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METHODOLOGY:
ARCHAEOLOGICAL LIDAR AND GIS ANALYSIS OF THE EARLY MEDIEVAL SETTLEMENTS

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Abstract

This introductory chapter explores the application of Light Detection and Ranging (LiDAR) and selected relevant aspects of Geographic Information Systems (GIS) in archaeological research.

Archaeological LiDAR is typically used as a tool to visualise and analyse the morphological aspects of archaeological landscapes, greatly enhancing the detection of archaeological features and sites. However, here we address the use of LiDAR for the reconstruction of landscapes, which offers new avenues for research, such as palaeogeographic analysis and the study of agricultural land use in historical contexts.

The second part focuses on GIS analysis of the landscape context, especially in relation to Early Medieval settlements in the Eastern Alpine region. An overview is given of previous studies analysing settlements based on environmental factors such as soil type and topography, highlighting the influence of agricultural potential on settlement patterns. It also discusses the theories of central land cores and site-catchment analysis, and illustrates how modern GIS methods enhance the understanding of settlement landscapes by providing realistic estimates of land use areas based on DEMs and time-distance computations.

Keywords: archaeology, LiDAR, airborne laser scanning (ALS), geographic information systems (GIS), site-catchment.

1. ARCHAEOLOGICAL LIDAR

This chapter presents the methodological background shared by the Leibnitzer Feld (Lozić, Koch 2024 in this volume) and Bled (Lozić 2024 in this volume) studies.

Light Detection and Ranging data (hereafter LiDAR) is used in archaeology for the visualisation and detailed morphological analysis of the archaeological landscape. First and foremost, LiDAR has become an essential component of archaeological prospection as a tool for detecting archaeological features (Devereux et al. 2005; Thompson 2005; Chase et al. 2011; Evans 2013; von Schwerin et al. 2016; Canuto et al. 2018; Inomata et al. 2018; Menéndez Blanco et al. 2020; Stanton et al. 2020; Swieder 2021). The free availability of LiDAR data in Slovenia since 2015 (Triglav Čekada, Bric 2015), for example, has led to the discovery of numerous archaeological sites and features – such as prehistoric settlements, prehistoric and Roman field systems, Roman military camps, and Late Antique settlements (Štular 2011; Laharnar et al. 2015; Bernardini et al. 2015; Bernardini, Vinci 2020; Mlekuž 2018; 2013) – especially in densely forested areas. In addition, LiDAR data allows the observation of any site or feature at different scales (Crutchley 2009; Crow 2010; Doneus, Kühteiber 2013). From the large "human" scale, which provides overwhelming detail at the intra-site level, to the small landscape scale, where patterns of site distribution can be easily observed, they have enhanced our understanding of archaeological and historical landscapes. However, LiDAR data is only suitable for detecting those archaeological features that are visible in the terrain morphology (Štular et al. 2021). Therefore, the impact of LiDAR data on archaeology as a discipline has been uneven. One area of limited impact has been the detection of Early Medieval settlements in the Eastern Alpine region (hereafter EMS). EMS are preserved almost exclusively as scarce remains of wooden structures in the form of minute post holes, while the remains of larger buildings, stone architecture, and larger earthworks are almost non-existent (e.g., Pleterski 2010). Therefore, EMS are not discernible in the terrain morphology and thus cannot be detected directly with LiDAR data or any other type of archaeological prospection.

However, in addition to the archaeological prospection, LiDAR data can also be used for landscape reconstruction (e.g. De Boer et al. 2008; Coluzzi et al. 2010; Prufer, Thompson 2016), in a process known as deep interpretation (Doneus, Kühteiber 2013; Lozić, Štular 2021). Such applications open up a wide range of research opportunities and approaches, for example the reconstruction of historical geographical elements, paleogeographical analysis (De Boer et al. 2008; Pierik, Lanen 2019), and the archaeology of agricultural land use. We follow this approach and are particularly interested in understanding archaeological sites in their land use context. This is possible because LiDAR provides the landscape configuration in the form of a high-resolution digital elevation model (hereafter DEM). The DEM allows us to provide measurable parameters and qualitative and quantitative characterisations of the landscape configuration and thus objectively define physiographic regions. When these are correlated with other environmental factors such as soil type, hydrology, and geological data, sites can be accurately characterised.

The focus of the use of LiDAR in this volume is on agricultural land use and its direct or indirect influence on settlement location choice. Landscape configuration undoubtedly had an influence on the potential for agricultural land use in the archaeological past, and LiDAR data have recently been used for this purpose (e.g. Weishampel et al. 2013; Ringle et al. 2021; Schroder et al. 2021). And under conditions of agricultural subsistence economy, agricultural land use in turn has an important influence on the choice of settlement location (e.g. Kos 1970; Zeman 1976; Wawruschka 2009; Pleterski 2013). This is not to say that there are not many other factors that can significantly influence settlement patterns in different areas and at different times, for example cultural (Hamilton et al. 2018), historical (Casana 2007), social (Carboni 2015; Duncan-Jones 2004; Mensing et al. 2018; Tuan 1980) or climate (Huebner 2020; Lawrence et al. 2021). However, like most of the studies cited, we focus on one that we consider to be the most important in this particular context.

2.1. GIS ANALYSIS OF THE LANDSCAPE CONTEXT

Archaeological GIS is a broad topic which is relatively well known and published (e.g., Gillings et al. 2020; Štular, Eichert 2020). The aim here merely to provide a brief overview of the scientific background on the topic of GIS analysis of the landscape context in Early Medieval archaeology relevant to our case studies Leibnitzer Feld (Lozić, Koch 2024 in this volume), Bled (Lozić 2024 in this volume), and the Drava plain (Dravsko polje; Magdič 2024 in this volume).

Previous attempts to understand the landscape context of Early Medieval settlements in the Eastern Alpine region (hereafter EMS) often reduced observations to height above sea level and soil type. One early analysis found that Slavs in Slovenia settled mainly in upland areas with dry soils and tended to avoid plains, narrow valleys, and wet soils (Kos 1970). In a preceding analysis of the Bled microregion the reconstruction of the field system located the most suitable areas for Early Medieval agriculture and concluded that local topography had a direct influence on the EMS location choice model (Pleterski 1986; 1987; 2013). A similar attempt to define the landscape type and soil type in which EMS occurs was made in Lower Austria. Under the term mesoregion, 36 EMS were analysed within their respective 5 km radii. Soil type and geomorphological context, which provided a description of the predominant landform types, were considered. The results showed that the EMS occur in two landscape types: (flood) plains and mountainous regions. Approximately half of EMS were located on alluvial river terraces, at least some of them within coeval floodplains on naturally elevated land. The other half of EMS was located in upland and hilly areas above 300 m a.s.l. In these areas, loess and brown earth soils were clearly preferred (Wawruschka 2009).

In the archaeologically relevant neighbourhood, river terraces and hills were also recognized as the predominant locations for EMS in Bohemia (Zeman 1976). Similar conclusions regarding landscape preference, habitat description, and soil conditions were also drawn for Great Moravia in Czech Republic (Měřínský 2002), Slovakia (Fusek 1994), and for several microregions in Slovenia (Krško polje: Rihter 2019; Prekmurje and Podravje: Magdič 2017; 2021; 2024 in this volume), and Bled (Knific 1984; Pleterski, Belak 1995). Somewhat different situation was detected for the sixth-century Slavs in the Northern Danube region (present-day Slovakia, Moravia, Czech Republic, and Upper Austria), who settled the lowlands in strategic locations along roads and at river fords, while mountainous terrain was avoided (Kazanski 2020).

Perhaps the most detailed study to date combined archaeology, written sources, and retrograde analysis of historical cadastres (Pleterski 1986; 2013a). It reconstructed the arable areas, which occurred in small patches scattered in the valley plains. Settlements were located adjacent to soils suitable for agriculture. The study was able to infer where and when the settlement took place with a great level of confidence, but not why and how.

These studies confirmed the theory of central land cores put forward for the Medieval settlement of present-day Slovenia by Ilešič (1950). He noted that each Medieval settlement initially had relatively little cultivated land on particularly favourable soils in the immediate vicinity of the settlement. As the settlement grew, the existing fields were divided up and new ones further from the village were asserted. Thus, the central land core became increasingly fragmented and the total area of cultivated land increased.

The theory of central land cores has good parallels with the site-catchment analysis proposed in the 1970s (Vita-Finzi, Higgs 1970). The similarities are not coincidental, as both are based on mid twentieth century human geography. The site catchment was defined as an area within which the exploitation of natural resources is economically justified. The area was proposed as 5 kilometres or an hour's walk for sedentary farming communities and the share of arable land was estimated to be between 5% and 10%. Flannery (1976b), Rossmann (1976), and Zarky (1976) empirically tested the model on Mesoamerican villages and found that the site catchment area was at least half and the share of arable land up to ten times smaller than in the original theoretical estimates. They concluded that the distance between villages was determined by social rather than ecological factors.

Similar conclusion was reached for the Early Medieval Bled microregion, where the site catchment for the field was estimated to be 7 minutes walking distance (Štular 2006, 200). Modern studies of the site catchment reinforce the distinction between the exploitation area and its social status, i.e., direct exploitation is not the same as the area that is claimed to define the political status of a settlement (Seubers 2016). The key advantage of modern studies is that the catchment area is no longer forcefully simplified into circles, but is much more realistically estimated in terms of time of walking or energy expended. This is achieved in GIS by computing the time distance based on DEM and realistic formulas obtained through experiments (Langmuir 1984; Tobler 1993; Štular 2006; Richards-Rissetto, Landau 2014; Field et al. 2019).

The data for the Bled case study (Lozić 2024 in this volume) and Drava Plain allowed (Magdič 2024 in this volume) to implicitly implement the theory of central land cores, whereas in most archaeological case studies only the site catchment theory can be applied. The latter was the case for the Leibnitzer Feld (Lozić, Koch 2024 in this volume).

As a note, it should be mentioned that EMS within floodplains would have severely restricted access to agricultural land. This suggests that the exploitation of riparian vegetation and other resources must have played an important and hitherto neglected role in Early Medieval economic life. The riparian zone was able to provide for fish, freshwater crabs, various edible plants; wild vines and similar could be gathered without having to invest in cultivation. Reeds for covering houses, but possibly also for making vessels, and willow twigs for building wattle walls in house construction could be gathered in the floodplain forests, as well as wood for timber construction (Wawruschka 2009; Rihter 2019).

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