

Experimental Land Evaluation in Archaeology: An Application to Model the Accessibility of Nuragic Sites with Mycenaean Materials in Sardinia

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Abstract

In Sardinia Mycenaean pottery has been discovered on 14 sites. Since Mycenaean material could have arrived only by sea, we need to understand the relationship between coastal sites and the sea, the relationship between coastal sites and the inland sites, the potential influence of the Sardinian landscape on the distribution of Mycenaean pottery and the accessibility of the sites where Mycenaean pottery was discovered.

The following analyses were performed and tested with GIS technologies:

- 1) Land evaluation and the creation of a “land units” thematic map for the area around each site (based on geological, pedological and morphometric data), from which an accessibility classification was derived.
- 2) Creation and development of potential distribution roads between coastal and inland sites, developed with Cost Surface Analysis.

The results of the trial will provide a starting point for further research.

Keywords

Land evaluation, accessibility, cost surface analysis, Mycenaean finds, Sardinia

1. Introduction

The goal of this study was to understand the accessibility of Sardinia's sites, where the Mycenaean pottery was found. It aims to be a new step for further research, with the purpose of understanding the dynamics and intercultural process between the East and West Mediterranean in the 2nd millennium BC. This process places the island as the protagonist at the centre of a complicated plot.

Previous studies about Mycenaean pottery in Sardinia¹ have always had the following as their ultimate goals:

- the understanding of the traffic of goods used by tradesmen;
- the nature of trade routes in the Mediterranean in the 2nd millennium BC;
- which people or group of people transported the Mycenaean material, a subject particularly

important after the findings of Nuragic pottery in *Kommós* (Crete) (Watrous 1998, 337–340).

Starting from the observation that the presence of certain Mycenaean materials in Sardinia is a given, and since their origin is exclusively through the sea, we want to carry out an investigation aimed at the evaluation of the land-accessibility of sites, where the Mycenaean material was found.

There are 16 sites (Soro 2009) where the Mycenaean material was found and the questions are:

- What is their relation to their surrounding area and² especially to the sea?
- Since not all of them have a direct relation to the sea, how could they relate to each other in a territorial analysis?

¹ There are many studies about the Mycenaean materials in Sardinia. We highlight the most significant ones in the references section.

² In 14 sites (Nuraghe Antigori, Nuraghe Sa Domo 'e s'orku, Nuraghe Arrubiu, Nuraghe Nastasi, Nuraghe Duos Nuraghes, Nuraghe Is Baccas, Nuraghe Su Nuraxi, Area of Orosei, Tharros, Nora, Sulky, Medau is Lais, Monti Zara, Corti Beccia) were found Mycenaean pottery (imported or local imitated). In the site of San Cosimo fragments of a faience beads necklace were found and in the site of Mitza Purdia an ivory plack with the depiction of the head of a warrior with a boar tusk helmet were found.

- Can the distribution of the material be consequential to the spatial distribution of sites in the area?

The number of sites where Mycenaean materials were found is very small and, as such the number of finds is also limited.

We know that the Sardinian landscape has changed greatly between the Late Iron Age and modern times, however, there are few studies on these environmental changes, especially in relation to cultural adaptation.

Unfortunately there is very little archaeological material, and even less that is discovered in a secure context.

The following study, that is just the beginning of a larger research project, will include the 14 sites where the presence of imported and/or imitated pottery (Vagnetti 1998, 286) was recorded with a good geographic reference, i.e. which will provide the most reliable data, and a convenient link of uniformity of material production.

It will be more difficult to analyse areas where the material comes from sporadic finds or surveys, at which the discoveries were not supported by geographic or instrumental (GPS) mapping³.

Analyses of site accessibility will be carried out in a multidisciplinary way through:

- Land evaluation and creation of land units.
- Creation of a cost-surface analysis (CSA) using the “accessibility classification” developed for the land units.

2. The land evaluation

The application of the “land evaluation” for archaeological purposes was widely discussed at a workshop in Groningen, entitled “Potential Land Evaluation in Archaeology” (Attema 2002, 185–202).

On this occasion we attempted to assess what potential impact the environment had on ancient archaeological sites and their area of influence.

Since the “land evaluation” method was mainly developed with the purpose of understanding the potential of agricultural lands, it follows that its application in archaeology is linked to the understanding and appreciation of agricultural uses of certain areas of archaeological interest, i.e. an assessment of the paleo-agricultural landscape.

Land unit mapping in archaeology can be defined as the synthesis of territorial aspects of the landscape. Moreover, these territorial aspects of the landscape are linked to the location of an archaeological site and to the surrounding land, which influenced the life of the population and that was conditioned by the life of the same site.

The creation of the land units allows us to report an archaeological site and its probable paleo-

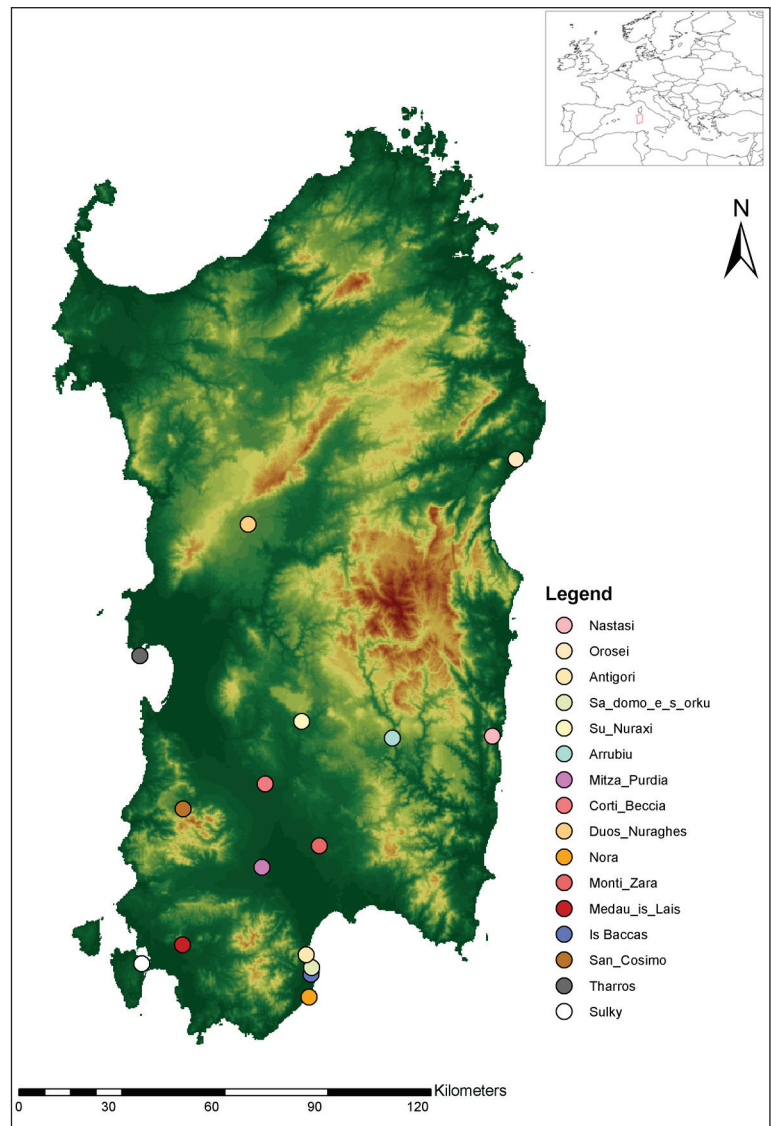


Fig. 1. Mycenaean finds in Sardinia. Distribution map.

³ For this reason, a georeferencing–reliability scale has been created.

landscape, in order to understand which reciprocal influence the landscape and the site share.

Although methods of land evaluation should still be refined, land evaluation presents itself as a flexible system and applicable to a large number of purposes.

This research will apply this experimental land evaluation to the accessibility of previously cited archaeological sites. This is a new approach which, to the best of our knowledge, has never before been used in a Sardinia. The attempt to classify the landscape situation of an archaeological site (based on its accessibility and that of its surrounding landscape, according to the geomorphologic framework) may help us understand the meaning of the site within its territory, and its consequent accessibility.

The potential success of this operation depends on the scale, content and accuracy of cartographic material and also on other available data.

According to the available information, we know that for the period taken into account, in relation to used maps, there were no substantial changes in the selected variables (slope changes for hill or plain sites; coast line variation; climatic variations).

We decided to create an evaluation scale of the accessibility of Land Units, related to the territory (Sardinia) and the period (Middle and Late Bronze Age)⁴.

In order to transform the “land units” map into an “accessibility” map, one should first consider the possible methods of movement and transport used in Sardinia in the Middle and Late Bronze Age.

Based on recent archaeozoological data, the presence of horses and donkeys, although

very sporadic, seems to have started in Sardinia in the first Iron Age (Wilkins 2003, 185–187).

However, during the Bronze Age we can see the importance of cattle as working animals. This tells us that, based on the data we have, the possible transport of the time, was on foot, or with the use of large animals (cattle, for example) either individually, or in conjunction with small wooden carts. It is unlikely without horses that any higher speed transport was possible.

Classes of accessibility	Definition
S1	Easily accessible/practicable on foot, for animals and for draws animals.
S2	Possible to access/practicability with a few difficulties on foot, with animals and with draws animals.
S3	Moderately accessible/ practicable on foot, difficult to access for animals and for draws animals.
S4	Difficult to access/practicability on foot or for animals, very difficult for draws animals.
S5	Almost inaccessible/practicable on foot or for animals, inaccessible for draws animals.
N	Not accessible/practicable with commons steps.

Table 1. Classification of accessibility.

On these assumptions a scale of accessibility was created, which follows the scheme developed by the FAO in 1978 and 1983 and used to determine the suitability of the land. This scheme provides an order S (suitable) and N (unsuitable) and three or more classes that indicate the degree of a particular attitude to the land (1, 2, 3 etc.) (Giordano 1999, 323–326).

The cartographic creation of the land units is the result of the interaction between geological, pedological, and slope data⁵, motivated by the goals

Slope's classes	%	Slope definition	Landscape definition	Accessibility's evaluation
1	0–2 %	Level ground	Level ground	S1
2	2–10 %	Lightly slope	Lightly undulating	S2
3	10–20 %	Sloped	Ondulating	S3
4	20–35 %	Moderately steep	Hill	S4
5	35–50 %	Steep	Steep	S5
6	50–70 %	Very steep	Very steep	N
7	> 70 %	Extremely steep	Extremely steep	S1

Table 2. Suitability to the accessibility of the slope classes.

⁴ We speak of Middle and Late Bronze Age because the Mycenaean material was dated between the LH IIIB and LH IIIC, and because most of the investigated sites are Nuraghi or nuragical contexts.

⁵ Geological map (1:100000) from *Servizio geologico Nazionale*; Slope's map (1:20000) from DEM; Pedological map (1:250000).

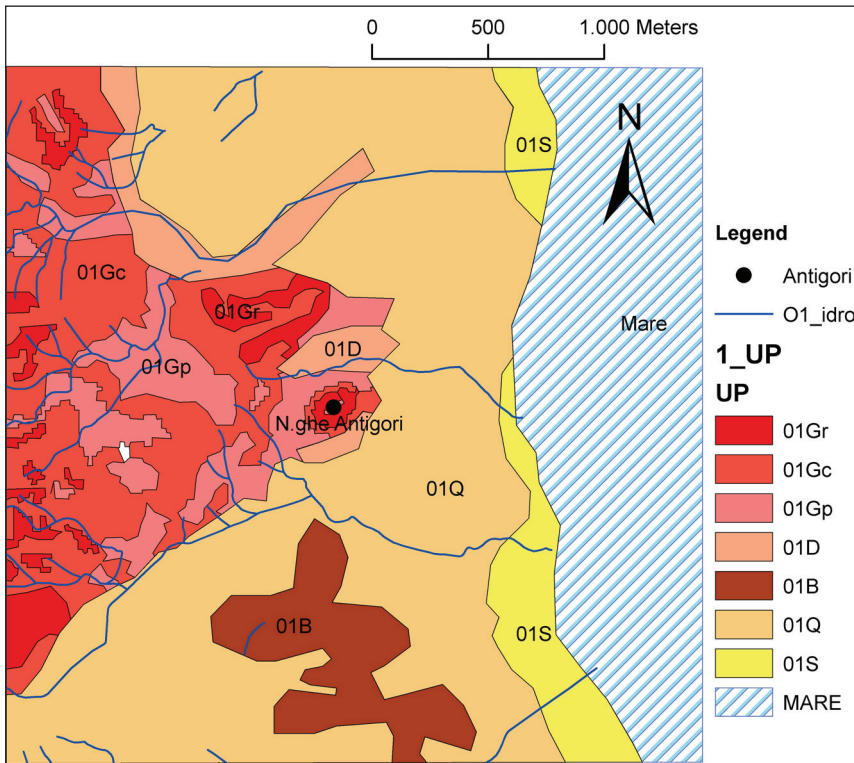


Fig. 2. Example of land unit map. Nuraghe Antigori.

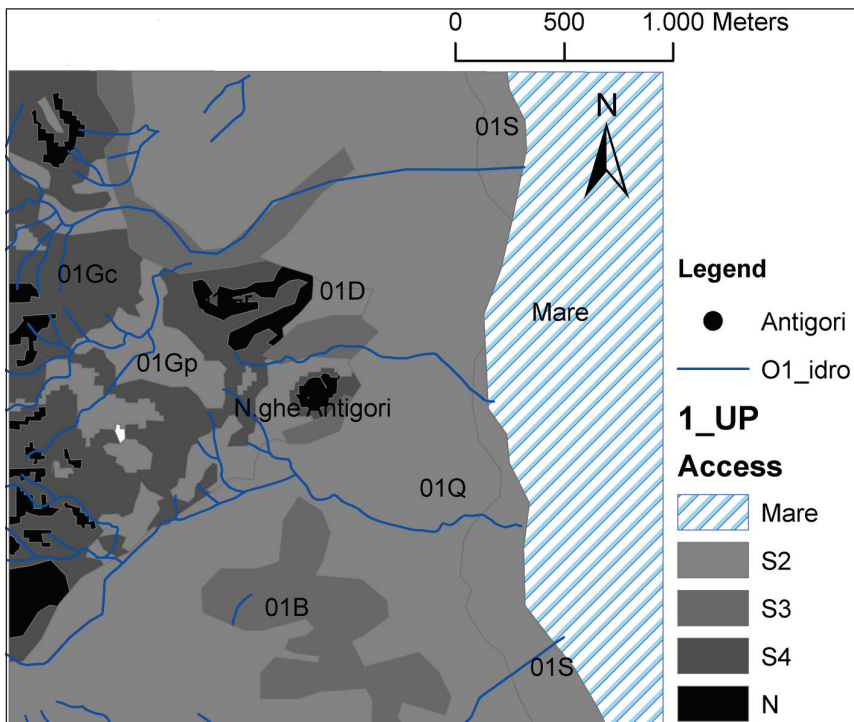


Fig. 3. Example of accessibility map. Nuraghe Antigori.

that we set at the beginning. In order to increase the level of detail it was decided to split each geological unit in sub-units defined on the basis of one or more classes of dominant slope.

For this reason the slope-map was divided into the slope classes commonly used in Italy for the study of physical landscape.

On the basis of the scale of accessibility, if we link a value of suitability for accessibility to each category of slopes, each class will have a degree of practicality.

Finally, the pedological map, available only in 1:250000 scale was used to justify a further grouping of classes of slope within each geological unit.

The obtained land units are the result of the union of the cartographic data.

The classification system was created with flexibility in order to better evaluate the integrated data.

So, every land unit has an absolute value, but must be contextualized with respect to the site and its surrounding area.

The Land Units of the sites taken into consideration and their surrounding area are the result of the integration of map data available, and have a specific class of accessibility (S1, S2...N).

This classification system has allowed us to assess whether and how much the examined sites have common particularities of accessibility.

3. Cost surface analysis (CSA) and creation of a least cost path (LCP)

In order to model the pottery distribution from sites on the coast to those located inland, it was decided to experiment with CSA (Forte 2002, 107; Ejstrud 2005, 135; Van Leusen 2002, 6.4).

This CSA was done on the basis of land evaluation, which could create a potential route of distribution sites along the coast and to some internal sites (least cost path).

It should be stressed that this type of analysis is not designed to create absolute values, or provide truly representative maps of the road network which was possibly used to transport the Mycenaean material.

The process should be treated as an experiment which aims to provide new ideas and targets for future research.

The model remains a model, although it is based on numerical data, or is rather one of the many potential models that can display any Mycenaean material distribution network in the island.

The applied CSA results will be used during the evaluation of the potential viability of the sites considered and their surrounding territories.

For the implementation of the CSA, the *Nuraghe Antigori* as a site along the coast, and the *Nuraghe Arrubiu* and *Su Nuraxi* as internal sites were chosen.

The proposed CSA is limited to a mask and will be the result of a union of main variables, which were used to create the landscape units: the slope and lithopedological characteristics.

It is preferable not to use the same land units as variables, as the territory taken into consideration is too large.

Since the pedological map has fewer details than the geological map, we chose to use the most significant element of the map (the depth of soil) as more relevant to the issue addressed.

The depth of soil reflects aspects of land related to the potential soil trample, to the stoniness of the land and the risk of being bogged. The combination of data of soil depth with the underlying geological formation has produced a new type of experimental mapping.

The creation of the model requires that each variable has a weight and a subsequent numerical evaluation, and consequently, the same accessibility classes will have a numerical classification.

Since the testing of the model is to apply the principles of assessment already implemented in the creation of the landscape, the two variables that will be used are both associated with classes of accessibility (S1, S2...N). In this classification it was chosen to assign a numerical scale of values in which 100 is the maximum and 0 is the minimum value although any linear scale would have given the same results. (Table 3)

In our assessment, we cannot assign the value “0” to any class. In fact the same class “N” does not denote a situation of total inaccessibility, but a situation of non-accessibility with common means⁶.

Within the cost model the two chosen variables will have different weights.

The slope will be the predominant variable because with the simple human means (which is what we take into consideration in this work) it has certainly carried more weight, and it is the variable that had the smallest changes since the Bronze Age.

We were aware of the limits of the operation because CSA is applicable to modern maps. We are not able to reconstruct a reliable DEM which reflects the real landscape situation of the Bronze Age and the resulting map of the slopes. But we know from the bibliography (Ulzega 1988) that Sardinia had a fairly stable geological history during the Holocene. The slope map is a manifestation of the geological

Class of Accessibility	Definition	Numerical value
S1	Easily accessible/practical on foot, for animals and for draws animals.	100
S2	Possible to access/practical with a few difficulties on foot, with animals and with draws animals.	90
S3	Moderately accessible/practical on foot, difficult to access for animals and for draws animals.	70
S4	Difficult to access/practical on foot or for animals, very difficult for draws animals.	50
S5	Almost inaccessible/practical on foot or for animals, inaccessible for draws animals .	30
N	Unaccessible/practical with commons steps.	10

Table 3. Variables classification and numerical evaluation.

⁶ Before defining an area as totally inaccessible, we must consider a large number of factors. We must ask how, by whom and when the area in question is inaccessible. Man has proven to adapt to local situations that may seem on the edge of unsuitability. Therefore the classification of accessibility presented here and its numerical evaluation is an arbitrary system, based mainly on empirical knowledge of the territory that was taken into account. Despite several trials, we concluded that it is impossible to find an objective classification that defines a set of values.

process which can be preponderant when considered in reference to an ancient landscape⁷.

In the cost surface model, we decided that the slope obtained from the DEM in raster format, with pixel size of 20 x 20m, previously classified according to six classes of accessibility (S1, S2 ... N), will have a weight of 70%, while the lithopedological map will have a weight of 30%.

We can apply an easy ratio: given two known values (S1 absolute value=100; S1 in the slope map=70, S1 in the lithopedological map=30), we can calculate the values of the remaining classes (S2, S3, S4, S5, N). Multiplying the absolute value of each class of accessibility (S2 = 90, S3 = 70, S4 = 50, S5 = 30, N = 10) by the weight that the two variables (slope and lithopedology) have in the cost model (70 and 30), and dividing the result by 100, we get the values of individual classes of accessibility.

We can give the correct numerical value to each class of slope map or lithopedological map already

assessed in accordance with the classification of accessibility.

The values obtained for the individual classes of our variables indicate a greater or lesser degree of practicability/accessibility of each: the higher the value, the higher the degree of practicability.

Since the software will calculate the path letting the road pass through the lighter cells (pixels that have a least cost passage), it will be necessary to reverse the values.

Maintaining the same ratio of the numerical parameter we made a simple reversal when we put the data into the GIS platform (Table 4 and 5).

To create the cost's model we decided to multiply the two variables, so it can be a raster map in which each pixel has the weight of two connected variables. The operation to create the CSA and the consequential LCP was done by the "Raster Calculator" function of the "Spatial Analyst" extension in ESRI ArcGis.⁸

The GIS software will create buffer zones indicating the cost of travel from Nuraghe Antigori to

Slope classes	Classes %	Accessibility evaluation	Numerical evaluation of access	Value of cost (GIS)
1	0-2%	S2	63	21
2	2-0%	S1	70	7
3	10-20%	S2	63	21
4	20-35%	S3	49	35
5	35-50%	S4	35	49
6	50-70%	S5	21	63
7	> 70%	N	7	70

Table 4. Numerical evaluation of slope.

Pedological unit codex	Accessibility's evaluation	Numerical evaluation of access	Value of cost (GIS)
A	S2	9	27
B	S3	15	21
C	S4	21	15
D	S3	15	21
E	S3	15	21
G	S2	9	27
M	S2	9	27
N	S3	15	21
O	S2	9	27
R	S1	3	30
S	S5	27	9
T	S1	3	30
V	S4	21	15

Table 5. Lithopedological units with accessibility evaluation.

⁷ The slope map has a resolution of 20mX20m for pixel, like the DEM produced by the Sardinia Regional Administration (Regione Autonoma della Sardegna eds. 2005, 13).

⁸ <http://webhelp.esri.com/arcgisdesktop/9.1/index.cfm?id=2970&pid=2965&topicname=Cost%20Distance%20algorithm>

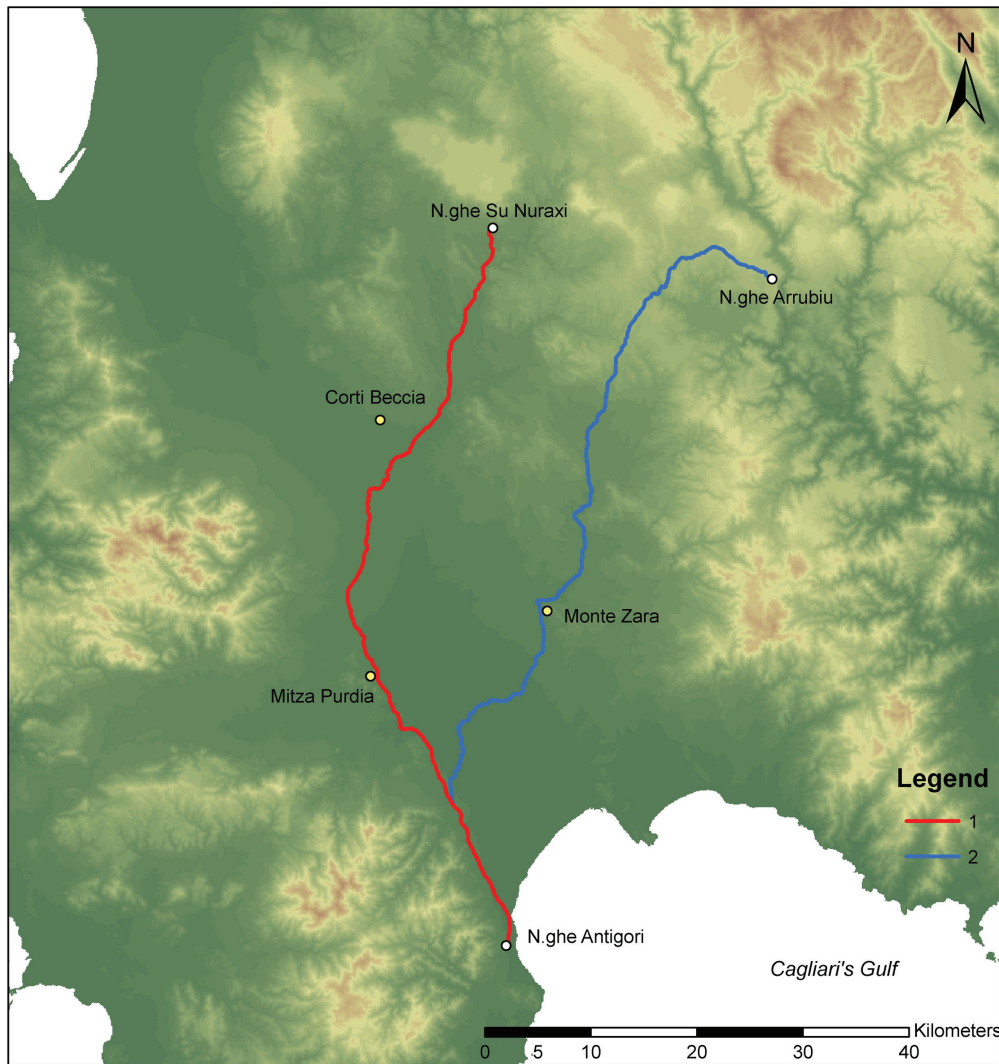


Fig. 4. CSA results: distribution roads.

the surrounding area. Following the creation of the model, we try to first rebuild the road from Nuraghe Antigori to Su Nuraxi and from Nuraghe Antigori to Nuraghe Arrubiu. Established the starting point (Nuraghe Antigori) and the point of arrival (Su Nuraxi and Nuraghe Arrubiu), the GIS software creates the line indicating the area where, according to the proposed model, there is the lower cost of travel. The analysis can be considered an anisotropic analysis (Weathley and Gillings 2002, 151; Pizziolo and De Silva 2001, 280; Gherdevich 2008, 43). In fact during the elaboration of the consequential least cost path (LCP) we take into consideration the created raster file “Cost direction” from Antigori.

To understand how the raster “Cost direction” weighted in the creation of the LCP, we performed the same procedure for Su Nuraxi and Nuraghe Arrubiu. The resulting “paths”, which start either from Su Nuraxi to Nuraghe Antigori or from Nuraghe Arrubiu to Nuraghe Antigori showed minimal differences

compared to the potential pathways shown in Fig. 4. These differences are not decisive for the purposes of research. They do not show alternative paths, which may be taken into account in analyzing the potential distributional logic of Mycenaean material in comparison with the landscape.

Although we speak of a time when the historical sources are virtually absent and for which no current written information regarding the road exists, we can imagine that roads have a social as well as geographical importance.

Since the aim of this study is the observation of what may have been the distribution network based on factors related to the landscape, the subsequent progress of this research will mean that potential social and anthropological factors which may also have influenced a particular route, will be taken into consideration.

What we proposed is a cost model based on the evaluation of accessibility of the ancient landscape,

which is limited to the information in the few existing studies⁹.

5. Conclusions

After initial consultations, data collection and preliminary stages in which the objectives of this research were identified, it became necessary to accept the need to “classify them to evaluate”.

Classification is the basis of a methodological process, which can rearrange data and make them potentially objective and useful to the community. After this, the user can recognize the differences and similarities, the particularities and peculiarities of each single datum in order to interpret and understand.

The process is simple: it is with a classification born phenomenon of associations that we are able to shape guidelines that bring forth a critical issue and a subsequent evaluation.

The key to this lies in the methodology, classification parameters and outcome evaluation.

The data and the information they provide seem to contain intrinsic class limits, which are perceived at the individual level and are made explicit in clusters and associations.

Perhaps the awareness of this can be defined almost as a limitation to the need to classify. But it should be the starting point for a constantly evolving research process, where a vortex of classifications is always questioned by the acquisition of new data and insights.

Acquiring this awareness means understanding that we cannot assert absolute postulates and an irrefutable truth. Those are not only obstacles to research but the end of that natural process inherent to man who wants to have explanations that meet, in a given time and place, the need to have answers.

Classification is often necessary, but we cannot forget that it has in itself very strong limits. Classification of a full range of accurate data often hides (or even transforms) the possible potential truth. Therefore it is impossible to produce classifications that have absolute value.

The data materials (Mycenaean pottery) still pose several questions. In order to have plausible answers on their movement and their presence on the island,

the typological information and its confrontation are not sufficient.

Since this work is a first on the study of territorial distribution of Mycenaean pottery in Sardinia, the classification of certain aspects of the landscape was necessary to identify some lines of assonance or dissonance of a particular anthropic process.

6. Results

Thanks to the classification of the territories with the available data (Land Evaluation), we can identify four examples of “accessibility attributes”.

6.1. Antigori- Sa Domo'e s'orku- Is Baccas- Nastasi

There are four Nuragic sites positioned less than a mile away from the sea and always on a small promontory or in a position dominating the surrounding territory. Based on the created land units we noticed that the best way to access the monument is unique compared to the coastline and can use the optimal characteristics of the territory. In August 2006, we carried out a survey at the three sites to see if the parameters of access to them, obtained on the basis of land units, had good feedback. It resulted in that practical access ways, in some cases unique, were identical to those obtained on the basis of land units. Although all these four sites are located in front of the coast, the only gateway to the monument always forces the traveller to circumvent the relief where the same site is located and thus to enter from the side opposite to the coastline. The gateway to the sites is easily controlled by a person who is on the monument and is generally a path along a stream or a river.

6.2. Su Nuraxi-Nuraghe Arrubiu-Duos Nuraghes- Is Lais

For internal sites such as *Su Nuraxi* or *Nuraghe Arrubiu*, the situation is different. Here it was not necessary to establish the distance to the coast and their relationship to the sea through the surrounding territory. Again, being in front of nuragic sites, we confirmed their higher position to the surrounding

⁹ At the present state of knowledge is it not possible to determine whether, for example, the site Antigori can be regarded as the site along the coast from which the distribution of Mycenaean material in Sardinia began, but it is the coastal site that returned the greatest archaeological information on the Mycenaean finds in Sardinia (Soro 2009).

area, ideal for this type of monument, especially for the position of which they find themselves. In these two cases, the accessibility to the site appears to be easier than that of the sites along the coast.

6.3. Corti Beccia- Monti Zara

Another example is Corti Beccia. In this case the site is not located on a hill, but in a flat landscape. However, it is in a higher position than, for example, the nearby pond (now no longer visible). Monti Zara's position is comparable to that of the Nuragic sites along the coast. Indeed, the site overlooks the surrounding plains but behind it lie the sandstone formations of the mountains.

6.4. Tharros- Nora- S. Antioco

Special consideration should be shown for the Phoenician-Punic sites along the coast, such as Nora, Sant'Antioco Tharros.

Because of their special position near the coast, which identifies them as important Phoenician-Punic and then Roman centers (where it is difficult to identify the former Nuragic occupation), it is preferred to focus the investigation and analyses on all paleolandscape issues. This made it possible, for instance, to consider the hypothesis that during the Bronze Age Sant'Antioco Island may have been united to Sardinia by an isthmus.

Following the identification of four examples of "accessibility attributes" it was decided to try a CSA in a subsequent trial of a road reconstruction site from *Antigori* to *Su Nuraxi* and *Arrubiu*.

The proximity of the sites *Corti Beccia*, *Monti Zara*, and *Mitza Purdia* (where a piece of ivory head was found) to the hypothetical road network, may mean that the distribution of Mycenaean pottery in the island could also be influenced by landscape factors.

We will obtain new information from the integration of typological and chronological pottery data, from variables about the structure of sites, and from the study of the relationship between the sites. For the results obtained, the methodology we applied, which only aims to be a modest experiment, has the advantage of allowing more in-depth studies.

But the main credit of this research is not the results, which so far are only partial and require further study, but to have captured a methodology: highlighting the need to assess the landscape on a scientific basis, in order to make useful comments and to pose multidisciplinary questions¹⁰.

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