Summary in English

European research into the archaeological, historical and heritage dimensions of landscape is extremely varied. In terms of spatial scale, studies may vary from the national landscape in its international context to the unique landscape settings of local histories or individual buildings. From a temporal perspective, the research field covers changes that took thousands of years, as well as thin time slices of only a few years. Over the last decade, the varied mosaic of studies, schools and orientations in European landscape research has led to various innovative research strategies such as Landscape Biography and the Recommendation on the Historic Urban Landscape adopted by UNESCO. Given the spatiotemporal nature of these approaches and landscape research in general, this dissertation researches the potential of Geographic Information Science (GIScience) for research into the archaeological, historical and heritage dimensions of landscape. Furthermore, the research presented is to be seen in light of a broader trend in science, the digital revolution which is transforming many research domains from data-scarce to data-rich.

The overall hypothesis of this dissertation is that, given the spatiotemporal nature of these landscape approaches, GIScience will offer many opportunities to facilitate landscape research. This dissertation aims to provide an insight in the various opportunities of GIScience tools and approaches in this research domain. The main research question is: what significant contributions can recent methods and technologies from GIScience make to innovate the research on the archaeological, historical and heritage dimensions of landscape in light of the digital revolution in academic research? To answer this question four trends have been identified which have been further investigated in this dissertation.

I. First, we have identified that the growing corpus of spatial information generated by the digitalisation of historical sources and archaeological research calls for a digital Spatial Data Infrastructure (SDI) approach. A SDI would enable landscape researchers to better explore, exchange and combine this increasing amount of digital data and information about the history, archaeology and heritage of the landscape. It would allow them to make new connections and comparisons by cross-cutting existing boundaries between different disciplines, time periods and geographical areas.

II. Second, we have observed a trend of landscape researchers working in a more inter- and transdisciplinary way for the purposes of heritage planning. Here we hypothesize a key role of GIScience approaches to translate conceptual innovative landscape methods and tools into digital spatially oriented knowledge interaction tools.

III. Third, we have identified a high potential to apply 3D geospatial technologies for the analysis of landscapes composed of complex structures. 3D technologies offer
new methods to analyse such landscape exchange knowledge on an inter- and transdisciplinary level, yet the application of such technologies in the field of historical, archaeological and heritage landscape research is in an early stage of development and case studies are required where its usefulness and added value can be evaluated.

IV. Fourth, we have witnessed a shift in landscape research towards studying long-term processes on a regional scale. Landscape researchers attempt to apply complex spatial simulation frameworks, which integrate socio-cultural and biological physical factors. Yet, complex models that integrate multiple factors are scarce.

This dissertation provides an in-depth analysis of the opportunities of GIScience for the research on the historical, archaeological and heritage dimensions of landscape. It does so through a series of peer-reviewed research articles, each addressing one or multiple topics listed above.

The dissertation starts with a chapter containing a qualitative analysis on how a SDI can be developed that facilitates the research of the historical, archaeological and heritage dimensions of landscape (Chapter 2). The next chapter addresses the challenges of trans- and interdisciplinary knowledge exchange of urban historical and heritage landscapes (Chapter 3). In this chapter heritage management arrangement tools recommended through HUL are extended with digital methods and digital tooling from the GIScience domain. It presents the design, deployment and evaluation of a heritage instrument, the “digital cultural biography” (DCB), to allow future oriented disciplines to make more historical and heritage informed decisions. This chapter presents a methodology to collect and disseminate geographic information across disciplines by applying the Biography of the Landscape research strategy. Furthermore, it presents how to translate such a landscape approach into a digital heritage instrument using the most recent geospatial technologies. Finally, it presents the applicability of this instrument by evaluating the added value in the course of a design experiment for the neighbourhood of Testaccio in Rome. Furthermore, we have set up an evaluation framework using methods such as technology acceptance and landscape valuation.

Chapter 4 presents a case study for the development of a 3D geospatial application for the complex multi-layered archaeological landscape of the Via Appia Antica near Rome. The highly complex and multi-layered nature of the study area provides a suitable laboratory to research how 3D technologies can handle large datasets and facilitate archaeological and heritage analysis of complex landscapes. This chapter exists of two articles. The first article presents the development of a 3D digital geospatial tool from the perspective of the archaeological domain. The second article provides a more technologically in-depth approach for the GIScience research community that studies ways to virtually represent complex study areas.

For the fifth chapter, a simulation framework to study long-term land-use change is introduced. The aim of this chapter is to research how this simulation framework can
integrate cultural and natural factors in order to understand long-term spatial developments. The basic principle of the framework is that it simulates land-use patterns based on estimated regional demands for various types of land use and local assessments of suitable locations for these uses. To balance the demand for land for different types of use with the supply of suitable locations, a logit-type approach is applied that simulates the competition for land. Like chapter four, this chapter also exists of two articles. The first article introduces the modelling framework and applies it to the western part of the Lower Rhine region during the early- and middle-Roman periods. It evaluates hypotheses posed by other researchers on the demand for food producing land-use types by running various scenarios. The second article elaborates on the model by extending the time range to the early medieval period and focuses on the eastern part of the Dutch Rhine-Meuse delta. In addition, this second article introduces a demographic model producing different scenario configurations on the demand for land for different purposes.

The main findings of this dissertation can be summarized as follows:

- This dissertation has provided an answer to how methods and technologies from GIScience can aid the research on the history, archaeology and heritage of the landscape. The research has shown that the opportunities of 3D technologies for the analysis of complex sites are promising, that these are still relatively new and that, especially from a technological perspective, more developments need to take place. Furthermore, the research has demonstrated that a simulation modelling framework and tools that include social-cultural factors to analyse long-term spatial processes is an upcoming field, but that the impact of this type of research is still limited due to its complexity. Finally, it has shown how an innovative landscape approach, i.e. the landscape biography, can be translated into a geospatial instrument to facilitate trans- and interdisciplinary knowledge exchange interactions.

- Considering the growing corpus of spatial information in landscape research, all chapters have provided valuable insights into the technological innovations related to the concept of Big Data. The research has demonstrated that new methods and tools are required and that an infrastructural approach is inevitable. The DCB approach presented in Chapter 3 anticipates a data-rich situation for landscape research. The changing data landscape will allow methods such as the DCB approach to be applied in a more extensive and standardized way. The study has thus not only demonstrated the potential value of the DCB approach to foster trans- and interdisciplinary knowledge exchange, but also the potential for GIScience SDI tooling. Chapter 4 has offered a strategy for 3D data landscape information which exceeded the available technological capabilities. It offers a technological solution by developing different visualisation and analysis interfaces to handle these large and complex datasets.
This dissertation has also demonstrated how to develop geospatial technologies for different users with heterogeneous disciplinary backgrounds and various IT- and geospatial-skill levels, by applying a user-centric approach. The theoretical framework for this has been provided in Chapter 2 and implemented in Chapters 3 and 4, for which geospatial tools were developed in close collaboration with the users. In Chapter 3 this led to the use of innovative geospatial technological instruments, i.e. mobile tablets. In Chapter 4 a data infrastructure was set up with various clients for different purposes aimed at different types of users.

Finally, this dissertation shows how GIScience methods and technologies can be systematically evaluated, and how these evaluations can teach us how to improve them. It is interesting to point out the difference between the ease of use and the usefulness. These considerations should be taken into account when applying a user-centric developing strategy.

The dissertation applies a theory-driven research approach. It advocates the embedding of GIScience, Data Science and landscape research in multidisciplinary research teams. In other words: researchers with an interdisciplinary perspective who understand the main issues in both landscape research and GIScience are necessary to innovate landscape research in the perspective of the digital revolution with respect to Big (spatial) Data.

To conclude, this dissertation has demonstrated that recent developments within the GIScience domain have a great deal to offer for landscape research. It has shown the opportunities provided by GIScience for better exploring, exchanging and combining the increasing amount of digital data and information about the archaeology, history, and heritage of the landscape. It is urgent to make use of the knowledge from this dissertation to generate additional new insights on past dynamics and the incorporation of past features in the current landscape. The results of the dissertation can be an important source of inspiration: the results are evidence of a broader breakthrough in the way to look at and think about the landscape. Landscape representations are no longer static flat-drawn but are digital, multi-layered, dynamic, and in virtual 3D.