APPLICATIONS OF GIS IN LANDSCAPE DESIGN RESEARCH

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Introduction

Despite its widespread availability there is evidence that GIS is underused in the realm of landscape architecture and related disciplines (Drummond & French, 2008; Göçmen & Ventura, 2010). Though recognized as a useful tool for mapping and planning, the potential of GIS is often still underutilized due to a lack of awareness and prejudice. This paper explores some concepts of GIS-based analysis which link to the very heart of landscape architecture in a natural and intuitive way. Hence the possibility to break down barriers of using GIS in landscape architecture this paper aims to put forward some characteristic principles of study and practice in landscape architecture which can be made operational via GIS while cultivating spatial intelligence by means of geo-information technology. Here the focus is on applications of GIS in landscape design research – investigating landscape designs to understand them as architectonic compositions (architectonic plan analysis) (Steenbergen et al. 2002). By exploring landscape architectonic compositions with GIS we can acquire design knowledge that can be used in the creation/refinement of a new design (Nijhuis, 2014). Like other tools, such as microscopes and telescopes, GIS can help landscape architects to see what cannot be seen by the naked eye, realistically simulating past, present and future situations or superimposing information for means of analysis.

The next section addresses landscape architecture and its principles of study and practice, followed by an exploration of how these principles can be made operational elaborating on GIS-applications in landscape design research. The paper closes with some conclusions.

Landscape architecture: principles of study and practice

Landscape architecture is according to the International Federation of Landscape Architecture (IFLA): “A profession and academic discipline that employs principles of art and the physical and social sciences to the processes of environmental planning, design and conservation, which serve to ensure the long-lasting improvement, sustainability and harmony of natural and cultural systems or landscape parts thereof, as well as the design of outdoor spaces with consideration of their aesthetic, functional and ecological aspects” (Evert et al., 2010, p. 509). Within this broad definition there are three main areas of activity: landscape planning, landscape design and landscape management (Stiles, 1994;

Thompson, 2008). These activities overlap and address different spatial levels of scale with different degrees of intervention. They require a multi-layered understanding of landscape regarding its spatial structure, development over time, the relational context, as well as the ecological, economic and social processes involved. Hence, over time a repertoire of principles of study and practice typical for landscape architecture has been developed to understand landscapes as (I) three-dimensional construction, (II) history, (III) context/scale-continuum and (IV) process (Nijhuis, 2013; cf. Prominski, 2004; Marot, 1995). These principles and their interplay are considered to be characteristic for landscape architecture and are embedded in theories, methods/process and products of design; landscape architecture's body of knowledge.

Particularly the products of design – landscape architectonic compositions – embody a great wealth of design knowledge regarding the application of the principles. In general landscape architectonic compositions carry knowledge about how to satisfy certain requirements, how to perform tasks, and it is a form of knowledge that is available to everyone (cf. Cross, 2006). The concept 'composition' refers to a conceivable arrangement, an architectural expression of a mental construct that is legible and open to interpretation. In that respect the landscape design is regarded as an 'architectonic system' by which rules of design common to all styles are established (Colquhoun, 1991; Steenbergen et al., 2002). By studying landscape architectonic compositions landscape architects can acquire knowledge of the possible relationships between conceptual thinking and the three-dimensional aspect (Steenbergen & Reh, 2003). Landscape design research is a vehicle to acquire knowledge of spatial composition via architectonic plan analysis. It is a matter of developing and deploying spatial intelligence, the architectural capacity or skill to think and design in space and time (Gardner, 1999). In short: understanding is the basis for intervention. This implies that landscape design research is at the core of landscape architecture. But how can we apply GIS in landscape design research?

GIS-applications in landscape design research

There are at least three operations in which GIS could be useful for landscape design research exploiting GIS in its powerful integrating, analytical and graphical capacities (Nijhuis, 2014):

- Spatial modelling: description of existing and future landscape architectonic compositions in digital form;
- Computer-aided architectonic analysis: exploration, analysis and synthesis of landscape architectonic compositions in order to reveal new or latent architectonic relationships, while utilising the processing capacities and possibilities of computers for ex-ante and ex-post evaluation via measurement, simulation and experimentation;
- Computer generated visual representation: representation of (virtual) landscape architectonic compositions in space and time in order to retrieve and communicate information and knowledge of landscape design.

These operations have a great potential for measurement of relevant and new aspects of landscape architectonic compositions, as well as offering an alternative ways of understanding them. In particular while using the typical principles of study in landscape architecture as a point of departure for computer-aided architectonic analysis a ‘toolbox’ emerges for GIS-based landscape design research. This toolbox consist of a set of GIS-analysis methods and techniques stratified according the typical principles of landscape architecture. In that way concepts of GIS-based analysis can be linked and deployed in accordance with the experience of landscape architects.

(I) Understanding landscape architectonic compositions as three-dimensional construction

In this principle the focus is on GIS-applications for exploring the landscape architectonic composition ‘from the inside out’, as it could be experienced by an observer moving through space using concepts of GIS-based visibility analysis (e.g., viewsheds, isovists) and virtual 3D-landscapes. Here GIS is employed to explore the visual manifestation of open spaces, surfaces, screens and volumes and their relationships in terms of structural organisation (e.g., balance, tension, rhythm, proportion, scale) and ordering principles (e.g., axis, symmetry, hierarchy, datum, transformation) (cf. Bell, 1993). The basic premise is that the shape of space, plasticity (form of space-determining elements) and appearance (e.g., colour, texture, lighting) of spatial elements in the composition determine the relation between design and perception. GIS-based landscape design research addresses the form and functioning of three-dimensional landscape space, which creates a certain spatial dynamic. Here GIS is employed to study the framing of a landscape or urban panorama, or the construction of a spatial series along a route, making a pictorial landscape composition (Figure 1).

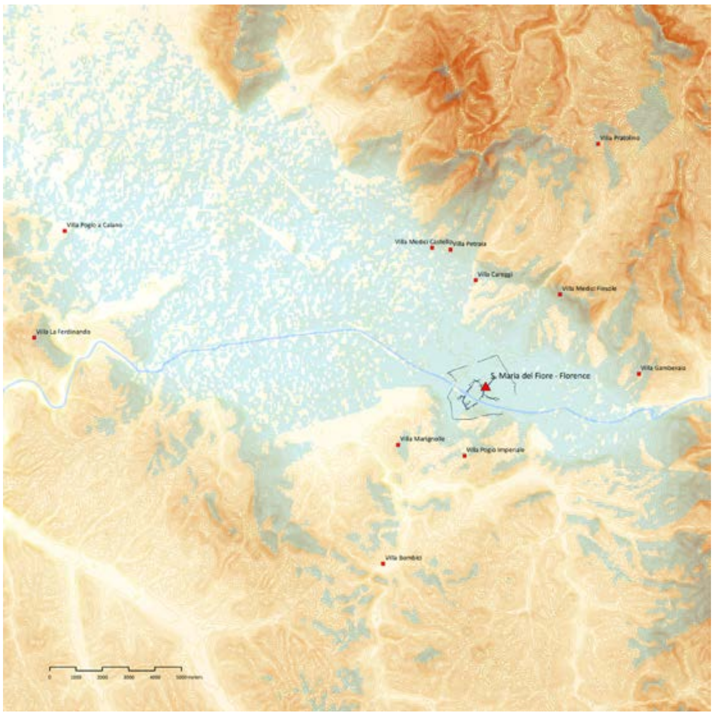

Figure 1: The visibility of the Duomo of Florence (Italy) is an important feature for the allocation orientation of famous Italian Renaissance villas and their gardens in the hilly countryside around the city. GIS-based viewsheds, taking into account atmospheric circumstances, helped to identify important visual relationships (source: S. Nijhuis)

(II) Understanding landscape architectonic compositions as history

GIS-applications focus on 'reading' the landscape as a biography, as a palimpsest that evidences all of the activities that contributed to the shaping of that landscape. Here the landscape architectonic composition is regarded as a layered entity where traces that time has laid over can reinforce or contradict each other. Knowledge of these layers is one of the starting points for new transformations of the composition involved, or adding a new design layer. This principle involves the evolution of the composition over time and investigates operations of 'erasing' and 'writing' history (Lukez, 2007). Operations of erasing history include: complete or partial eradication, etching, excision, entropy and excavation. Operations of writing history include: parcelling, infill, addition, absorption, enveloping, wrapping, overlay, parasitize and morphing. Here GIS is employed to get to know the historical situation and the development of the composition via time-slice snapshots. Via the construction of GIS-based virtual historical landscapes of a certain time-slice snapshot or comparisons of several of them (via overlay, attributes or in a series) the dynamics and change over time can be explored (Figure 2).

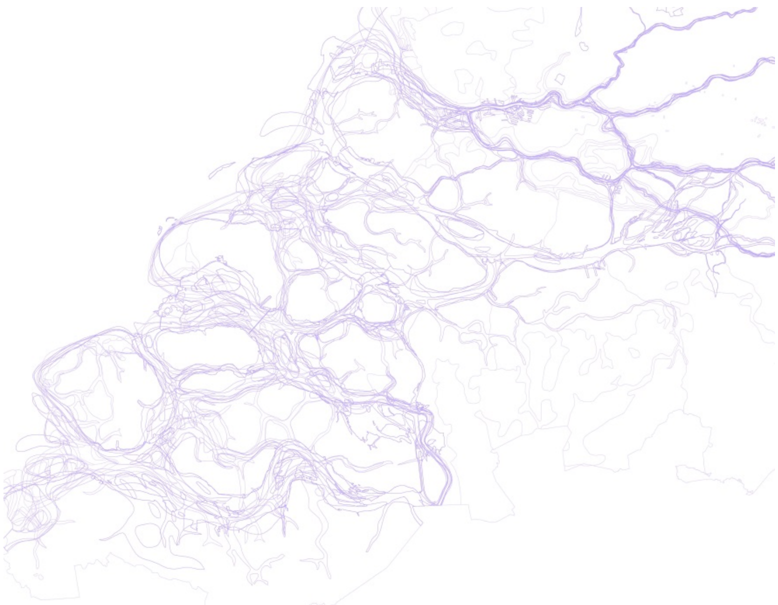

Figure 2: GIS-based mapping of change in space and time via overlay. Different time-slice snapshots from different eras of the land-water contour are combined in a composite space-time map in order to show the dynamics and development of the southwest Dutch Delta (Source: Nijhuis & Pouderoijen, 2014)

(III) Understanding landscape architectonic compositions in context

In this principle the focus is on GIS-applications addressing the landscape architectonic composition as being part of a scale-continuum. The level of scale of a composition under study is important, because any size larger than that of the study area supposes a 'larger context', but any size smaller than that of the smallest detail supposes context as well (De Jong, 2006). The composition is considered to be part of a relational structure connecting scales and spatial, ecological, functional and social entities. GIS-applications focus on exploring topological (vertical) and chorological (horizontal) relationships, the embedment of a specific site or location into the broader context at different scale levels. Here spatial patterns are studied by map dissection (selection and reduction) as a basis for spatial association analysis, which explores the relation between different patterns. Techniques for spatial association analysis are overlay analysis and cross-reference mapping. Here GIS is employed to explore for instance the position of the designed landscape in its natural, cultural or urban context on multiple scale levels (Figure 3).

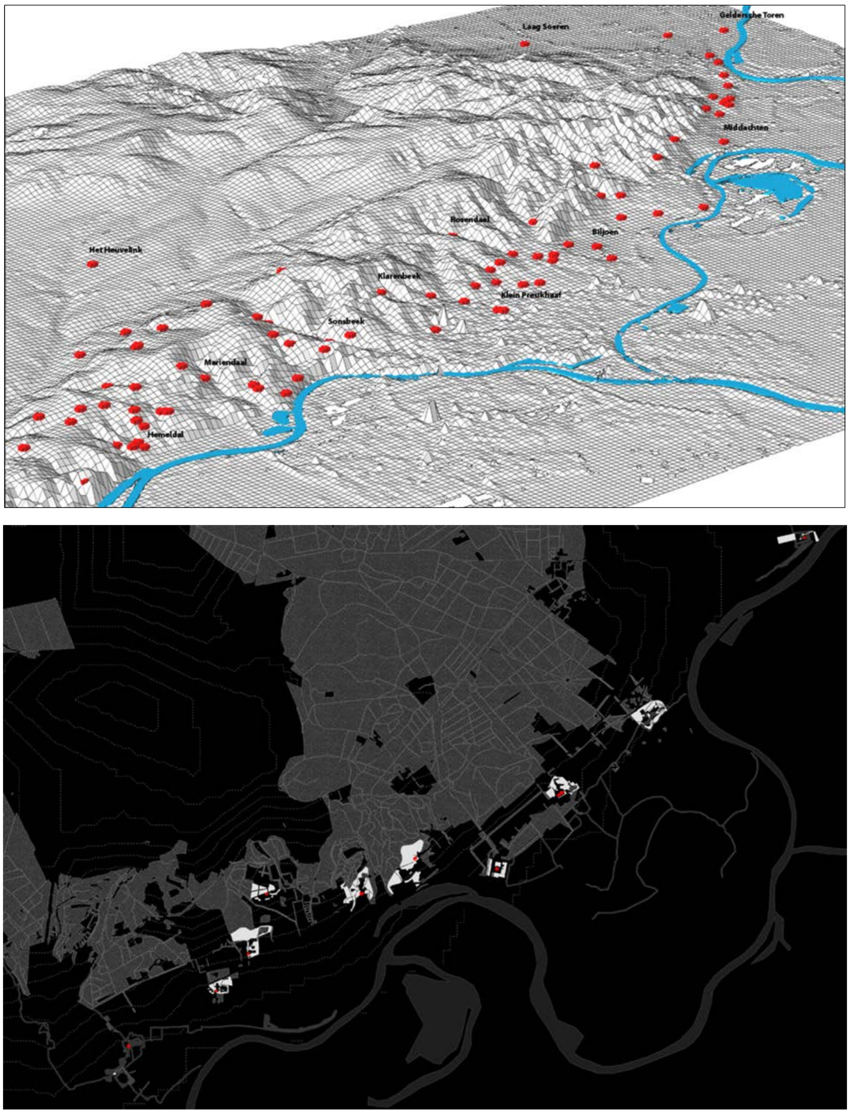

Figure 3: GIS-based spatial association analysis of the distribution and allocation of historical estates of Guelders Arcadia (near Arnhem, Netherlands) in the natural landscape dominated by the ice-pushed ridges of the Veluwe-East (top) and analysis landscape architectural compositions of selected individual estates which show a remarkable sensitivity towards natural conditions (source: S. Nijhuis)

(IV) Understanding landscape architectonic compositions as process

GIS-applications focus on the interaction between landscape processes and typo-morphological aspects and address aesthetic, functional, social and ecological relationships between natural and human systems. The landscape architectonic composition is regarded to be part of a holistic and dynamic system of systems as an expression of the interplay between formal aspects and interaction between ecological, social and economic processes (Zonneveld, 1995). The composition is considered as an ongoing process rather than as a result. Natural and social processes constantly change compositions, making the dynamics of the transformation a key issue in research and design. Here GIS is employed to understand the landscape as a system employing geo-computational models (deterministic or stochastic) such as morphological models exploring the social logic of space, or ecological process models investigating the spatial development and expression ecosystems (Figure 4). Also time-geographic models, traffic and transport models, planning models, economic models, cognitive models, multi-actor models, building technology and logistical models, hydraulic engineering models, nature and environmental models, agricultural models, energy models are of use. Spatial association analysis and (automatic) construction of virtual 3D landscapes are useful analytical operations.

Figure 4: The spatial distribution and expression of ecosystems is depicted through a combination of GIS, models of planting physiology and real-time rendering. Simulation of alpine plant communities in the UNESCO biosphere reserve Entlebuch in Switzerland (Source: Philip Paar, Wieland Röhricht, Olaf Schroth and Ulrike Wissen, Lenné3D & ETH Zürich, 2004)

In conclusion

The here briefly discussed toolbox for GIS-based landscape design research is not about presenting new GIS-analysis methods and techniques. It rather re-presents or frames useful GIS-concepts from the perspective of landscape architecture. Hence, this toolbox embodies a way of thinking typical for landscape architecture which is visible in landscape architecture theories, planning and design processes and products. It offers the possibility to link concepts of GIS-based analysis to the very heart of landscape architecture in a natural and intuitive way in the hope to break down barriers of using GIS in landscape architecture. The typical principles of landscape architecture can also serve as a basis for cultivating spatial intelligence by means of geo-information technology while raising awareness and take away prejudice. It can serve as a basis for the academic underpinning and the development of a digital culture in landscape architecture exploiting GIS in its powerful integrating, analytical and graphical capacities. Educational and research institutions have an important part to play, they must take the lead in inspiring students and practitioners, building up their knowledge and passing it on, and adding new tools to the traditional craftsman's toolbox.

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