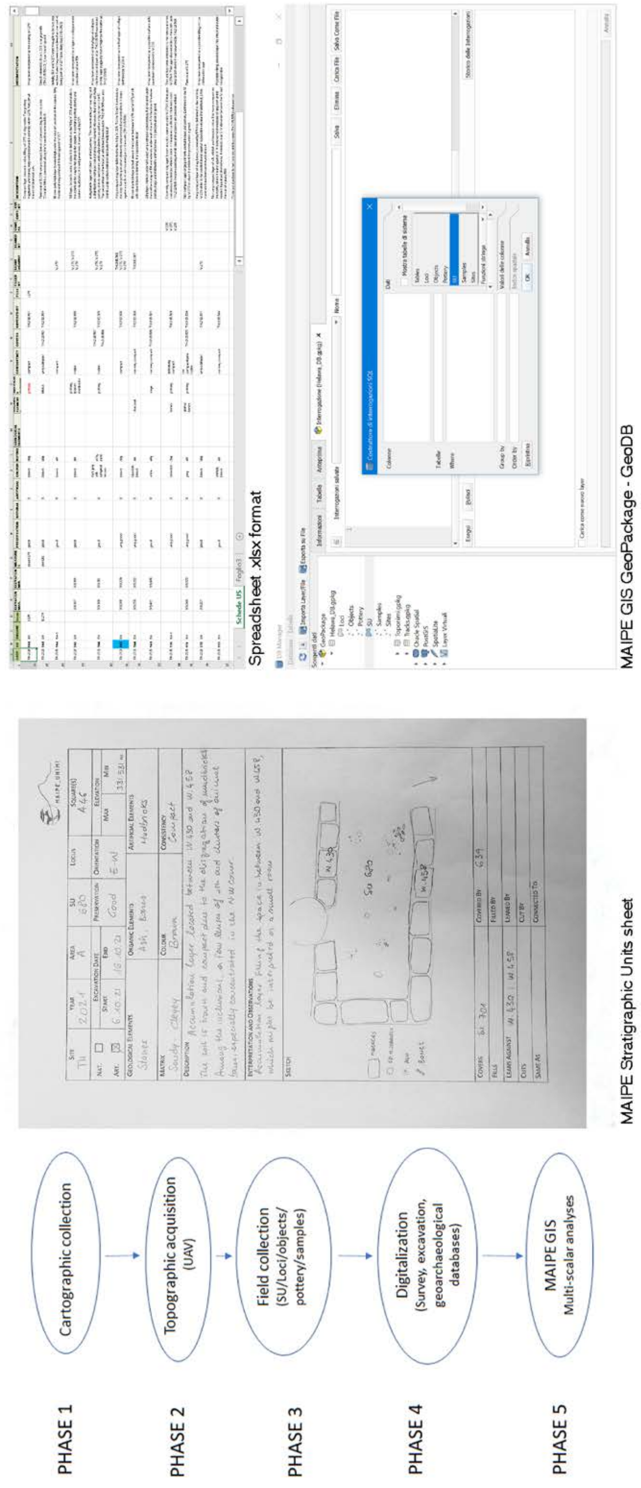

Figure 1. Organization of the MAIPE workflow. © MAIPE – University of Milan

(https://corona.cast.uark.edu/). In addition, a DSM with 1° horizontal resolution (~30 m resolution at the equator) was extrapolated from Alos Jaxa and processed for further analysis such as slope aspect, asperity and hillshade, to highlight specific geomorphological features like escarpment, fluvial landforms, wadi valleys and paleo-valleys related to "underfitted streams model" (Dury 1964). Through this approach, we reconstructed the evolution of the landscape during the Holocene, intending to understand how variations of the local fluvial network influenced settlement dynamics and land use around the two sites. The area is characterised by "underfitted streams", defined by the interplay between the large former valley, whose riverbeds are incised by extant *wadis*, and ancient and recent human exploitation of the channel network and the floodplain.

The comparison of field data and remote imagery analysis was useful to place the two sites in the environmental context existing at the time of their occupation and to identify the natural and anthropogenic surface processes currently underway, which are influencing the preservation of the archaeological record (Forti *et al.* 2020) (fig. 2).

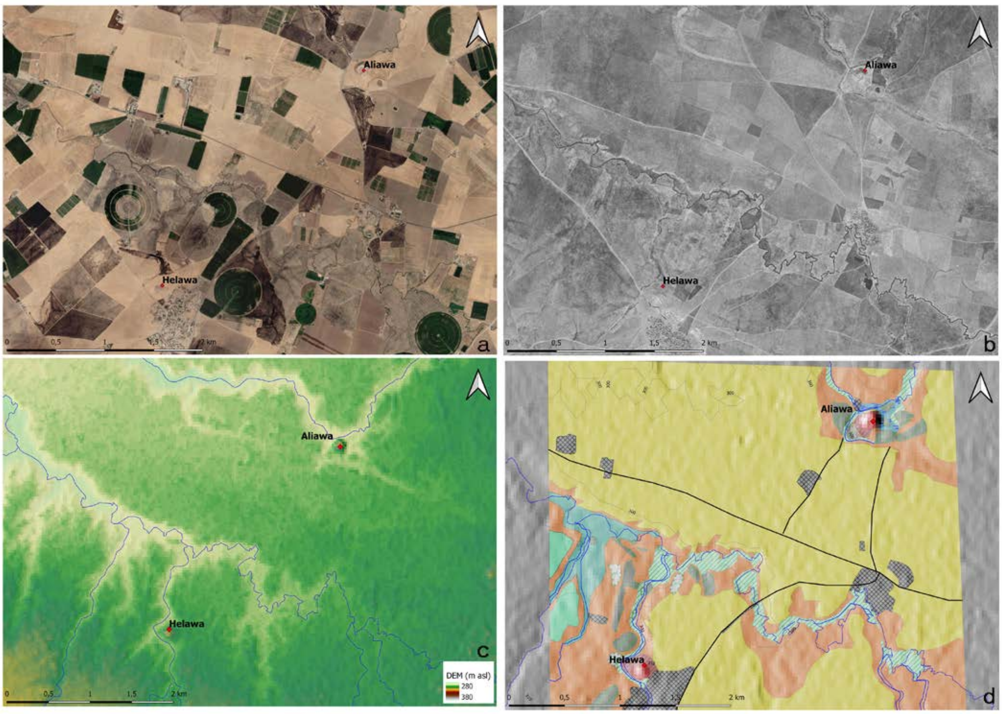

Figure 2. QGIS display of various WMS, raster, and shapefiles from the MAIPE GIS. a) Recent satellite Imagery (GoogleTM Earth). b) Historical satellite Imagery (1967 Declassified CORONA; USGS, 1968). c) 30m (ALOS) DEM (JAXA, 2021) with superposed slope and hillshade (extrapolated through GRASS GIS). d) Geomorphological vector layers (polygons and line geometries). © MAIPE – University of Milan.

The Archaeological Survey: Predictive Intra-site Analyses (MC, VO)

In 2013 and 2015, MAIPE carried out an integrated archaeological survey of Helawa and Aliawa to establish the sites' chronological occupations, to make predictions on their morphologies and extensions within the different periods, and to assess the effects of natural phenomena on the archaeological deposit (Peyronel and Vacca 2015; Peyronel, Vacca and Zenoni 2016).

In order to gain statistically relevant information on the spatial distribution of surface finds for GIS-based analyses, georeferenced Collection Areas (CAs) and Collection Units (CUs) were established on the mounded area of Helawa (c. 1.2 ha), while the lower sector, more disturbed by modern ploughing, was investigated through an extensive survey. These areas were then digitised within the MAIPE GIS as polygon shapefiles, and the finds collected from the field were assigned to the specific CUs thanks to the "Insert Random Point" function in QGIS which allowed us to visualise the different phases of occupation at the site from the Late Neolithic to the mid-2nd millennium BC and to identify the sporadic findings dating up to the Islamic period (Oselini 2020, fig. 4; Peyronel, Vacca and Zenoni 2016; Vacca, Moscone and Rosati 2020).

Similarly, at Aliawa, the site was initially divided into 14 different topographically relevant CAs, departing from the central mound and extending towards the lower sector. Artefacts were collected in each of these areas. Also, in this case, the pottery collected was recorded in QGIS following the method used for Helawa which showed that the site was occupied during the Early Bronze Age (EBA), the Middle and Late Bronze Ages (MBA, LBA), and from the Iron Age (IA) until the Hellenistic/Seleucid and Parthian periods, with the latest settlement dated to the Late Islamic period (Peyronel and Vacca 2020).

In order to assess the extension of the various occupational phases at the sites, the MAIPE GIS was then used to run a combination of spatial analyses such as Kernel Density Estimation (KDE), heatmaps, and the interpolation functions, all of which are available in QGIS. The aim of KDE, which is commonly used in GIS-based archaeological research, is to provide a smoother visualisation of the various degrees of distribution of items around a specific core, given a predetermined radius which may either be set up manually or automatically through the GIS (Bonnier, Finné and Weiberg 2019, 72-73).

Moreover, the integration of survey and geomorphological data enabled us to carry out multi-scalar and predictive modelling on the interplay between natural phenomena and the archaeological deposits at the sites. In the case of Aliawa, for instance, the combination of the geomorphological analysis of natural and anthropogenic processes, the chronological data obtained from the collected sherds, the density clusters detected through the KDE, and the slope analysis run through the QProf plugin available in QGIS, suggested that the southern side of the central mound of Aliawa was potentially of great interest for further research due to the likely presence of an underlying multiphase stratigraphy which would allow a chronological reconstruction of the site's occupation.

Based on these predictions, Step Trench A was therefore excavated in 2019 and 2021 in the south-eastern sector of the mound, where the site's topography was easily accessible (fig. 3).

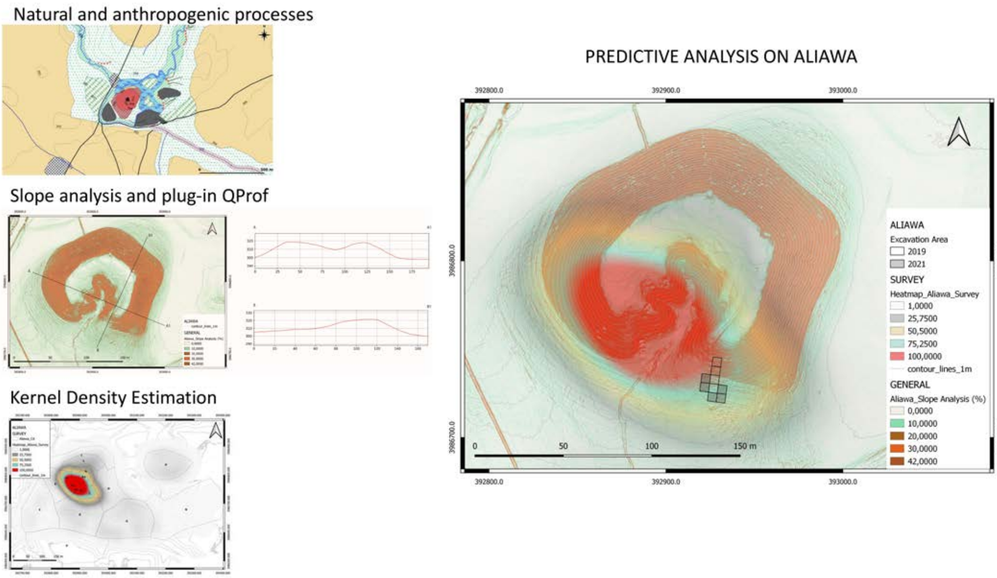

Figure 3. Predictive analysis on Aliawa, after analysing the natural and anthropogenic processes, the slopes and by applying the Kernel Density Estimation. © MAIPE – University of Milan.

QGIS for the Archaeological Excavation (MG, EG, VO)

In addition to its use for large-scale operations such as survey and landscape investigations, the MAIPE GIS is also being employed as the project's repository for the data collected at a stratigraphic and micro-morphological level from the ongoing excavations at Helawa and Aliawa.

Topographic plans of the excavation areas are obtained from photographs. The workflow consists of two stages: the first phase is carried out in the field, while the second may also be performed remotely. During the first phase, control points are positioned within the area of interest and their absolute elevation is recorded through the total station. This operation is necessary to scale and position the photomosaic correctly within the excavation area so that it may be used later in the documentation process. Numerous nadiral photos are then taken through a camera mounted on a telescopic rod or using a UAV (Fig. 4a-b).

Later, during the second phase of the process, the partial photos of the excavation area are assembled both through the photomosaic and photogrammetric techniques to obtain a total image of the desired area with realistic proportions and as less distortion as possible. Once this "base" image is produced, it is imported into QGIS and processed through the "georeferencer" plugin, which links it to the absolute coordinates of the control points previously positioned in the field. This way the photomosaic is correctly scaled, oriented, and positioned within the excavation area and is ready to be digitised in a shapefile format through polygons and polylines in QGIS and further characterised based on the typology of the architectural elements (wall, bench, floor, etc.) for visualisation purposes (Fig. 4c-d).

The shapefile layers corresponding to SUs (stratigraphic unit) and Loci are subsequently linked to their respective attribute tables, derived from the .XLSX spreadsheets transformed into several .CSV, and which contain information regarding the occupational phase, the stratigraphic relation to other layers, dimensions, elevation, and associated materials. Micromorphological samples were also taken from the excavation sections at Helawa (Step Trench B) to investigate the archaeological record at a microscopic scale and were positioned by the Total Station, uploaded to the GIS project, and linked to the metadata in the attribute table associated with the SUs shapefile (Fig. 4e).

Shapefiles and relative attribute tables are all correlated to one another thanks to the relational structure of the MAIPE GIS Geopackage database which allows users to rapidly filter and perform queries for the excavated sequence, carry out distribution analyses of the materials found in the archaeological context and examine the associations between the diverse types of artefacts.

Discussion and future perspective (MC, VO, LP, AV)

The use of QGIS to assemble information from the different teams involved in the MAIPE project is advantageous for the development of analyses and multi-scalar interpretations of the complex relationship between human communities and the natural landscape of the southwestern Erbil plain in a *longue durée* perspective. The combination of geomorphological data and the analyses on the distribution of the archaeological material within a multidisciplinary relational database in QGIS, in addition to the use of various plugins, made it possible to identify specific points of interest and create new insights for further investigation at Helawa and Aliawa.

In terms of future perspectives, MAIPE aims to speed up the work in the field to simplify the data management stage and reduce post-processing and publishing times. In this regard, during the 2021 campaign, MAIPE experimented with the app QField for processing data directly on the field (Montagnetti and Guarino 2021). The geomorphological and archaeological survey in the Aliawa surroundings was implemented to obtain insight into the settlement's spatial development and its geomorphological setting in the different phases of occupation. QField was run on Android tablets and was used as a direct recording tool for surface findings and observations on the territory by incrementing the shapefile layers previously created on the GIS project and corresponding to the survey transects and collection areas, the archaeological and geomorphological features, and the pottery concentrations. The use of this app for the management of the archaeological excavation is still experimental, but it could be used to streamline the documentation of lists during the excavation and for the positioning of pottery and small finds.

MAIPE's choice of an Open Source software like QGIS provides solutions to both practical and research issues and agrees with its pursuit of a policy of open access data for scientific research, a practice which we hope will be increasingly adopted by a wider community. In fact, in addition to being an easily accessible medium in a multidisciplinary research project, QGIS can be transformed into a web-GIS and can be made available to a wider audience of users, both for academic and dissemination purposes.

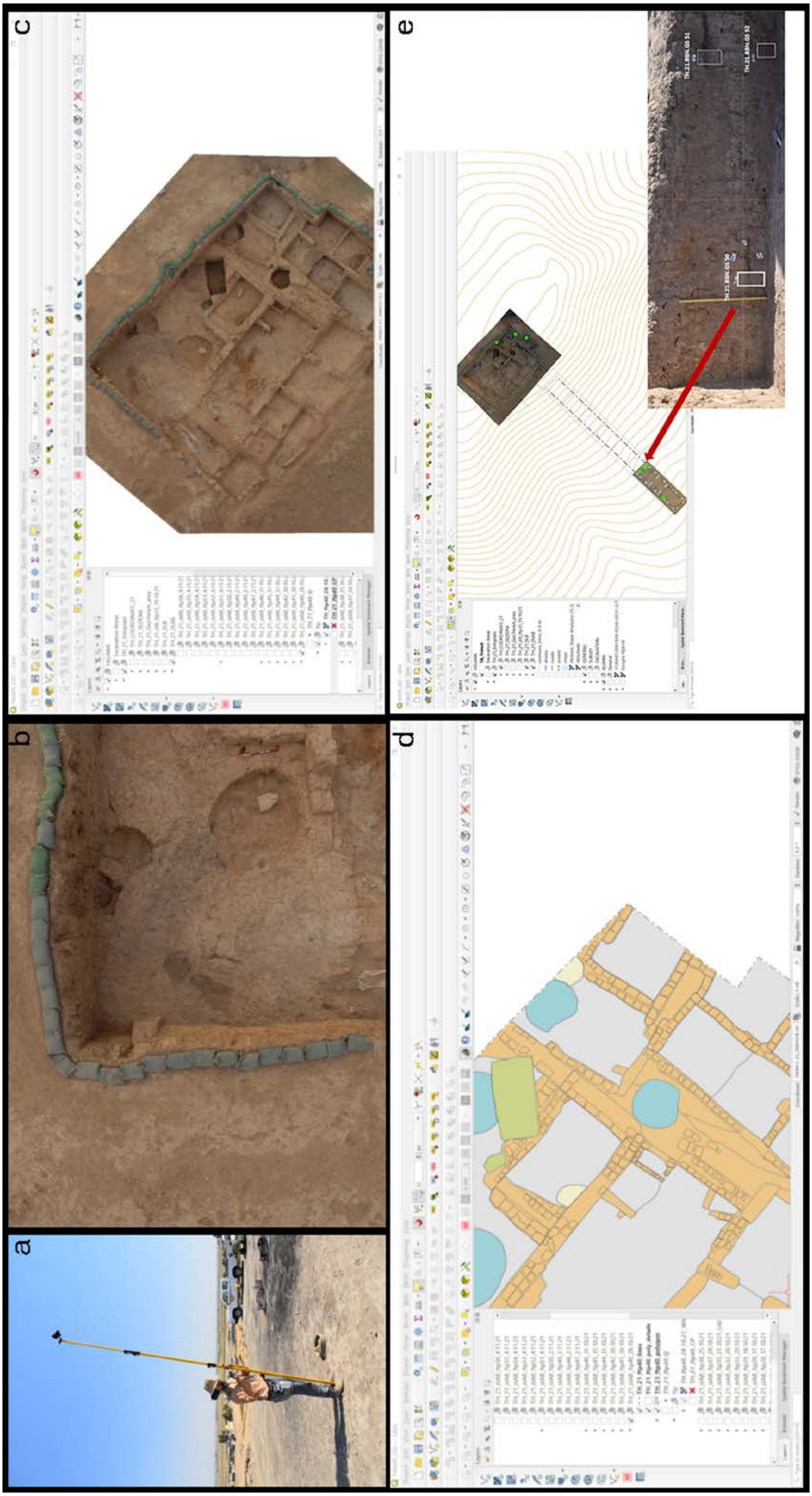

Figure 4. The various steps of the topographic process: a) acquisition of nadiral images on the field; 2) example of a UAV image of the excavation trench at Helawa; c) orthorectified photomosaic of the entire excavated area uploaded and georeferenced in QGIS; d) digitalization of the SUs and Loci in the GIS in geometric shapefiles; e) geolocation of micromorphological samples. © MAIPE – University of Milan

References

Abdulnaby, W. 2018. "Chapter 4 - Structural Geology and Neotectonics of Iraq, Northwest Zagros." In *Developments in Structural Geology and Tectonics Vol. 3,* edited by Ali Farzipour Saein, 53-73. Amsterdam: Elsevier. DOI: 10.1016/B978-0-12-815048-1.00004-4

Ardissone, P., F. Balossi Restelli, E. Borgia, and E. Brienza. 2008. "Web-GIS Solutions for the Analysis and Valorisation of Archaeological Sites in the Mediterranean Basin." In *Layers of Perception. Proceedings of the 35th International Conference on Computer Applications and Quantitative Methods in Archaeology (CAA). Berlin, Germany, April 2-6, 2007 (Kolloquien zur Vor- und Frühgeschichte, Vol. 10),* edited by Posluschny A., Lambers K. and Herzog I., 1-7, Bonn: Habelt.

Bonnier, A., M. Finné, and E. Weiberg. 2019. "Examining Land-Use through GIS-based Kernel Density Estimation: A Re-evaluation of Legacy Data from the Berbati-Limnes Survey". In *Journal of Field Archaeology,* 44 (2), 70-83.

Boyd, M. J., R. Campbell,, R.C.P. Doonan, C. Douglas, G. Gavalas, M. Gkouma, C. Halley,B. Hartzler, J. A. Herbst, H.R. Indgjerd, A. Krijnen, I. Legaki, E. Margaritis, N. Meyer, I. Moutafi, N.P. Iliou, D.A. Wylie, and C. Renfrew. 2021. "Open Area, Open Data: Advances in Reflexive Archaeological Practice." In *Journal of Field Archaeology,* 46 (2): 62-80. DOI: 10.1080/00934690.2020.1859780

Casagrande, L., P. Cavallini, P. De Rosa, P. Napolitano, and F. Iancobellis. 2012. "5. Quantum GIS in GIS Open Source." In *GRASS GIS, Quantum GIS e SpatiaLite. Elementi di software libero e applicato al territorio,* edited by Casagrande L., Cavallini, P., Frigeri, A., Furieri, A., Marchesini I., and Neteler, M., 33-40. Palermo: Dario Flaccovio Editore.

D'Andrea, A. 2003. "Analisi Spaziali Intra-Site. Soluzioni GIS per lo Scavo Archeologico." in *Archeologia e Calcolatori,* 14, 329-335.

Dell'Unto, N. and G. Landeschi. 2022. "Geographical information systems in archaeology." in *Archaeological 3D GIS*, 5-17. London and New York: Routledge.

Di Giacomo, G. 2016. "Sperimentazione di un sistema GIS cloud open source per la condivisione e la valorizzazione del patrimonio archeologico." in *Archeologia e Calcolatori,* Supplemento 8, 181-187, Firenze: All'insegna del Giglio.

Dury, G.H. 1964. "Principles of underfit streams." in *Geological Survey Professional Paper, no.* 452, (US Government Printing Office, 1964), 1-67.

Frigeri, A. 2012. "2. Software libero, licenze e dati geografici." in *GIS Open Source. GRASS GIS, Quantum GIS e SpatiaLite. Elementi di software libero e applicato al territorio,* edited by Casagrande L., Cavallini, P., Frigeri, A., Furieri, A., Marchesini I., and Neteler, M., 13-18. Palermo: Dario Flaccovio Editore.

Forti, L., E. Regattieri, A.M. Mercuri, I. Mazzini, A. Pezzotta, A. Florenzano, C. Conati Barbaro, L. Peyronel, D. Morandi Bonacossi, and A. Zerboni. 2020. "Geoarchaeological and paleoenvironmental reconstruction of the Late Quaternary climate- environmental-human nexus in the Kurdistan region of Iraq." in *EGU General Assembly 2020, Online*, (4–8 May 2020): 545. DOI: 10.5194/egusphere-egu2020-545

Forti, L., A. Perego, F. Brandolini, G.S. Mariani, M. Zebari, K. Nicoll, E. Regattieri, C. Conati Barbaro, D. Morandi Bonacossi, H.A. Qasim, M. Cremaschi, and A. Zerboni. 2021. "Geomorphology of the northwestern Kurdistan Region of Iraq: landscapes of the Zagros Mountains drained by the Tigris and Great Zab Rivers." in *Journal of Maps*, 225-236. DOI: 10.1080/17445647.2021.1906339

Fouad, S.F.A. 2015. "Tectonic map of Iraq, scale 1:1000,000, 3rd edition." in *Iraqi Bulletin of Geology and Mining*, 11, 1–7.

Grabowski, R.C., and A.M. Gurnell. 2016. "Chapter 4. Using historical data in fluvial geomorphology." In *Tools in Fluvial Geomorphology, Second Edition*, edited by G. Mathias Kondolf and Hervé Piégay, 56-75. Hoboken: JohnWiley & Sons.

Hrtiz, C. 2014. "Contribution of GIS and Satellite-based Remote Sensing to Landscape Archaeology in the Middle East." in *Journal of Archaeological Research,* 22, 229–276. DOI: 10.1007/s10814-013-9072-2

Koliński, R. 2019. *Catalogue of Archaeological Sites. Navkūr Plain, Al- Ḫazir River Basin. Settlement History of Iraqi Kurdistan Vol. 3.* Wiesbaden: Harrassowitz Verlag.

Marchetti, N., I. Angelini, G. Artioli, G. Benati, G. Bitelli, A. Curci, G. Marfia, and M. Roccetti. 2018. "NEARCHOS. Networked Archaeological Open Science: Advances in Archaeology Through Field Analytics and Scientific Community Sharing." In *Journal of Archaeological Research,* 26, 447-469. DOI: 10.1007/s10814-017-9112-4

Montagnetti, R. and G. Guarino. 2021. "From QGIS to QField and Vice Versa: How the New Android Application Is Facilitating the Work of the Archaeologist in the Field." in *Environmental Sciences Proceedings,* 10 (1), 6. DOI: 10.3390/environsciproc2021010006

Orengo, H. 2015. "5 Open-Source GIS Geospatial Software for Archaeology: Towards its Integration into Everyday Archaeological Practice." In *Open-Source Archaeology,* edited by Andrew T. Wilson, 64-82. Warsaw: De Gruyter Open.

Oselini, V. 2020. "Defining the MB-LB Transition in Northern Mesopotamia: Some Archaeological Considerations on the New Data from the Erbil Plain and Neighbouring Regions." In *From the Prehistory of Upper Mesopotamia to the Bronze and Iron Age Societies of the Levant. Proceedings of the 5th "Broadening Horizons" Conference (Udine 5-8 June 2017), Vol. 3,* edited by Costanza Coppini and Francesca Simi, 206-220. Trieste: EUT.

Pescarin, S. 2006. "Open Source in archeologia. Nuove prospettive per la ricerca." In *Archeologia e Calcolatori*, 17, 137-155.

Peyronel, L. and Vacca. A. 2015. "Northern Ubaid and Late Chalcolithic 1-3 Periods in the Erbil Plain. New Insights from Recent Researches at Helawa, Iraqi Kurdistan." In *Origini,* 37, 89-127.

Peyronel, L., D. Bursich, and G. Di Giacomo. 2016. "QuantumGis per la gestione dei dati della survey 2013 a Helawa nella piana di Ebil, Kurdistan, Iraq." In *Archeologia e Calcolatori,* Supplemento 8, 88-96.

Peyronel, L, A. Vacca, and G. Zenoni. 2016. "Helawa: A New Northern Ubaid/Late Chalcolithic Site in the Erbil Plain." In *The Archaeology of the Kurdistan Region of Iraq and Adjacent Regions,* edited by Kostantinos Kopanias and John MacGinnis, 309-321. Oxford: Archaeopress.

Peyronel, L., C. Minniti, D. Moscone, Y. Naime, V. Oselini, R. Perego, and A. Vacca. 2019. "The Italian Archaeological Expedition in the Erbil Plain, Kurdistan Region of Iraq. Preliminary Report on the 2016-2018 Excavations at Helawa". In *Mesopotamia,* 54: 1-104.

Peyronel, L. and A. Vacca. 2020. "The Italian Archaeological Project in the Erbil Plain (2013-2017)". In *Proceedings of the 11th International Congress on the Archaeology of the Ancient Near East: 03-07 April 2018, Munich. Vol. 2. Field Reports, Islamic Archaeology,* edited by Adelheid Otto, 317-330, Wiesbaden: Harrassowitz Verlag.

Scianna, A. and B. Villa. 2011. "GIS applications in Archaeology." In *Archeologia e Calcolatori,* 22: 337-363.

Ur, J., N. Babakr, R. Palermo, P. Creamer, M.N. Soroush, S. Ramand, and K. Nováček. 2021. "The Erbil Plain Archaeological Survey: Preliminary Results, 2012–2020". In *IRAQ,* 83: 1-39.

Vacca, A, D. Moscone, and P. Rosati. 2020. "Mapping Survey Data from Helawa, Erbil Plain (Kurdistan Region of Iraq)". In *From the Prehistory of Upper Mesopotamia to the Bronze and Iron Age Societies of the Levant. Proceedings of the 5th "Broadening Horizons" Conference (Udine 5-8 June 2017), Vol. 1,* edited by Marco Iamoni, 107- 124. Trieste: EUT.

Zebari, M., C. Grutzner, P. Navabpour, and K. Ustaszewski. 2019. "Relative timing of uplift along the Zagros Mountain front flexure (Kurdistan Region of Iraq): constrained by geomorphic indices and landscape evolution modelling". in *Solid Earth*, 10: 663–682. DOI: 10.5194/se-10-663-2019