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An Integrated Workflow for Dealing with Prehistoric Landscapes: Reconstructing Structures, Relationships, and Places

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An Integrated Workflow for Dealing with Prehistoric Landscapes: Reconstructing Structures, Relationships, and Places

Since uncertainty is part and parcel of archaeology, using the scientific method to reconstruct historical processes is an absolute priority. This is even truer for prehistoric contexts, where human traces on the territory are ephemeral and less invasive. Working on prehistoric landscapes presents the researcher with complex methodological issues that must be dealt with. GIS technology is a leading method of highlighting the elements that condition settlement choices; it clarifies the interaction among different types of sources and increases their informative potential. This contribution describes the methodological workflow we applied to deal with such issues through a case study of settlement strategies during the Bronze Age in Tuscany, Italy.

Ancient landscapes; computer applications in archaeology; GIS; Bronze Age; prehistoric archaeology; settlement strategies.

1 Introduction

This contribution describes the methodological workflow we applied to a case study of settlement strategies during the Bronze Age in Tuscany. Since a degree of uncertainty is inherent in all archaeological reconstructions, the scientific method should take priority when reconstructing a historical process. This is even truer in prehistoric contexts, where human traces on the territory are usually ephemeral and less invasive. Working on prehistoric landscapes presents several objective difficulties and forces the researcher to face complex methodological questions. A correct methodological approach should overcome the antinomy between determinism and relativism, striving for scientific objectivity without losing sight of the cultural, symbolic, and ideological variables that contribute to landscape formation. This makes setting up a suitable methodology not only a starting point but also a goal for any study in the field of landscape archaeology.

2 A complex case study: Investigating settlement strategies during the Bronze Age in Tuscany

The case study we present in this paper describes the research process for investigating the dynamics of the prehistoric population during the Bronze Age in Tuscany. A large number of archaeological investigations have sought to understand settlement strategies in central Italy, a pivotal region between northern European and Mediterranean cultures. We can outline current theories about this topic as follows:

- At the beginning of the Middle Bronze Age, the distribution of settlements in central Italy showed a clear preference for morphological highs, both for defensive purposes and for the strategic control of natural resources and pathways.[1]

- Long-term settlement continuity and expansion of strategic sites occurred in tandem with settlement abandonment of nonstrategic sites: this process of "settlement selection and concentration"[2] led to the growth of proto-urban centres during the Iron Age.[3]

- Caves and rock shelters were only used as temporary refuges, in connection with pastoral activities like seasonal transhumance.[4]

- There was consistent and dense occupation of coastal and internal wetlands throughout the Bronze Age.[5]

- A dynamic agro-pastoral system developed progressively, with a consequent need for exploitable territories.[6]

The wide chronological and geographical framework of our research necessitated a rather large number of both general purposes and specific objectives.

One of the main general purposes was the synchronic analysis of the settlements network in Tuscany during the different phases of the Bronze Age, in order to understand the effects of human action on the landscape. Another general aim was the diachronic analysis of settlement strategies in relation to geomorphology and natural resources, so as to identify those elements that may have conditioned the continuity and/or change in settlements through time. For the historical reconstruction, we wanted to test current theories regarding settlement strategies during the Bronze Age in central Italy and uncover possible discrepancies or confirmations by using an updated data set and new tools and methods. With regards to the specific objectives, we first aimed to create thematic cartography for Tuscan settlement network during the different phases of the Bronze Age; this step was also necessary for the identification of possible biases that could have influenced the distribution of archaeological sites. We then sought to investigate the synchronic and diachronic location of different typologies of sites (settlements, funerary sites, manufacturing sites) and identify their relationship with natural resources (water, good soils, metals), not only in terms of exploitation but also in terms of control and management. Our broad aim was to correlate settlement continuity of occupation with strategic control of natural resources and exchange paths and/or accessibility to these. Our emphasis on material culture (ceramics and/or metals) was intended to detect possible associations between settlements and funerary sites, manufacturing sites, ritual sites, and metal hoards; this focus was also fundamental in investigating mobility and cultural exchanges between different cultural groups (with a special focus on northern Tuscany and neighbouring regions). Our last specific objective was the in-depth investigation of some case studies at an intra-site scale of analysis, in order to collect detailed and concrete data on the settlement strategies eventually identified at a regional and subregional scale of analysis.

1 Di Gennaro 2006; Pacciarelli 2009.
2 Di Gennaro 2006.
3 Pacciarelli 2009.
4 Cocchi Genick 1996; Maggi, Nisbet, and Barker 1991.
5 See, e. g., Pacciarelli 2009.
6 Pacciarelli 2009; Maggi, Nisbet, and Barker 1991.

3 Methodological, practical, and 'ethical' issues in dealing with ancient landscapes

The definition of archaeology as buried patrimony refers not only to individual archaeological sites, but also to the settlement networks to which they belonged. In order to reconstruct the historical and cultural evolution of a territory, researchers need to uncover these hidden relationships: they are among the main methodological issues in dealing with ancient landscapes. It is necessary to think of the formation of a landscape as the result of different kinds of both conscious and nonconscious choices, both rational and nonrational; for this reason, the idea of presenting schematic and universally valid models is, to say the least, a naïve conviction. Admittedly, some essential prerequisites condition the choice to occupy an area and the evolution of that area.[7] Basic examples are the availability of natural resources (especially water) and access to mobility networks. Adopting suitable methods to detect these prerequisites and their relationship with the social, political, economic, and even spiritual geography of a territory is ultimately one of the main goals of any landscape archaeology project.

This general consideration aside, there are several other practical matters to deal with: first of all, the discrepancies between the landscape as it is now and as it once was, both in relation to environmental changes and, therefore, in terms of landscape perception. Such discrepancies are extremely complex for the prehistoric period and must not be ignored, however complex it may be to overcome them. Another difficulty in dealing with prehistoric landscapes is the complex concept of 'simultaneousness' in prehistory. Beyond the actual difficulty of integrating results from different dating methods into a single chronology (either relative or absolute), there is a strong absolute temporal dilation that characterizes different periods in prehistory.[8] This means, for example, that a map of Early Bronze Age sites could actually show sites that never really coexisted and could have been occupied by communities from different generations, well separated in time. The only way to solve this question is to work hard on the archaeological data, in an attempt to link stratigraphy and scientific dating methods where possible and to build strong chronotypological sets, especially for those periods lacking diagnostic finds. A further, troublesome problem is linked to the heterogeneity of the archaeological sources, in terms of either their spatial distribution or the different ways of investigating and discovering the sites. In this case, the only solution is to check the consistency and validity of the archaeological data set to identify biases in its composition, as well as to highlight the different characteristics of each site (in terms of investigation methodologies, means of discovery, positioning accuracy, etc.), ideally creating homogeneous subsets of data to work with.

3.1 The importance of remaining unbiased

The issue of heterogeneity in archaeological site distributions is tightly linked to that of the bias elements affecting archaeological data. Current theories and best practices about biases in Mediterranean archaeology have been extensively debated in the last decade.[9] Identifying and, where possible, quantifying and correcting biases in archaeological distributions is accepted as an absolute priority when working on ancient landscapes through field survey. Nevertheless, it is still necessary to develop suitable methods for quantifying and correcting biases in data sets that come from published data arising from earlier

7 Macchi Janica 2001.
8 Pizziolo, Sarti, and Volante 2009.
9 See Van Leusen, Pizziolo, and Sarti 2011.

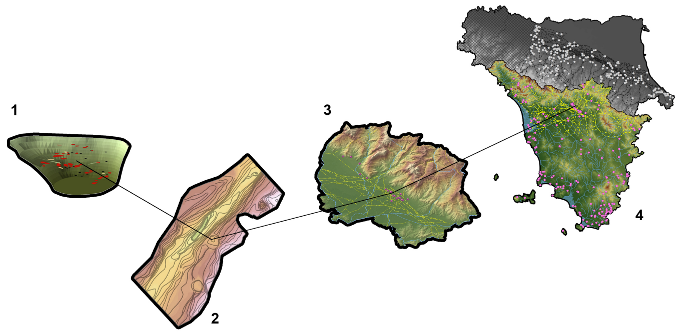

Fig. 1 | Multi-scale analysis for the case study of Bronze Age Tuscany: from the single structure (1) to the archaeological site (2), up to the subregional (3) and regional context (4).

surveys.[10] Taking as a starting point the guidelines emerging from the recent proceedings of the Hidden Landscape in Mediterranean Europe conference[11] and from other significant practices,[12] it is possible to categorize the potential biases in archaeological site distribution into three main categories: history of research, archaeological visibility, and incorrect data interpretation. In our own case study of Bronze Age Tuscany, we checked the initial data set for several biases affecting archaeological visibility, such as land cover and post-depositional factors (in particular, alluvial accumulation and erosion), after highlighting discrepancies between high-density and low-density areas resulting from the area's research history. We then identified particular categories of data whose statistic incidence could have produced an incorrect interpretation of settlement strategies during the Bronze Age.[13] The correct reading of high-density and low-density areas has been of a fundamental importance for every subsequent step of the research.

4 General methods, specific tools, and accurate procedures: Modelling the workflow

Considering the general methodological issues discussed above and the specific case study of Bronze Age Tuscany, which provides a wide and diversified chronological and territorial context, we used a multi-source and multi-scale methodology to carry out our research. This approach is based on a bi-univocal interaction between analysis done on a reduced scale (regional or subregional) and analysis done on a more detailed scale, up to the intra-site level (Fig. 1).

This dialogue and interaction among different kinds of sources, allows the largest possible amount of information to be obtained concerning a particular area.[14] Starting from a more general analysis and reaching a detailed point of view, and vice versa, one can supply a landscape with a component of concreteness, which helps in its interpretation. On this specific case study, this kind of approach allowed us to highlight particular elements that told the story of a complex landscape and a particular time period, featuring cultural exchanges, communication between communities, and definition of pertinent

10 Morabito 2013.
11 Van Leusen, Pizziolo, and Sarti 2011.
12 For a synthetic review, see Bintliff 2011; Van Leusen 2002.
13 This is, for example, the case of metal hoards, which during the Early Bronze Age represent almost 40% of all the sites located on morphological highs. Other examples are Middle Bronze Age-Stage 3 and Late Bronze Age sites, highly under-represented because of an admitted difficulty in identifying finds that were not strictly diagnostic (Morabito and Giovanna 2012).
14 Pizziolo, Sarti, and Volante 2009.

areas, issues which could not be ignored.[15] In order to manage the huge amount of data and to shift quickly between different scales of analysis, a computer science-linked approach was deemed the best solution to reconstruct the Tuscan landscape during the Bronze Age. The main computer science resources used in our reconstruction of the ancient landscape comprise:

- Data Base Management Systems (DBMS): an alphanumeric relational database was used to record archaeological sites in order to simplify the cross-checking of data through ad hoc queries. In addition to the standard information fields (site typology, position, geomorphological context, chronology, description, and others), we set up special fields, such as positioning accuracy and times and methods of discovery and investigation, which proved very useful when checking the effective utility of some data for the different kinds of subsequent analysis.
- Computer Aided Design technology: CAD software is of primary importance for intra-site analysis, mainly because of its three-dimensional rendering ability. The analysis of the elevations of artefacts, structures, and their spatial relationship with base morphologies is an essential tool for checking site stratigraphy and micromorphology.
- Geographic Information System technology represents the final computer science support in our workflow. The development and use of GIS in both landscape archaeology and intra-site analysis not only simplified the comparison and interaction among different kind of sources, but also significantly increased their informative potential by their greater interconnections, thanks to the layered structure of the technology and its ability to overlay the information levels topologically. The choice of this approach partially influenced the sequence of the general workflow and the tools used in each stage. The working stages were as follows:
- Design and construction of a relational database for the recording of archaeological sites
- Collection and review of the available archaeological data
- Establishment of a suitable cartographic basis
- Acquisition (and re-elaboration, when necessary) of a good digital elevation model
- Design and construction of a GIS platform for the analysis of the data collected
- Geo-referencing of information on the GIS platform
- Classification of archaeological sites on a functional, locational, and chronological basis
- Identification of physiographic units, in order to make the heterogeneity and the extension of the study area more manageable[16]

15 Morabito and Giovanna 2012.

16 The identification of subregional physiographic units is initially based on the principles of physical geography, starting with the definition of the main river basins, but aims at a better understanding of human geography. River valleys are, in fact, not only a natural means of communication and cultural exchange, but also possible basins of different human communities. Once the main basins were identified and compared to topography and archaeological data, 11 physiographic units were mapped. After this detailed subdivision, an accurate reading of the archaeological data led us to outline two macro-physiographic units, almost perfectly corresponding to the macro-basins of the two main Tuscan rivers, the Arno and the Ombrone. These two macro-physiographic areas of southern and northern Tuscany

- Identification of eventual bias elements in the archaeological distribution (comparison with history of research, geology, land use, and soil erosion reclassified in terms of visibility)
- Spatial analysis of the relationship between archaeological sites' distribution and geographical variables
- Spatial analysis of the relationship between archaeological sites' distribution and water or mineralogical resources
- Spatial analysis of the relationship between archaeological sites' distribution and mobility paths
- Statistical analysis aimed at identifying specific trends in locational choices
- Visual analysis in a CAD environment and spatial analysis in a GIS environment in case of intra-site zooms
- Data processing and creation of settlement strategy models, both synchronically and diachronically
- Data restitution through a specific cartographic corpus

The integration of different tools borrowed from computer science and statistics, the generation of unbiased data sets, the individuation of essential geographical and topographical attractors in settlements choices, and an eye toward the social, political, economic, and symbolic dimension of proto-historic communities: this was our main theoretical and methodological framework, so that we could avoid mere geographical determinism without falling into total relativism.

5 Does the workflow work? Recomposing data, outcomes, and perspectives for a complex case study

We have already highlighted the objective difficulties we encountered in dealing with prehistoric landscapes during the development of the research presented here as a case study. The main issue was the irregular and biased distribution of the archaeological data sources, in terms of both data consistency and the availability of publications.

The main methodological means of facing this bias was to develop a multi-source and multi-scale approach. The starting point of the research was the preliminary quantification and regional scale analysis (scale 1:1,250,000) which allowed us to highlight some issues that were examined in depth at a later stage, at other scales of analysis and/or with specific methods.

The opposition between low-density and high-density areas in the archaeological distribution forced us to consider possible bias elements in the initial data set. Modelling and interpreting the different kinds of biases (scale 1:1,250,000) concretely helped in reading the different densities in the archaeological distribution correctly and avoiding errors in their interpretation. Similarly, modelling the available paleo-environmental data (scale 1:1,250,000 to 1:25,000) and extending the model to those areas with no specific studies in this field was of primary importance for a correct reading of the archaeological distribution, especially in relation to water and coastal resources. This was possible

correspond to different macro-cultural areas, characterized during the entire Bronze Age by distinct material cultures and settlement strategies. These two macro-areas intersect in a very well-known ritual area, the Cetona Mountain, which is also a cultural link between them, as clearly shown from the material culture (Morabito and Giovanna 2012).

thanks to the in-depth analysis at subregional scale (scale 1:500,000 to 1:250,000) and at physiographic unit scale (scale 1:350,000 to 1:250,000). The importance of water resources has also been analysed from the point of view of the possibility of using river valleys as natural communication paths. An in-depth analysis of this perspective was presented for the case study part of our research project of the cultural relationship between the Italian regions of Tuscany and Emilia Romagna (scale 1:750,000). The application of innovative models in Italian archaeology (such as the MADO model[17]) and the comparison with other reconstruction methods of prehistoric mobility allowed us to generate a contact network between the two cultural groups we analysed. Mobility analysis highlighted how the Florentine plain played a leading role in the process of cultural exchange between Tuscany and Emilia Romagna.[18] Moreover, we selected this area as a case study for the intra-site analysis (scale 1:100 to 1:10) because of the peculiarity of this context – an alluvial plain that was a wetland during the Bronze Age – which provided a focal point from different points of view. Coming down to this scale of analysis facilitated a better understanding of the contacts with the Emilia Romagna cultural groups, and especially of the relationship between communities and wetland resources. In the Florentine plain, in fact, research into this natural resource implies the reiteration of the same settlement strategy for centuries during prehistory and beyond.

Another focal point of our research has been the analysis of the motivations for continuity of occupation of particular sites or contexts; since the general presentation of the data set highlighted how the majority of long-term continuity sites were placed in southern Tuscany, we selected this area as a case study at a subregional scale of analysis for this issue (scale 1:500,000). After analysing variables such as the availability of water and mineral resources, an innovative approach to the analysis of site accessibility generated stimulating results from the methodological point of view (the elaboration of "focal mobility networks" and "accessibility signatures"[19]), and a more complete reading of successful settlement strategies.

Beyond enabling us to deal with specific issues, shifting between the regional and the physiographic scale of analysis (scale 1:350,000 to 1:250,000) allowed us to more concretely read the relationship between sites' intrinsic characteristics (typology, chronology, function) and geographical variables. This was achieved by using inferential statistics to test the actual influence of the variables (Fig. 2).

At the end of the process of data analysis and processing, some general trends and patterns in settlement strategies during the Bronze Age in Tuscany emerged. The main focal point was the accurate reading and interpretation of differences and *trait d'union* between southern and northern Tuscany.

One of the main differences is the nature of long-term continuity in the occupation of sites and particular areas. In southern Tuscany, long-term continuity is mainly linked to high morphological position and defensive potential. In northern Tuscany, continuity means reiterated but not constant (possibly seasonal) occupation of areas with particular geographical and locational characteristics, as in the case of the Florentine plain or the caves and rock shelters used as refuges in connection with pastoral activities like seasonal transhumance.

Another pronounced difference between southern and northern Tuscany is linked to the impossibility of applying to northern Tuscany the traditional patterns elucidated for central Italy in the literature. These patterns are, on the other hand, partially confirmed for southern Tuscany: from the latest phases of the Early Bronze Age, this macro Tuscany unit shows a stabilization of the relationship between settlements and territory, understood as

17 See Morabito 2013.
18 Morabito 2015.
19 See Morabito 2013.

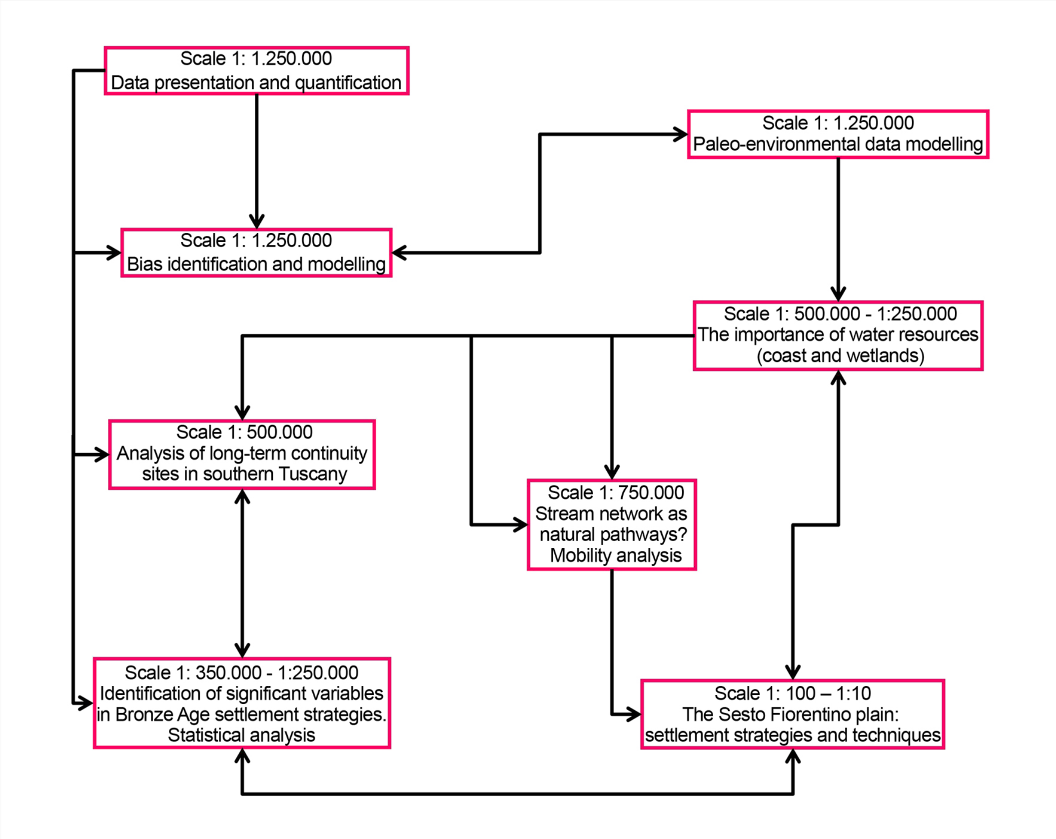

Fig. 2 | Interaction among different kinds and scales of analysis.

the beginning of a long-term occupation of suitable sites, not only in connection with the exploitation of natural resources, but also with strategic and tactical needs. This is clearly suggested by the number of settlements created at morphological high spots with high defensive potential, coinciding exactly with the latest phases of the Early Bronze Age. This pattern becomes canonical for the subsequent phases of the Bronze Age in southern Tuscany. One innovative outcome of the present research has been the impossibility of confirming another pattern for this area, one specified in the archaeological literature: the process of the selection and concentration of settlements, which basically consists of the expansion of strategic sites and the abandonment of nonstrategic sites during the last phases of the Bronze Age, with a consequent decrease in the number of sites.

This particular process is not clearly readable from the results of our research, since during the Late Bronze Age the number of southern Tuscany sites actually increased.

Beyond the differences between southern and northern Tuscany, an important *trait d'union* is the progressively more organized and intensive exploitation of natural resources, with a particular focus on wetlands and metallurgical resources.

6 Final remarks

While we consider the multi-source and multi-scale approach the strongest point of the workflow, the computer science approach to managing the huge amount of data and information has undoubtedly been another significant outcome of this study. The opportunity to recompose the data into a GIS platform allowed us to generate a holistic and hyper-informative environment that became the basis for our complex analysis of the multifaceted Tuscan territory during the Bronze Age. In particular, the option of creating

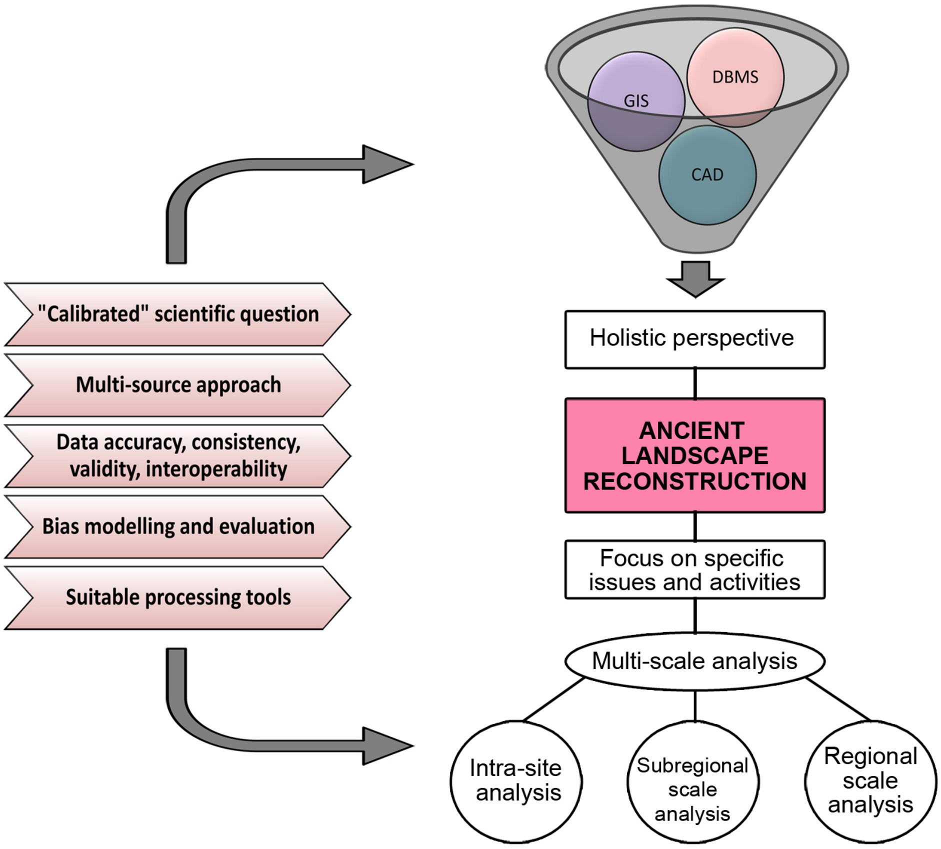

Fig. 3 | Interaction among different kinds and scales of analysis.

a large number of both synchronic and diachronic thematic maps was in itself a goal we achieved, as well as the basis for further spatial analysis.

Summing up the complex set of methodological and practical issues that emerged during the development of our workflow for dealing with prehistoric landscapes, it is possible to say that the reasoned use of computer science and especially GIS can enable archaeologists to obtain both a holistic perspective on ancient landscapes and to focus on specific issues and activities connected to ancient landscapes. This is made possible mainly by GIS's potential to manage a large number of different kinds of sources, both archaeological and geographical (broadly defined), and to perform multi-scale analyses. The availability and accuracy of the initial data set, the evaluation of bias elements, and the inclusion of appropriate functions and geo-processing tools will determine the outcome of the research, and may even lead us to reconsider the initial research question (Fig. 3).

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