Forest: 0 or 1? Interdisciplinary challenges and methods for the classification of landscape data

Philipp Striedl (University of Zurich)

Abstract

Successful environmental policy often depends on the interpretation of large amounts of landscape data and its classification. However, classification remains challenging. Improper categorisations cause problems in local communities and endanger sustainable landscape initiatives.

From a linguist's perspective, I revisit interdisciplinary research methods that are apt to assist landscape planning and policy to overcome classificatory challenges. By juxtaposing scientific perspectives that are relevant for landscape research, I argue that linguists are equipped to interpret landscape data in a way that is sensitive to cultural and linguistic diversity. Interdisciplinary research collaborations between geographers, linguists, cognitive and computer scientists most effectively address environmental challenges that prevail globally, but are affecting each community in a different way.

Geographic Information Science (GIS), linguistics, landscape, classification, algorithmic bias

1 Introduction

1.1 Digitalisation and science

Digitalisation creates new possibilities and challenges for science. As Nassehi (2019) argues, our guiding question should not be whether digitalisation is useful or harmful. Instead, we should ask ourselves: Why has it been so successful? From his sociological perspective, digitalisation is the consequence of modern societies' attempt to structure our environment: to detect patterns and – essentially – to classify them. Along this trend, methods for the collection, storage and classification of data have been developing rapidly. Landscape planning and environmental policy have increasingly been relying on the collection and analysis of large amounts of data. Nevertheless, interpretation of data and detection of patterns remains challenging, as the following example will demonstrate.

In 2013, scientists created the first high-resolution global map of percentage tree cover using satellite images (Sexton et al. 2016). Despite the increasing accuracy of satellite data, it still remains highly ambiguous what is considered as forest. Sexton et al. (2016) showed that for about 13% of the Earth surface there was maximal disagreement on the presence or absence of forest between 8 sets of satellite data. This massive disagreement between the datasets is initially puzzling. However, disagreement is primarily caused by classificatory challenges rather than the structure of the data: As long as the definition of the category *forest* varies, algorithms cannot uniquely classify landcover into "forest" or "no-forest" – "*1*" or "*0*" in digital language. With a set of examples, I will highlight real-life implications of improper forest definitions and underline that we are preoccupied with more than a merely abstract terminological problem.

1.2 Implications of wrongful landscape categorisation

In their ethnographic study about the indigenous Takana in Bolivia, Wartmann and Purves (2018) describe how protecting wrongfully classified rainforest disturbs traditional sustainable ways of life. As one consultant explains during a field walk, he can no longer cultivate his inherited land that was used by his ancestors because it has been classified as rainforest by the authorities. He refers to this piece of land as "my *barbecho*" – a Spanish term that designates 'fallow.' He explains that his community has traditionally been alternating cultivation on this type of land according to their needs. Thus, sustainable practices of land use have been disturbed by the wrongful classification of *barbecho* as protected rainforest.

Essentially, the same problem of inappropriate landscape categorisation has been affecting farmers across the globe. The Austrian documentary *Der Bauer und der Bobo* (Langbein 2022) depicts controversies about sustainable agriculture in alpine Styria. Main protagonist Christian Bachler explains that his cattle farming is no longer subsidised because his high-altitude pasture has been categorised as forest instead of pasture. The institutional definition depends on the number of trees in a fixed area, but not on their size. Therefore, the number of small trees sparsely spreading on Bachler's high-altitude pasture suffice to classify the land as forest. This sort of wrongful landscape classification has seriously been affecting the farmers' livelihood and the maintenance of sustainably managed farms.

1.3 The need for context-sensitive landscape definitions

The examples above show that developing definitions for landscape elements such as forests which are meaningful for local populations and sensitive to their contexts is crucial to enhance sustainable landscape management. Landscape researchers and policy makers have been aware that effective sustainable landscape policy must be tailored to cultural specifics of the target population and to local needs (Burenhult 2023; IPBES 2022). The EU landscape convention has been recognising landscapes as shaped by human perception and consequently by cultural and linguistic factors. Thus, landscape is defined as "an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors" (Council of Europe 2000).

Despite growing awareness of cultural differences in conceptualisations of landscape, any meaningful classification of landscape data remains challenging. Some classificatory problems have been addressed by so-called artificial intelligence (AI). Yet, it is hardly possible to derive culturally sensitive meaning with algorithms. Up to date, the main challenge for landscape research – just as for most scientific domains – boils down to one question: How can we meaningfully interpret extensive data from diverse contexts? Crucially, we need to avoid algorithmic bias towards powerful worldviews and their reproduction through dominant languages such as English (Bender et al. 2021; Vallego 2023). This suggests that we cannot simply transfer scientific classification systems of landscape that were developed by experts in English speaking Western societies because they are inherently biased towards this particular worldview.

1.4 Call for interdisciplinary scientific action

With collaborative research designs, linguists, geographers and computer scientists will be better equipped to address environmental challenges that prevail globally, but affect each community in a different way. This is not the first call for interdisciplinary scientific action in the domain of landscape research:

> [L]anguage provides insight into how people conceptualize landscapes. GIS researchers and practitioners, landscape linguists and cultural scholars need to work together to develop theoretically robust representations of landscape. (Brabyn & Mark 2011: 406)

However, linguistic and cultural diversity has commonly been overlooked in landscape sustainability science (Burenhult 2023; Zhou et al. 2019). By juxtaposing scientific perspectives from linguistics and geographic information science (GIS), I argue that linguists provide the methods to interpret landscape data in a way that is sensitive to cultural and linguistic diversity. In Section 2, I will review different theoretical approaches to landscape before describing interdisciplinary research applications in Section 3.

This article reflects my perspective as a linguist who has been researching at the Department of Geography at the University of Zurich where I discovered the multifaceted character of geographic research, existing collaborations and further potential for interdisciplinary research. Instead of aiming at a comprehensive review of any research approach, I attempt to share information that may be new and helpful for anyone who is firmly rooted in their discipline – be it a branch of geography, computer science or linguistics. I would like to create awareness for existing interdisciplinary work, its potential and political relevance and thereby encourage further exchange and research collaborations.

2 State of the art

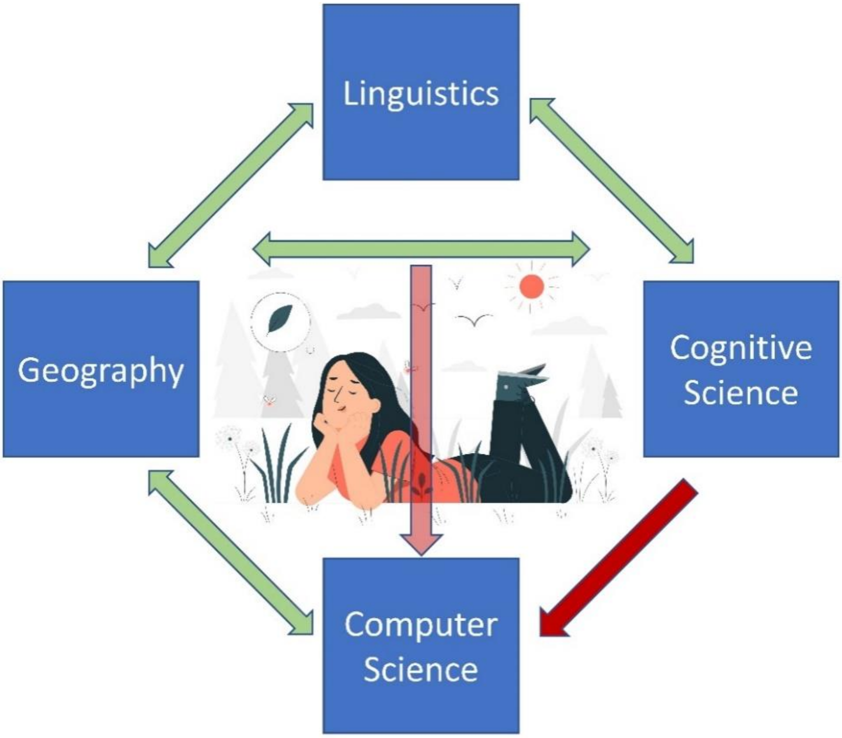

Fig. 1: The interdisciplinary character of landscape research: Green arrows symbolise scientific exchange, while red arrows indicate research gaps and time lags in knowledge transfer[1].

[1] Edited image from storyset on Freepik: https://de.freepik.com/vektoren-kostenlos/naturvorteilskonzeptillustration_13416096.htm#query=landscape%20woman&position=5&from_view=search&track=ais (accessed: June 17, 2023)

Like dialectology, landscape research has been solidifying as research domain since the second half of the nineteenth century (Antrop & Van Eetvelde 2017; Chambers et al. 1998). It comprises the study of landscape objects, holistic landscapes, people's perception of and actions with them as well as their dynamics and change (Bender 2006). Different aspects of landscape research are symbolised by the central scene in Fig. 1: A human being is located in and thinking of a surrounding landscape that is made up of elements such as grass, trees, clouds and the sun.

Landscape research and linguistic anthropology aim to get at the meaning of their object of study. They investigate the semantics of landscapes, landscape elements and linguistic forms. With the examples of forests as landscape objects, I showed that this is not an easy task because meaning is subject to change across time, space, speaker communities and individuals. In landscape research, forests feature as prominent examples for the intricacy of landscape classification. Forests are to landscape research what *snow clones* are to linguistics. *Snow clones* – i.e. the alleged abundance of lexical items that refer to sorts of snow in Eskimo languages – have been used to illustrate challenges for lexical classification due to cross-cultural diversity in landscape conceptualisation (Cichocki & Kilarski 2010; Regier et al. 2016).

Traditional research methods for a semiotic approach to both landscape and language – i.e. for the study of their meaning – are similar and resulting data can potentially be used for both research domains. Thorough linguistic descriptions contain metadata about consultants as well as their landscapes and cultural practices (e.g. Jaberg & Jud 1928; Plomteux 1980), just as landscape descriptions contain language and behavioural data (e.g. Beaucage 1996).

Within landscape research, there have been opposing universalist and relativist research strands, just as in linguistics and cognitive science where this discussion is known as Sapir-Whorf hypothesis (Kay & Kempton 1984). The approach of deriving general landscape ontologies (e.g. Mark 1993) has given way to a more differentiated treatment of landscape concepts (Mark & Turk 2003; Rundstrom

1995). Universalistic landscape definitions that are characteristic for the exact Sciences have been criticised:

> These [scientific] landscape categorisations and their definitions are typically based on biophysical properties of landscape and result from negotiations between expert groups, which often makes them difficult to understand for the public (Wartmann & Purves 2018: 77)

Consequently, knowledge exchange between linguistics, cognitive science and geography has been leading to the understanding that conceptualisations of landscape depend on human perception and differ in changing geographic, cultural and linguistic contexts. Processes of categorisation are at the heart of cognitive psychology (Rosch 1978) and cognitive linguistics (Lakoff 1987; Lakoff & Johnson 1980). Therefore, landscape researchers have started to explore cognitive science to tackle classificatory challenges. What is termed as *spatial turn* has been inspiring research about conceptualisations of space, landscape and their linguistic encoding (Brabyn & Mark 2011; Burenhult et al. 2017; Burenhult & Levinson 2008; Levinson 2003; Levinson & Wilkins 2006; Mark & Turk 2003; Stock et al. 2022).

For almost a century, theoretic turns – linguistic, cognitive, spatial and digital – that originated in one of the academic disciplines involved in landscape research have been diffusing disciplinary borders. Still, there remains much unused potential for inter- and transdisciplinary collaboration: Innovative research on the intricate relations between cultural, linguistic, ecological diversity and justice is needed to understand and counteract the global climate crisis (Fine & Love-Nichols 2021; Lakoff 2010). This political stance is characteristic for the branch of *ecolinguistics* (Fill & Penz 2017; Stibbe 2014, 2021).

For example, algorithmic bias towards hegemonial worldviews and languages is a timely challenge that needs to be tackled with joint research effort (Chatila & Havens 2019; Friedman & Nissenbaum 1996; Janowicz 2023). Computer Science needs theoretical input from landscape research to implement appropriate representations of diverse landscapes. In the following, I will describe methods that are apt to inform context-sensitive landscape models.

3 Interdisciplinary methods for landscape research

The following sections showcase techniques for the collection, management, analysis and use of semantically rich landscape data.

3.1 Data collection

3.1.1 Qualitative and ethnographic approaches

Traditional ethnographic techniques that have been applied since the earliest dialectologist studies (see above) are still valuable today and indispensable for various research purposes. Participatory observation and interviews are especially useful in the first research stage in unknown contexts to openly explore the field. Grounded theory methodology approaches have been formalising this initial stage to delineate hypotheses and to develop further methods by defining e.g. interview guidelines that are used for data collection in subsequent research stages (Charmaz 2004; Corbin & Strauss 2015; Glaser & Strauss 1967; Hadley 2017).

Elicitation tasks and *sociolinguistic interviews* are designed to capture language data and yield insights into knowledge systems in diverse contexts – even for speaker communities who do not use a standardised written language (Labov 1984; Tagliamonte 2006). Naturally, ethnographic data contain references to places and landscapes that call for study. Ethnographic data are multimodal and potentially map diverse contexts. Typically, they are made up of graphical data such as drawings, writings and field notes, visual data such as photographs and videos recorded during interviews or participatory observation and audio data such as recorded speech and music.

Field walks (also *go-along* or *walking interviews*) have successfully been applied in landscape research and for the study of language in space. During a field walk, researcher and consultants walk along a trajectory chosen by the researcher or the consultants according to the research objectives. Thus, peoples' relations to landscape and geographical aspects of the consultants' environment are recorded for later study. Usually, walking is combined with elicitation and interview techniques to gather information about landscape elements and typical behaviour in a specific landscape. Field walks yield multimodal data such as georeferenced audio-visual recordings from the researchers' or the consultants' perspective. For example, Mallette et al. (2022) studied landscape values to inform landscape management and Obert[2] has been investigating the semantics of motion event encoding in the context of hunter-gatherer mobility. Larsson et al. (2021) outline methods to facilitate the analysis of multimodal geospatial data in these research contexts, using the software ELAN[3].

With the availability of increasingly elaborate recording devices and techniques, the quality of data resulting from ethnographic fieldwork is usually high. Furthermore, it is likely to serve the research objectives since the collection can be tailored to individual needs. At the same time, ethnographic data is subject to the observer's paradox, i.e. the unwanted influence of the researcher on the data collected in his presence (Figueroa 1994). Moreover, subjective criteria for the selection of consultants can easily be criticised against the backdrop of statistically balanced randomised sampling techniques. Under the premise of appealing to the wisdom of a mostly anonymous crowd, traditional ethnographic methods have been substituted by less time and cost intensive methods that use data which is already available online.

3.1.2 Crowdsourcing and Public Participatory Geographic Information Science

Despite the multimodal character of ethnographic data, many studies rely exclusively on textual data such as interview transcripts. However, there are various possibilities to retrieve textual data and narratives about landscape besides ethnographic methods. Textual narratives can easily be collected from consultants using traditional or digital communication tools.

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[2] https://portal.research.lu.se/en/projects/language-on-the-move-an-investigation-of-d%C3%A2w-motion-categories-in (accessed: June 17, 2023)

[3] https://archive.mpi.nl/tla/elan (accessed: June 17, 2023)

Participatory scientific approaches that aim to serve the research participants' community beyond the attainment of research objectives have been advancing these methods. For example, Bieling (2014) argues that methods such as a short story contest that she carried out in the Swabian Alb fosters local residents' "deeper connections to a place." In this fashion, so called Public Participatory Geographic Information Science (PPGIS) has been generating and using place-based data from the public and stakeholders for landscape planning (Brown & Fagerholm 2015).

Designing data collection as a contest or game has been explored to attract consultants and to keep them active in the process of data donation. Baer and Purves (2022) implemented an application called "window expeditions" that encourages consultants to explore "everyday landscapes" in their language of choice. Through an online interface, they can donate creative textual descriptions of the landscape that they perceive from a window. The resulting corpus contains multilingual, georeferenced documents from several regions around the world.

Similar applications (e.g. Hilton 2021; Leemann 2020; J. Smith et al. 2022) have also been collecting georeferenced instances of vernacular language use for the purpose of dialectology, both as text and voice recordings (see Leemann et al. 2016).

Besides the study of text and narratives, psycholinguistic methods are apt to compare conceptual structures of landscape between different speaker communities. Van Putten et al. (2020) implemented a free-listing task as online survey to elicit terms that refer to the semantic domains *landscape, animals*, and *body parts* from speaker communities of European languages. Thereby, they showed that the conceptual structure for landscape differs more between consultants from different speaker communities than for the domains *animals* and *body parts*. By applying psycholinguistic norm ratings, Purves et al. (2023) compared sensorimotor and emotional associations among German and English speakers for waterbody terms with an online survey. Consultants that were recruited through the platform *Prolific* rated water body terms by indicating the strength of their associations with a specific term, using Likert scales. Systematic studies of perceptual associations for landscape terms like these inform landscape character assessment initiatives that strive to include perceptual information on all senses (Tudor 2014).

The availability of online data that can be used for landscape research is already abundant. However, data quality can be an issue when using crowdsourced data. Often, important metadata about the authors is missing and it will become more and more difficult to distinguish human generated from automatically generated data. So far, applications that collect data for specific purposes (see above) allow for more control about who can provide data and can yield high quality data, even from large samples.

3.2 Data management and usability

For the sake of sustainable scientific practice, landscape data needs to be accessible for various research objectives from all the disciplines that work in the domain. As initial step, it is crucial that practices for data collection and storage adhere to the FAIR[4] principles: Accordingly, data must be findable, accessible, interoperable and reusable (Janowicz 2023). Even though large amounts of curated sets of landscape data have been available and easily accessible online for researchers, findability remains an issue. Numerous organisations, individuals and universities have been publishing resources in a non-standardised manner. National data repositories such as SWISSUbase[5] provide an opportunity to store datasets from at least one national research community and to make them findable through a catalogue.

Especially data sets that cover the same geographic area need to be comparable to comply with the standards of reproducible science. For example, geolinguistic data which is the basis for language atlases has to be consistent to a degree that allows researchers to compare datasets stemming from different research projects with the same analytic tools.

Commonly, the full potential of multimodal ethnographic data remains underexplored. Audiovisual recordings and transcripts collected for dialectologist aims can be used for the purposes of

[4] https://www.go-fair.org/fair-principles/ (accessed: June 17, 2023)
[5] https://www.swissubase.ch/en/ (accessed: June 17, 2023)

landscape research as they contain landscape narratives, references to places and are rich in metadata. On the other hand, interview data collected by landscape researchers are potentially interesting for linguists as they contain various types of linguistic data from diverse contexts in the form of audio recordings, transcripts or texts.

To improve data usability for various research purposes, it is crucial for scholars who use qualitative data to define criteria for publication that increase their findability and to agree on e.g., a list of metadata. that should be included to increase interdisciplinary usability.

3.3 Data analysis and representation

Landscape researchers have successfully been relying on methods from corpus linguistics, conversation analysis and GIS for the study of landscape narratives in textual data (Purves et al. 2022). Textual data can reveal cultural values and emotional attitudes towards landscape objects and their dynamics. For example, Bürgi et al. (2017) used interviews with local residents to assess changes of land cover together with perceived landscape changes. This method enables an understanding of how residents think of changes that actually occurred in their inhabited landscapes. Besides qualitative content analysis (e.g. Calcagni et al. 2022; Fagerholm et al. 2020), (semi-)automated classification techniques such as topic modelling and sentiment analysis have been used to extract meaning from textual corpora (Manley et al. 2022). Furthermore, Villette et al. (2022) demonstrated how GIS methods can help to analyse an indigenous place naming system through the comprehensive study of ethnographic, linguistic and geographic data.

Representing textual and linguistic data spatially is a complex matter because graphic possibilities to encode information on a map are limited to different shapes and colours and allow only for small amounts of text (Colcuc & Zacherl 2022). With increasing density of information, cartographic representations quickly become enigmatic. While some research projects have been relying on traditional forms of geolinguistic representation such as linguistic atlases (e.g. Elspaß & Möller 2003-), others have been using GIS methods for more dynamic representations with online interfaces (e.g. Krefeld & Lücke 2014; Schmidt et al. 2020-; see Colcuc & Mutter 2023). Special applications such as ArcGIS storymaps[6] can be used to represent multimodal geographic data in the form of consecutive sequences that facilitate causal explanations and storytelling. However, most dynamic representations based on web-technologies have not yet established a common symbolic language which makes it difficult to compare and interpret data from different sources.

3.4 Preserving cultural and linguistic diversity

Algorithms can play a major role in how we organise our societies and consequently in how we tackle challenges such as climate change. With recent advances in AI and applications such as ChatGPT, questions have been raised about moral and legal implications. Vallego (2023) illustrates the shortcomings of ChatGPT when it comes to ecological topics. He suggests that the program could be improved with additional training data or by refining the model. However, he does not address the inherent linguistic bias of ChatGPT that captures only a small percentage of the world's languages.

One of our main challenges is to implement cultural and linguistic particularities to meet humanity's diverse needs – instead of reproducing English based hegemonic discourse – with algorithms. It is well known that we need to understand different conceptualisations of the world to improve our scientific models and to use them in beneficial ways (Friedman & Nissenbaum 1996: 343). Therefore, it is apparent that we cannot rely solely on petrified crowd wisdom as training data for large language models that is firmly rooted in the last century when the majority of internet users and developers were born and grew up. Instead, we need to find ways to implement recent insights from landscape research into these algorithmic models.

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[6] See one example of mapped landscape perceptions: https://storymaps.arcgis.com/stories/68baaebe003c42cb99d7c6a0b3ff051d (accessed: June 17, 2023)

For example, landscape narratives as they are expressed in different languages from diverse cultural contexts can serve to model different speaker communities’ relations to landscape, climate change and sustainability appropriately. Norm data about sensorimotor and emotional associations with landscape can be explored in order to inform language models about these essential components of meaning.

However, since language models depend on the availability of large amounts of data, it is questionable how regional implementations could handle the natural scarcity of data for narrow settings. The adjustment to speaker communities with only a few thousand speakers such as Rumansh in Switzerland or communities who do not use a standardised written language will continue to pose a challenge for AI applications. Moreover, the capacity of textual data to model natural language use is limited, especially in diglossic contexts or where no standardised written language is used. Can this limitation be overcome with audio or multimodal data to train the models? From a visionary perspective, linguistic research about sound symbolism (e.g. Blasi et al. 2016; Dingemanse et al. 2015) could even help to predict meaning from phonemes or graphemes, no matter what language is used as input.

4 Conclusion

After cognitive, linguistic and spatial turns, it may look like we have turned full circle. However, there is still much room for tighter inter- and transdisciplinary collaboration in the domain of landscape research. In this article, I identified a knowledge gap that extends between geography, linguistics and cognitive science on the one side and computer science on the other side. While information about how speaker communities of different languages conceptualise landscapes in diverse contexts has been gathered, knowledge about this diversity has not sufficiently been implemented in scientific models and algorithms.

One possibility to bridge this knowledge gap is by tackling a challenge that equally affects all scientific disciplines: digital transformation of society paired with the widespread use of so-called artificial intelligence. What essentially unites geographers and linguists is the need to keep track of usage, cultural differences and real time changes to landscapes and forms of life. These subtle but decisive nuances cannot be modelled with AI, so far. To come back to the initial examples, we have been misled when we were seeing zeros or ones where there actually is a forest or a *barbecho* – with all their cultural associations and ecological contexts.

Communication across scientific disciplines, with different methods and styles of doing research, is not straightforward, but requires constant translation effort. I demonstrated that linguists have been contributing to the analysis of purely textual and linguistic data, but their expertise is equally valuable for the classification of multimodal landscape data. Therefore, more linguists should engage in landscape research and aim for collaborations with cognitive scientists, geographers and computer scientists to enhance culturally sensitive classification techniques.

Global environmental challenges are affecting everybody, but each community is affected in different ways. By using interdisciplinary perspectives, landscape research is well equipped to inform decision makers about global and local impacts as well as to propose context-sensitive strategies for sustainable development.

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