The influence of landscape variation on landform categorisation

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Abstract

Categorisation in the geographic domain, including landform categorisation, is more subject to influence by cultural, linguistic, environmental and individual factors, than other domains. The results of research towards understanding categorisation drivers and the influence of landscape variation on landform category conception are presented in this paper.

Two study sites with distinctly different landscape types were chosen in Portugal. One study site was mountainous and topographically varied, while the other consisted of a more homogeneous, gently undulating terrain. Participants from each area were asked to name the landforms present in their own, and the unfamiliar study site. The interviews were conducted using video elicitation techniques. The results show that the participant group from the more homogeneous landscape has a smaller landform vocabulary, and primarily uses variations on a core set of landform terms to describe topographic eminences; the other group has a much larger and more varied vocabulary. Both groups used more landform terms to describe the familiar landscape and, similarly, specific place recognition appeared to stimulate an increase in landform categorisation detail.

A Digital Elevation Model (DEM)-based automated landform classification compared well with participants' landform categories at a macro scale. A qualitative analysis of participant responses suggested that their drivers for categorisation were the salient features of the landscape (such as elevation and land cover), as well as utilitarian motivations (such as land-use, context and familiarity).

Keywords: cognitive geography, ethnophysiography, Geographic Information Systems (GIS), landform categorisation, landform terms, landscapes.

1 Introduction

The conceptualisations of the fundamental objects or phenomena which form the basis of a GIS are often poorly considered or understood. This paper presents exploratory research results which contribute to the understanding of geographic object conceptualisation through an investigation of object categorisation variability. The categories (or objects) in question in this study are landforms, which are used to describe the features of the earth's surface - commonly mountain, valley and hill, for example.

The process of landform category conceptualisation is more subject to influence from language, culture, the environment and individual variations than categories of other domains due to the continuity of the (earth's) surface from which they must be extracted (Mark et al., 2010). Conceptualisation is a simplification, an abstraction, of the real world which we use to refer to what is there (Gruber, 1993). Defining the extent of concept non-universality and limitations using empirical testing is important for the development of accurate geographic domain ontologies (Levinson, 2008; Smith and Mark, 2001).

Relevant research in the area includes cross-cultural comparisons of landform conceptualisation and terminology conducted from GIScience (Pires, 2005), ethnophysiography (Mark and Turk, 2003) and linguistic perspectives (Burenhult and Levinson, 2008; Levinson, 1996). The work presented in this paper complements this research and makes a contribution towards achieving the interoperability of GISs across cultural, linguistic and domain boundaries (Kuhn, 2011).

2 Research methods

2.1 Conceptual framework

A simple conceptual model was designed to approach the research aims of this study (see Figure 1). There are two major components to the model: (1) landform categorisations given by participants from two study sites and (2) automated landform classifications derived from a Digital Elevation Model (DEM) of the same two sites. The study sites are located in two distinctly different landscape types. Both qualitative and quantitative methods are used to make comparisons between and within the two sets of results.

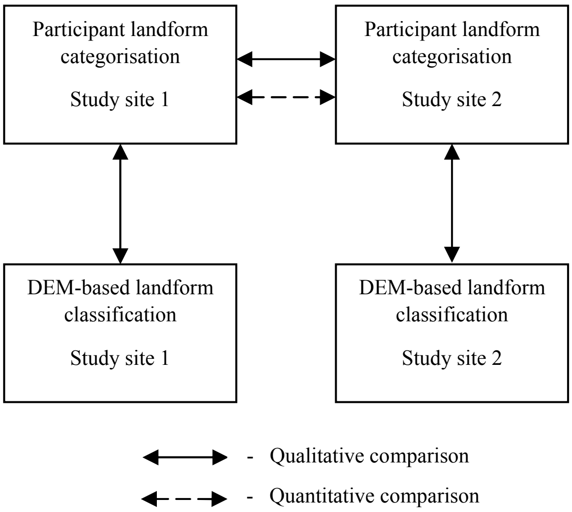

Figure 1. Research approach

2.2 Participant landform categorisation

The first component of the research involved interviewing participants from both study sites, using video-elicitation techniques. Photo (or video) elicitation methods involve the use of photographic or video material as interview prompts. The relevant applications of this interview technique have been documented in Turk et al. (in press), Bohnemeyer et al. (2004) and Surová and Pinto-Correia (2008). For this study video was considered a more useful medium. The video material consisted of four minute montages for each study site, made up of still and pan shots.

During the interviews participants were asked to watch the two videos; and (1) name the landforms they could identify, and (2) give the specific names (place names) of any locations they recognised. They were free to describe the landforms of their choosing with little prompting or questioning

Interview participants were selected according to purposeful criterion sampling (Patton, 1990). The only requirement was that the person had lived in the study area for more than five years. No limitations were placed on age, occupation or sex. The interviews were held in people's homes, workplaces and study places, and where possible, alone. The interviews were conducted in Portuguese and recorded using CamStudio software.

2.3 Automated landform classification

The second approach to the research involved a deterministic landform classification of the study areas using a 30 m pixel Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Digital Elevation Model (DEM). The implemented classification method is one based on a macro landform classification system developed by geographer Edward Hammond in the 1950s and 60s (Dikau et al., 1991). It has since been modified into a deterministic analysis which can be computed using elevation data and performed in a GIS (Dikau, 1989; Dikau et al., 1991). More recently a step-by-step approach to the pixel-based analysis using ArcGIS tools was published (Morgan and Lesh, 2005). Their approach, with corrections published by Drescher and de Frey (2009) was used for this study. The computation was done using the ArcGIS software and the result is a map with a subset of the 24 meaningful landform classes described by Morgan and Lesh (2005).

3 Study sites

Two locations with contrasting landscape types were chosen as study sites. The first site is situated in the Lousã and Góis *concelhos* in the north of Portugal (see Figure 2), covering an area near the Lousã town where the mountain range rises steeply with an elevation range of 200 to 1204 m. The second study site covers a portion of the Odemira *concelho* which lies in the south of Portugal (Figure 2). The area consists largely of lowlands and small undulating hills with a number of higher elevation ranges (up to 341 m) (Agência Portuguesa do Ambiente, 2007; Câmara Municipal da Lousã, 2008; Câmara Municipal de Odemira, 2007).

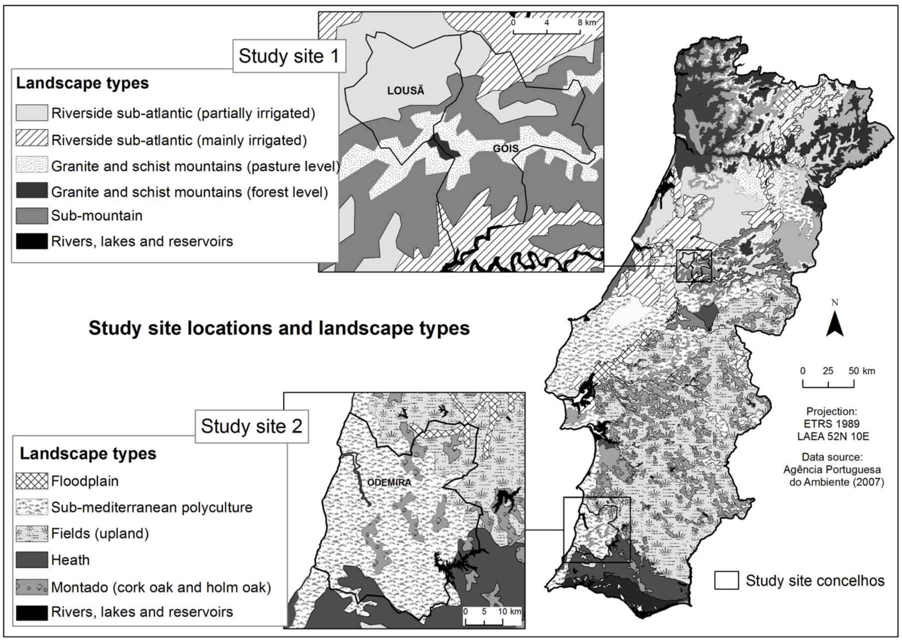

Figure 2. Study sites location map

4 Results and discussion

4.1 Notes on quantitative results compilation

A total of 10 and 11 participants were interviewed in the Lousã and Odemira study sites, respectively. With the aid of translators the interview recordings were studied, and landform terms and place names extracted. A list of 58 distinct landform terms was compiled and later aggregated into 18 meaningful groups. The resultant dataset is nominal discrete primary data with a sample size too low to permit the use of statistical significance tests. The frequency of occurrence of the aggregated group counts was used for all analyses.

It is important to note that due to the frequent reference to water features and water bodies they have been included as landforms. Descriptions of land-use were included only when used as a part of the landform term.

4.2 Quantitative comparison of participant categorisation

4.2.1 Effects of landscape type

The quantitative results show differences in landform vocabulary size between the two study site participant groups. The total number of distinct landform terms used by the Serra da Lousã participants was 44, while the Odemira participants used only 34 terms (Table 1).

Table 1. Total term counts and frequencies of occurrence per participant group

	Lousã participants		Odemira participants	
	Term Count	Term Proportion (%)	Term Count	Term Proportion (%)
Lousã video	30	68	18	53
Odemira video	27	61	26	76
Total number of terms	44		34	

Of most interest is that the content of these vocabularies is noticeably different. Figure 3 shows the percentage frequencies of occurrence of aggregated landform term counts. The translations of Portuguese terms are given in Table 2. The graph shows terms common to both groups in the centre (with almost equal occurrence) and sets of terms predominantly (or solely) used by each group on the left (Lousã) and right (Odemira).

The differences in vocabulary content appear to reflect the prominent features of the landscape in which each participant group lives. The Serra da Lousã landscape consists of many different shapes, elevations and contours. Correspondingly, inhabitants use many terms to describe the features; the common *serra, monte* and *montanha* terms are not sufficient and there are additional terms such as peak, ridge and *lombo*. The Odemira landscape is less variable, consisting predominantly of plains with occasional convex eminences which are usually of similar shape. Here inhabitants have a smaller landform vocabulary which makes use of descriptors such as 'big', 'small', 'smooth' to modify the common *serra, monte* and *montanha* terms as needed. This result reflects conclusions drawn by Mark and Turk (2003).

An additional result indicates that the vocabulary of the Lousã participants is more versatile than the Odemira vocabulary. Table 1 shows that both participant groups used more terms to describe the video of their area compared to that of the less familiar study site, however the margin of this difference is markedly more for the Odemira participants (an increase of 53% to 76% as opposed to 61% to 68% for Lousã participants). This indicates that they were not able to apply their vocabulary or that it was not sufficient for the description of the Serra da Lousã region, while the Lousã vocabulary was more applicable.

4.2.2 Effects of landscape familiarity

Both participant groups used more landform terms to describe the landscape which was most familiar to them (as described in the previous section). This gives some assessment of the effects of familiarity at a landscape level. At a finer scale of familiarity specific place recognition was considered. A comparison of the number of video scenes people recognised and the number of landform terms they used to describe the video yielded positive correlation coefficients of 0.74 and 0.55 for Odemira and Lousã participants, respectively. This suggests that place recognition – indicated by knowing a place name – promoted a more detailed landform categorisation.

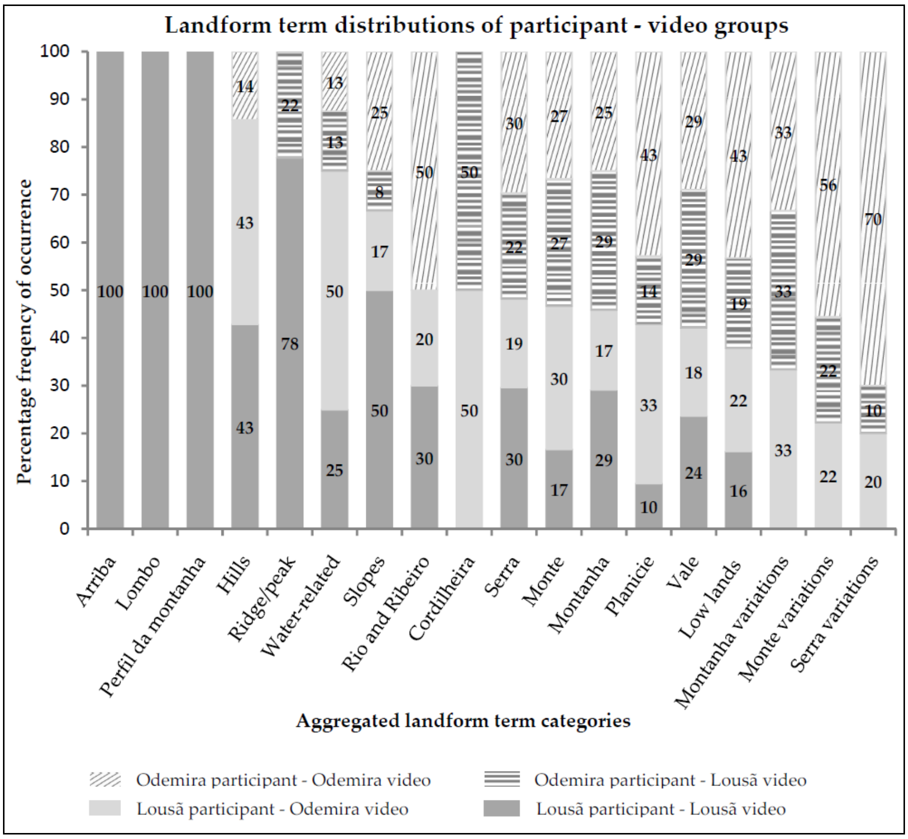

Figure 3. Landform term distribution between participant - video groups as percentage frequency of occurrence.

Table 2. Portuguese term translations

Portuguese term	English term
Arriba	Cliff
Cordilheira	Mountain range
Lombo	Back
Montanha	Mountain
Monte	Hill
Perfil da montanha	Mountain profile
Planície	Plain
Rio	River
Ribeiro	Stream
Serra	Mountain or mountain range
Vale	Valley

4.3 Qualitative results of participant categorisation

Observations of the way in which participants gave their landscape descriptions yielded more insight into the effects of place recognition. When participants recognised a place in the video, their descriptions began to follow their own understanding of landform connectivity, regardless of the video pan movement. They appeared to be referring to their previously composed mental map of the area rather than the video images in front of them and gave descriptions from a 'zoomed in' perspective of the landscape. They also appeared to be more enthusiastic about the description task and all sought to recognise places. Their behaviour suggested they preferred to orientate themselves within the landscape and describe it from an egocentric relative reference frame. These observations support the findings of other authors (Bian, 2007; Egenhofer and Mark, 1995; Montello and Golledge, 1999; Surová and Pinto-Correia, 2008).

4.4 Qualitative comparison of participant categorisation and automated classification

The DEM-derived macro landform classifications were produced using the methodology outlined in Section 2.3. The results are shown in Figures 4 and 5. From visual inspection the maps appear to well characterise the landscape variations at the macro scale. When compared with participant responses, however, it becomes apparent that in the Serra da Lousã region the topography of the landscape varies at a smaller scale than can be well represented by this algorithm, while the recognisable landforms of the Odemira region are better captured.

A comparison of the Morgan and Lesh landform class at the location of each video scene (views labelled in Figures 4 and 5) against the most common participant landform terms are shown in Tables 3 and 4. Table 3 shows there is a good correspondence between the participants' categories and the Morgan and Lesh classes. For example, in areas classified as '31 - Plains with hills', participants gave the categories *planicie* (plain) and *monte* (hill). In the Serra da Lousã region there is generally a greater variety of participant terms corresponding to each Morgan and Lesh class. For example, areas classed as '54 – High Hills' have received landform categories from valleys to slopes and mountain peaks from participants. The automated classification is clearly giving a much generalised representation of this landscape.

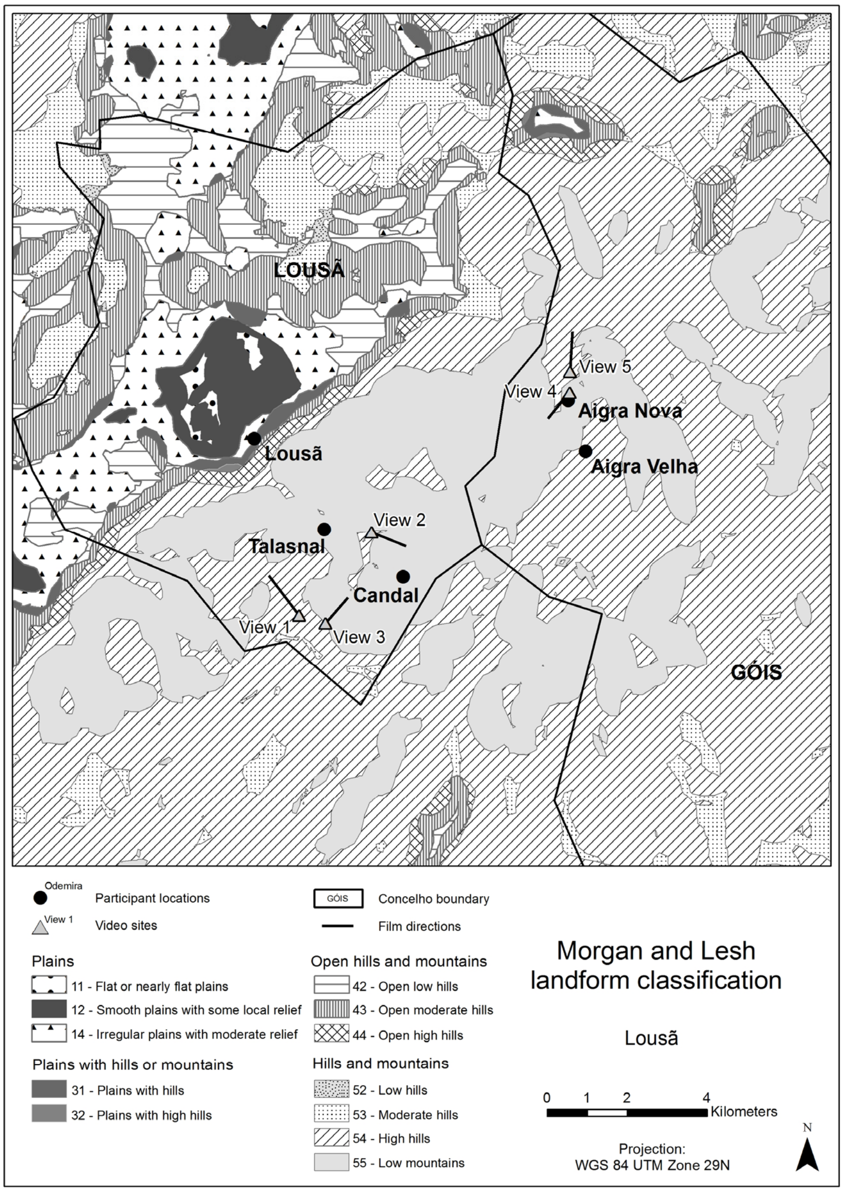

Figure 4. Lousã landform classification

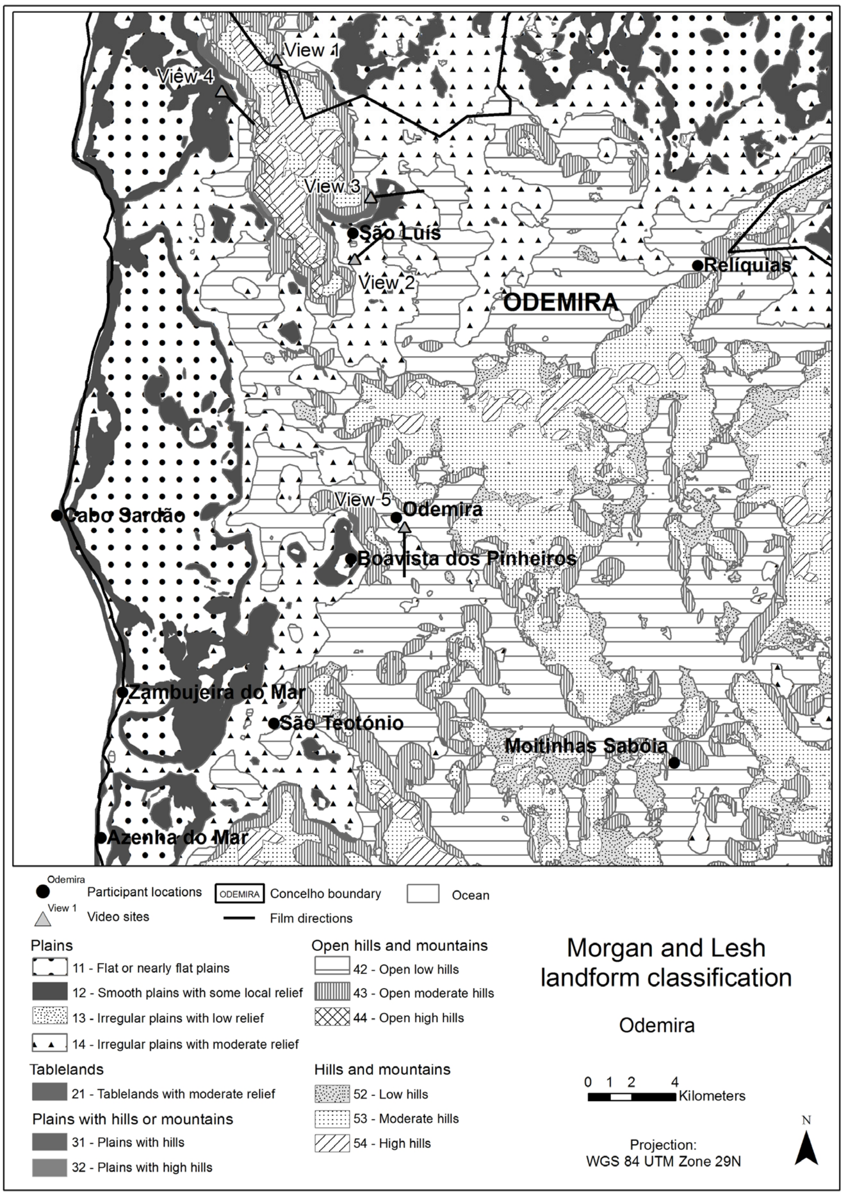

Figure 5. Odemira landform classification

Table 3. Morgan and Lesh landform classes with corresponding participant terms, Odemira video

Morgan and Lesh class	Participant terms (most to least common)
12 - Smooth plains with some local relief	Planicie[1], Planalto[2]
14 - Irregular plains with moderate relief	Várzea[3], Planicie, Planalto, Monte[4], Serra[5], Rio[6]
31 - Plains with hills	Planicie, Monte
42 - Open low hills	Serra, Montanha[7], Monte, Vale[8]
43 - Open moderate hills	Monte, Serra, Montanha
52 - Low hills	Serra, Montanha
53 - Moderate hills	Serra, Montanha
54 - High hills	Montanha, Serra

1. Plain
2. Plateau
3. Cultivated plain
4. Hill
5. Mountain or mountain range
6. River
7. Mountain
8. Valley

Table 4. Morgan and Lesh landform classes with corresponding participant terms, Lousã video

Morgan and Lesh class	Participant terms (most to least common)
14 - Irregular plains with moderate relief	Vale, Montanha, Monte
43 - Open moderate hills	Vale, Montanha, Monte
53 - Moderate hills	Vale, Montanha, Monte
54 - High hills	Montanha, Serra, Vale, Ladeira[9], Cume[10], Encostas abruptas[11]
55 - Low mountains	Montanha, Serra, Cume/cumeada[12], Montes

9. Slope
10. Peak
11. Steep slope
12. Ridge

4.5 Categorisation drivers

Observations of participant landform descriptions suggest there are multiple drivers for categorisation. These influences fall broadly into two types: salient perceptual features of the landscape, and landscape affordance or utilitarian motivations. These constitute two of the three drivers described by Burenhult and Levinson (2008). More specifically, the salient features referenced by participants were the shape and profile of the landforms, as evidenced by the good comparison with the DEM-derived classification (in the Odemira region particularly), and references to water, vegetation and land cover. The other influences are land-use, context (such as the presence of clouds around mountain peaks), and place familiarity (with corresponding use of mental maps). This second group of drivers are related to utilitarian motivations as they involve the participant's prior experience of the landscape or knowledge of how it may be used. No participant referred to only a single driver. Certainly no one type of driver (eg. salient features vs utilitarian motivations) appeared more predominant than the other.

5 Conclusions

The empirical research results show landform categorisation variations due to the type of landscape in which participants live, as well as the familiarity of the location they are describing. Their descriptions corresponded well to a DEM-derived macro scale landform classification at the gently undulating study site and were comparatively much more detailed at the more dynamic mountainous site. There was evidence of multiple categorisation drivers, relating to the salient landscape features and utilitarian understanding of the land.

This research could be further refined by considering participant age, occupation, lifestyle and sex demographics in the data analysis. It could be also be useful to use study sites of equal area. Reproductions of the study in different landscapes and countries would be interesting.

Acknowledgements

Thank you to the participants from the Lousã, Góis and Odemira *concelhos,* and to the employees of Dueceira in Lousã, Lojas Aldeias do Xisto in Candal and Airgra Nova, and Taipa in Odemira for their assistance. Thank you to Dr Marco Painho and Dr Werner Kuhn for their guidance, and to Dr David Mark for his contribution to the project.

This research was conducted as a part of a Masters dissertation completed with the support of the European Commission's Erasmus Mundus program.

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