Scaling and Timing the Past for the Reconstruction of Ancient Landscape

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Abstract. Any process of reconstruction of ancient landscape should consider with the greatest attention parameter of scale and time. In this paper we discuss about interaction between GIS technologies, landscape reconstruction and photorealistic visualization with a systematic control of accuracy and reliability for all information. The application of the research in the region of Modena (Northern Italy) proposes a simulated reconstruction of Bronze Age settlement pattern with the possibility to navigate through the ancient landscape and an increasing cognitive capacity for a feedback process, keeping active the interaction between GIS and environmental information.
Keywords: GIS, VNS, ancient landscape, Modena, Bronze Age

1. Introduction

The aim of this paper is to debate theory, methodology and tools for the evaluation and control of scale and time factors in the analysis of ancient landscape.
The archaeological process for the reconstruction of ancient landscape is actually based on GIS technologies. Several steps take part in the scientific process, including data acquisition, GIS analysis, simulating processes and virtual re-constructions. All these steps need to be explicated and declared through methods of processing and selecting data. Particularly in the evaluation of collected records we need to stress accuracy and reliability levels and we need to filter information and to translate them for GIS application.
This process risks to be invalidated if not supported by a strong control of time and scale parameters for each selected feature. Moreover only a feed back mechanism between GIS and simulating process can identify these scientific parameters.
Although we have not yet reached true innovations in this field, we intend to attract the attention on the topics of extension and chronology in connection with the capacity in reading, coding and interpreting data (McGlade, van der Leeuw 1997).

2. Theoretical Framework

To outline a scientific cognitive process for this research we use a combination of scientific approach and empirical methodology.
In our research we share with cognitive archaeology, the exchange from ideal model to real one and vice versa (Zubrow 1994, p. 108). The aim of each archaeologist, besides collecting records, is the extraction of cultural ideals from the complicated reality of material remains. Especially the reconstruction of ancient landscape is the result of continuous compromises between ideal and real models. During the process we can highlight following steps:

1. to organize data collected from survey, excavation and other sources with the aim to reconstruct real ancient settlement patterns
2. to structure the framework of GIS to store large amounts of data to define scale ranges for a validating reconstruction and to create representations that have visual forms.
3. to identify, but even simply to understand, limits, boundaries, how these were determined by resources exploitation or by peculiar symbolic elements or from hypothetical systems of information exchange.
4. to develop ideal models of settlement patterns that correspond to those on mind of ancients communities.
5. to apply several methods in simulating reconstruction at different scale as interpretive step with behavioural and geographic algorithms for a feed back process and for relating and adjusting the ideal to the real models.
6. to control variations through time for a long term interpretation.

3. The Application Case

The application case has multiple scales of investigation. It regards mainly the area west of Bologna (northern Italy) between Reno river on the eastern side and Panaro river as western limit.
In a wider perspective we deal with a full regional evaluation of the entire Po plain. In a more detailed investigation this area is restricted to the territory between Samoggia and Panaro rivers, that is mainly the area of the project of the Archaeological Map of Modena, started twenty years ago with fieldwork and digital archaeological maps (Cattani 1997, Cardarelli, Cattani 2000). The high amount of records collected allows to test the use of GIS for a simulating process of reconstruction of ancient landscape.
For the restricted area we will propose here a detailed reconstruction of Bronze Age settlement pattern with the evaluation of hierarchical position, soil exploitation and suitability, demography. In this reconstruction each step of scientific process was discussed and subordinated to declared parameters.

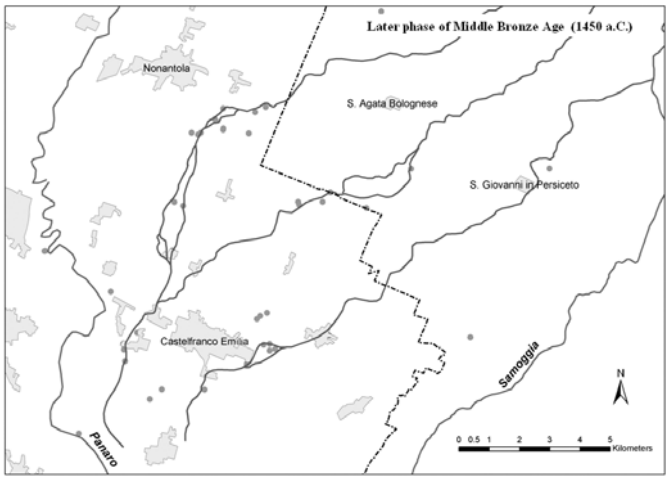

Fig. 1. Map of research area with main modern town, boundary lines between Modena province (west) and Bologna province (east), actual rivers (Panaro, Samoggia), Bronze Age sites and reconstructed ancient river beds.

4. Scale and Time

Starting from the assumption that space is not static, but a place with dynamic relations, it is essential that we proceed to define the scale of cultural process with two different research categories

In a macronalytical dimension, we consider a "Regional Extent", with large scale reproduction of several regional processes. It is a mosaic of simultaneous presence of territorial and social features: geomorfological, pedological and climatic conditions directed ancient populations to face and organize the landscape.

In a microanalytical dimension, we consider relations between ancient community and territory in a localized context. It is necessary to examine relations between single villages and landscape in a dynamic and historically very defined context, to understand the options and ways of territorial setting of a social group and to understand how landscape took shape.

The landscape is a product of a complex cultural process with symbolic aspects linked to ecological, technical and social framework (Lai 2000, Turri 2004) and we are aware that there is a direct relationship between social transformations and the use of land. Another assumption is that each socio – economic system tends to organize the exchange with natural environment, through the control and exploitation of resources, but it is only the belonging to a community to guarantee the access to these resources.

It is therefore true that from archaeological data we can define the relation systems of each social group as actors. From this point of view, space is the representation of social organization.

Ancients represent knowledge according a set of cultural norms and process information according to a set of cultural rules (Renfrew, Zubrow 1994). Similarly archaeologists manage knowledge and information, but with different rules. In particular we can resume the research according two main directions:

1. carrying capacity and site catchment
2. decisions and preferences independent from economic necessity or utility

On the first research line we must analyze features and characteristics of ancient landscape.

Following the other direction we have to recognize parameters and options that could have changed the adaptations or configuration of the ancient behaviour.

When we consider what elements took part in structuring the social space, we must include space and time: in the application case the extension of the region is 20 x 20 km during a period around 1450 BC for an approximate span of one hundred years (+/- 50).

Other elements that participated in structuring the social space were:

- relations between settlement and environment: it is necessary to establish ancient natural characters to reconstruct ancient landscape. The natural characters are available from a detailed analysis of palaeobotanic investigation, archaeozoology, and geomorphology;
- the analysis of good exchange: a variable is the identification of produced goods and what exchange could determine relations (kinship or neighbouring relations). In the application case we assume that we are evaluating a tribal organization with few evidences of chiefdom.
- relations of communication: it is necessary to fix on the terrain the possible intercommunication between different communities, evaluating cost distances and resources availability.

In the evaluation of scale and time we deepen into three main categories:

1. Environmental Archaeology (Cardarelli, Cattani 2004)
   For a scale factor environmental adaptations or configuring landscape, followed precise behavioural choices, while for time factor we must consider the fluctuations of river courses (Brown 1977), land exploitation and microclimatic changes
2. Demographic dynamics (Cremonini 1986, Cardarelli 1988). Demographic density, according parameters based on size settlement and carrying capacities and models of distribution of ancient settlements, including hierarchy and typology of sites
3. Local environmental parameters, usually definite. Cases of constraint settlements and relationships with river courses can simulate hypothetical periods of drought or of floods.

In the application case, we are going into the testing the analysis of collected data with two different tools: the production of high quality photorealistic reconstruction of ancient landscape through the combinated use of ArcGIS and VNS (Visual Nature Studio), a software for 3D landscape visualization. Next step will be the attempt to use simulation software developed on case base reasoning or agent-based social simulations.

First step in the reconstruction of ancient landscape is to determine ancient morphologies of land surfaces. By approximation we must use significant information dating to generic Bronze Age, selecting those belonging to ancient river ridges height, alluvial deposit thickness, depth of archaeological evidence.

The actual DTM is the starting point from which we must subtract all previous collected information, to obtain a series of data and simulate morphology of Bronze Age DTM. It is obvious, but however remarkable to follow and declare levels of reliability and resolution, both for the archaeological and geometrical point of view.

The archaeological process to determine through the use of GIS, the Bronze Age digital terrain model, starts from the actual DTM, built on actual elevation points and proceeds with the selection of all information regarding the considered period with a simple query for Chronology = "Bronze Age". With the use of GIS we go further in other queries:

- Select by location: in the GIS layer "river beds" we subtract the value of river ridges height; in the GIS layer "alluvial deposit zones" we subtract the value of alluvial deposit thickness. Select by attributes: in the GIS layer "cores and drillings" we subtract the value of ancient surface depth.
- Selection of Surface archaeological evidences in the GIS layer sites with depth = "0".

In this way we obtain a series of ancient surface elevation points and we can built a predicted Bronze Age DTM as final result.

The second variable for the reconstruction of ancient landscape is the location of river courses, dating to Bronze Age: in this case crossing data based on aerial photographs with evidences of ancient river beds, terrain survey, collection of associated finds dating to Bronze Age and above all, stratigraphic trenches and excavations, will allow to select segments of ancient river course, very far and different from actual Panaro and Samoggia river. Upon these segments we can simulate an ideal model of ancient courses and create buffers for flooding area. In this case very few data available did not allow to use more sophisticated operations to locate exactly which land could be flooded.

For the selection of archaeological evidence, after the analysis of the occurrence of finds (especially pottery and metals) for setting the chronological contemporaneity, we proceed to determine the typology of sites and to establish a hierarchy of settlement.This is based on the distinction of "terramara" settlements corresponding to main sites with size more than 1 ha., characterized by defensive structures (moat and earthwork) and smaller sites corresponding to scatter or isolated small sites (not yet analysed and interpreted in the archaeological literature).

On the selection of all terramara we built the Thiessen polygons and we extract size for each territory. The coincidence of location of most of the sites with rivers allowed to establish a river attraction in the settlement pattern.

For this reason we can exclude that rivers acted as frontier lines for ancient territories.

Following step of data elaboration is the calculation of food production and sustainability for each territory, calculating the allocation in four main categories: arable cultivated land, pasture, forest (wood) and marsh lands. The last was assumed to correspond to the buffer of 100 m along river courses. The arable land was determined by calculation of ratio between supposed population and soil index suitability, assuming for the location minimum distance from the settlement[1].

Parameter of terrain suitability were already applied in a similar landscape in the Po valley, not far from the research area (Cremaschi 1991). Wood lands are assumed to be the most far from the settlements, while pasture lands are assumed to locate in the middle area, between woods and cultivated fields.

The geometrical representation is obviously far from the real model of ancient landscape, but it is a necessary step for an easier calculation of parameters (surface, costs, ecc.). The benefit of this method is a high possibility to change values to suppose different models.

It becomes easier to simulate predictive changes, and to apply Case Based Reasoning (CBR) or Multi Agent Systems (MAS).

One of the best results of GIS application is the identification that minor sites are located exactly at the border between predicted arable land and pasture: in this location they can be configurated as settlements to control breeding activities, without the necessity to refer to the main settlements. Since no one of these minor sites has been investigated it appear now more evident the necessity to continue the research in some of these sites.

The application of virtual reconstruction of ancient landscape can be realized with a high quality of photorealistic reconstruction of ancient landscape through the data collected and

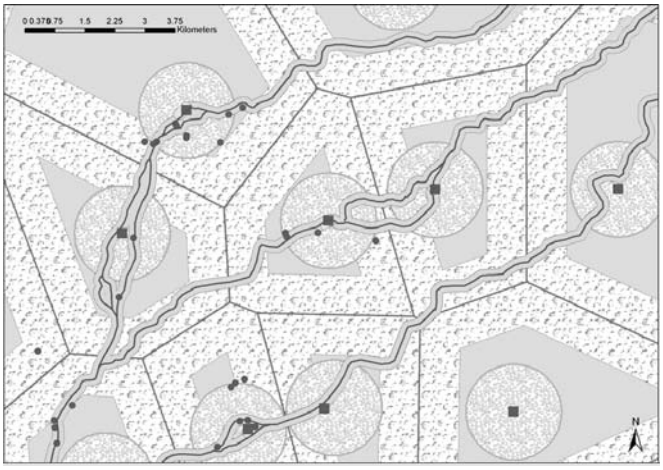

Fig. 2. Example of archaeological sources. Aerial photographs, trench and site excavations (from Bottazzi, Ferrari, Steffè 1995).

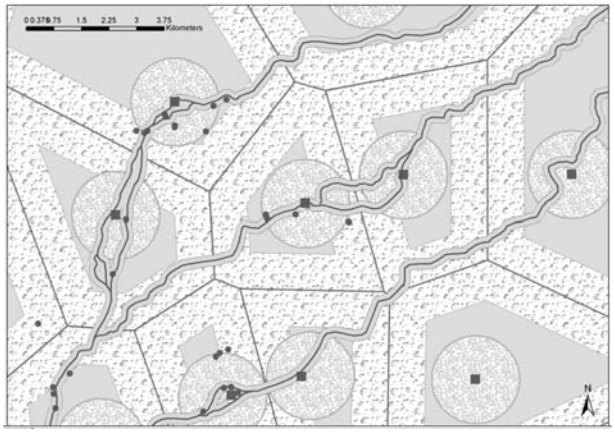

Fig. 3. Gis Analysis of ancient settlement pattern. Squares: ancient villages (terramare); dots: minor sites; circles: cultivated fields; Thiessen polygons inscribed area: wood land; remaining area: pasture land.

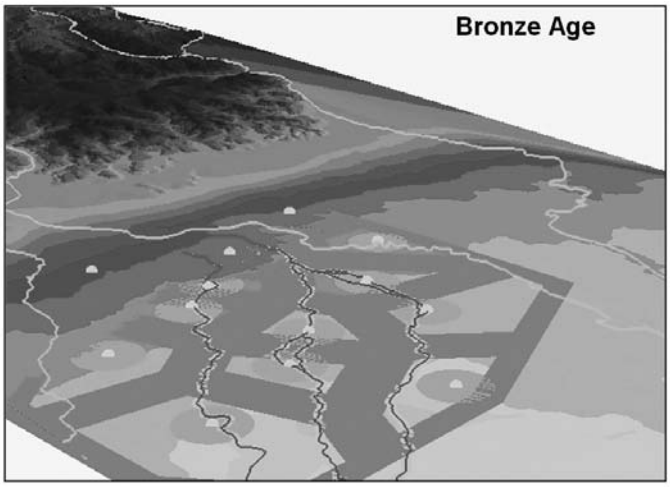

Fig. 4. Reconstruction of ancient landscape with ArcScene.

Fig. 5. Reconstruction of ancient landscape with Visual Nature Studio applying data elaborated in GIS software.

elaborated with ArcGIS moved to VNS (Visual Nature Studio) software. Next step (actually in working progress) is to create a system control for a classification and retrieval of several processes concerning thematic, chronologies, physical and logic topologies of archaeological records[2].

The use of a software for the simulation of ecosystems is noteworthy because of following reasons:

- the methodological approach to spatial analysis: we pass from a qualitative approach toward a quantitative approach;
- creation of 3d terrain models for the geomorphological analysis;
- reconstruction of ecosystemic models in GIS The reconstructed environment is based on natural parameters, available from distribution algorithms.

The results consist of geometrical congruence and assume a cognitive meaning improved by simulating modelling keeping active the interaction with GIS and environmental information. The simulated reconstruction of ecosystem and the possibility to navigate through the ancient landscape increase the cognitive capacity for a feedback process suggesting the following steps for the research and for the validation of the model.

Perception of ancient landscape allows to evaluate more carefully and more consciously details of relationships between man and environment. In the reconstruction of ancient landscape we can propose interpretation of different zones with specific character following hierarchical levels, based on variables, or we can apply random environmental clads. The benefit to proceed with zones consists in the continuous interaction with other disciplines, especially environmental studies, with detailed control of dimensions and characters.

The following step is to consider intervention of cultural factors to determine changes in demography or decision in the exploitation of landscape.

5. Models as Reasoning Tools

The deal is not to reach "the reconstruction" of past landscapes, but to propose simulation models based on scientific explanatory processes in order to understand variations and meanings in environmental and human landscape.

"Nothing should be wrong or "imaginary" in a virtual reconstruction, but should follow what we know be dynamical and be interactively modifiable" wrote and remarked Barceló few years ago (Barceló 2000), but we want to add that elaboration should be:

- with data completely verifiable with all applied parameters declared
- with data based on elaborated geometry and projections, therefore measurable
- with all information about methods, knowledge stage
- with all originary and elaborated information recognisable

We want to note that we cannot use for the representation of landscape reconstruction aerial foto or satellite image, that reflect the current situation and they are very far from ancient landscape (e.g., Landscape reconstructions in Forte 1993; Cremaschi, Ferretti, Forte 1994).

These two types of documents must remain sources, to be analysed and reduced to selected information according definite space and time of investigation subject. In this sense rendering built upon photo are wrong and misleading.

For this reason a GIS elaboration can supply any demand for the research giving all details for measuring, selecting. If we want to go further and enhance cognitive perception of ancient landscape we need to transfer all GIS elaborations to a different specific software that it will build a photorealistic treatment and we will obtain something similar to the aerial photo. The same software needs to maintain the scientific nature of original data and it can add more evaluation of environmental ecosystems of ancient landscape, giving a feed back to the GIS for a new calculation of extension, productivity, land use, compared with demographical data.

Notes

[1] We follow in this case a model established for most of agriculture based settlement known from geographical and historical studies.

[2] All processing with Visual Nature Studio were made by Dr. Marco Gualdrini, Geographica s.r.l., whom we want also to thank for continuous discussion and advices.

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