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Neolithic settlements in the Tavoliere Plain (Apulia, Southern Italy): predictive probability maps

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INTRODUCTION

Predictive models are often based on the extrapolation of geographical patterns and correlations between environmental and human parameters with the main aim being to describe and identify settlement patterns and various usages of the landscape.

Two different approaches can be considered for the implementation of these models: inductive and deductive. The inductive approach is based on the correlation between the location of the known archaeological sites and the attributes connected to the current natural landscape. By contrast, the deductive approach is based on *a priori* knowledge of social aspects (anthropological, historical, archaeological, etc.) and the location of known sites is used to evaluate the model (Kamermans 2006). The prediction of areas with a potential archaeological interest is a kind of investigation debated by several authors. Archaeological predictive maps can be produced correlating different information in GIS environment (Pappu *et al.* 2010) through the application of specific mathematical methods, such as Fuzzy logic (Alexakis *et al.* 2011) or linear logistic models, such as the Classification and Regression Trees (Espa *et al.* 2003).

In order to study the causality between the environment and the history of habitation, it is possible to build models correlating the choice of sites for settlement with a set of independent variables. The variables can be chosen on the basis of features regarding the study area (for instance, altitude in respect to the current sea level, topography of the area, slope orientation (aspect)), but they could also result from spatial analysis in GIS environment regarding, for example, sun exposure, visibility and accessibility (Garcia 2013). The variables can be represented as thematic maps containing environmental information organized in typological classes (geology, geomorphology, soil chemical–mineralogical composition, etc.).

Starting from this articulate background, an inductive predictive model has been implemented for the Tavoliere Plain (Southern Italy) taking into account several environmental features and a set of 120 reference Neolithic sites (mostly dwelling sites) known from archaeological field surveys, geophysical surveys and remote sensing data. This set of reference sites was divided into two groups: 80 were considered for model implementation, the model training step, and the remaining 40 (selected by a regular squared grid) were used to evaluate the archaeological predictive maps, the model validation step (Fig. 1).

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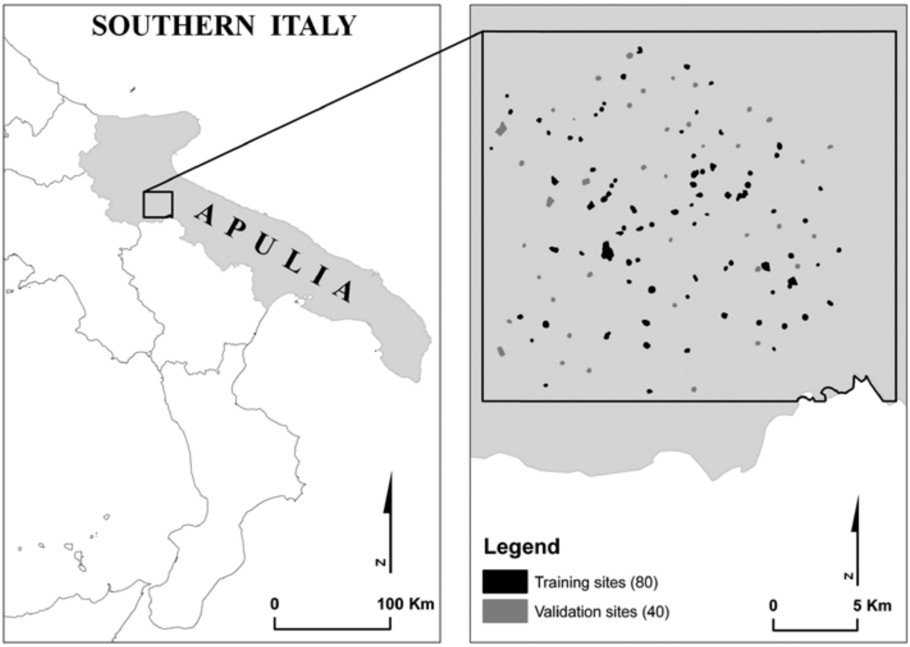

Fig. 1. Study area (left side); location of 120 known reference Neolithic sites (right side)

DATA AND METHODS

The inductive approach entails the choice of specific environmental features to evaluate the most favourable areas for human settlement. The following environmental features were considered:

- topographic characteristics (altitude, slope and aspect; processed from a Digital Terrain Model with a grid step of 8 m and altitude accuracy of 1 m),
- geomorphology (catchment basins, river modeling forms, that is, river bank borders, river erosion banks and quarries; from Apulia Region GIS shape files),
- covering vegetation stress generated by underground ancient remains (six vegetation indices processed from Landsat 8 image, acquisition date 20 June 2013).

Their importance was established by computing appropriate probability weights (PW). On the basis of the PW, an operation of reclassification was applied (after a resampling to make the pixel dimensions uniform for all the images) and the resulting maps became the input parameters of the model. They were organized in three categories: Terrain, Hydro-geomorphology and Vegetation Indices. All categories and relative parameters were multiplied by specific weighting values (respectively, Wcat and Wpar), producing their different significance in the processing of the archaeological predictive map. The set of Wcat for the three categories was defined by two different methods.

1) The arbitrary Weights of Significance (WS) method establishes several triads of numbers on the basis of three criteria: equal significance to each category (e.g., 33/33/33),

medium participation to two categories (e.g., 60/20/20) and very high participation to one category (e.g., 80/10/10).

2) The statistical Analytic Hierarchy Process (AHP) method (Saaty and Peniwati 2013), based on a decisional matrix, results in a priority matrix containing values indicating choice preferences, in this case three numbers (e.g., 73/22/5). These numbers were used as Wcat and were combined in the six possible ways.

The implemented model gives as output an archaeological predictive map (APM) for each iteration. ArcGIS and ERDAS Imagine were employed for the data processing.

The workflow of the training procedure described above, followed by the validation step (next section), is shown in Fig. 2.

RESULTS AND CONCLUSIONS

The analysis for the calculation of the PW enabled also the extraction of statistics for the Neolithic sites in relation to environmental factors. Considering the topography, for example, a large set of the 80 training sites (42.5%) is situated at altitude values included in the 150–200 m range. Slope was reclassified every 2.8° (approximately corresponding to 5% slope) and aspect was reclassified every 45°. As a result, most of the settlements (86.25%) were shown to be located on very flat ground (slope between zero and 2.8 degrees). Moreover, where the slopes are greater than zero (82.5% of the sites occur in zero slope areas), the preferential aspect is towards N-NE-E (11.25%) and N-NW (6.25%).

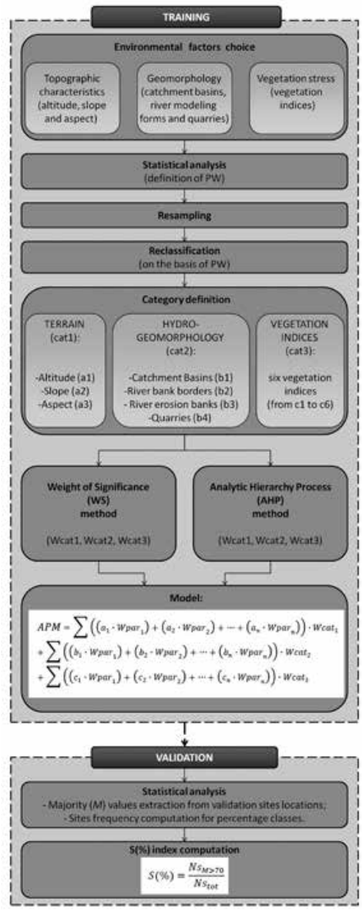

Fig. 2. Workflow of the training and validation procedure

Furthermore, several APM scenarios were processed with different Wcat combinations, giving a different importance to the three environmental categories at each iteration. As a result, different relative probabilities for locating Neolithic settlements were produced. One representative scenario map was chosen for the WS method and one for the AHP method (shown in Fig. 3). These operations were carried out by applying a validation procedure consisting in the computation of the S(%) index. This index gives the percentage number of the validating reference sites corresponding to a predictive probability (pixel values in the predictive maps) higher than 70%, an arbitrary threshold. The best scenario in Fig. 3, with S(%) equal to 63%, shows a high archaeological predictive probability zone in the central area and a gradual decreasing trend toward the top and bottom of the map. The map was obtained assigning the highest Wcat value to the Terrain category.

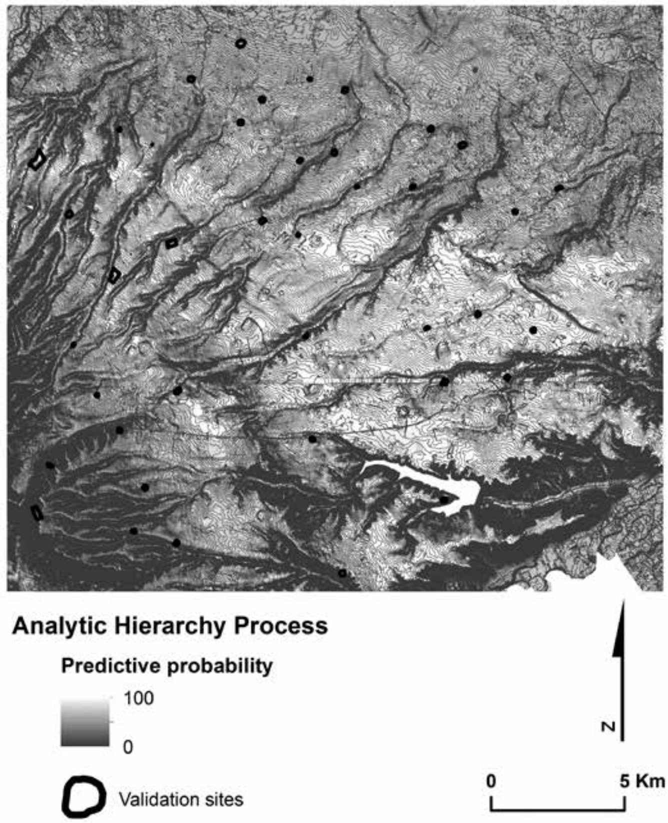

Fig. 3. AHP method (scenario 73/22/5): the resulting best scenario showing the probability of finding a Neolithic archaeological site in the study area

On the basis of the results, the implemented predictive model, combining different types of data in a synoptic investigation, may allow for a good identification of habitation loci during the Neolithic period.

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