# Mapping Spatial and Visual Landscape Characteristics:

# A Review of Quantitative Mapping Methods and Tools

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## 2 Background

### 2.1 Landscape as a changing phenomenon

Landscape as an area, set and perceived by people, including agriculture, small town (cultural landscape), nature resource (natural landscape), green and blue infrastructure (urban landscape), facilitates interaction between nature and human (Council of Europe, 2000; Council of the Environment and Infrastructure, 2015). However, it is not constant. All the adaption of climate issues, urbanization, growing population etc. cause irreversible landscape changes. With the expansion of dense urbanized areas, the crowed landscape shifts to fragment into small pieces, which results in the disappearance of several distinctive landscape elements. From this perspective, for both the authorities and the public, identifying appreciated landscape characteristics has played an essential role in landscape protection, design, planning and management. Additionally, visual landscape studies comprising all visible aspects and visual effects, have become one of the most intuitive and efficient approaches to classify and measure landscape characteristics with various of theories, methods and tools.

### 2.2 Landscape character assessment

From the 1970s, different landscape character assessment guidelines and tools have been gradually introduced to help recognize, predict and evaluate effects of landscape changes and gather information to provide better understandings for landscape sustainable development. Environmental Impact Assessment (EIA) has been initially announced to assess the effects of certain projects in the United Kingdom, and then become a key environmental management instrument used all over the world. In addition, as an important basis of strategic environmental assessment, Landscape and Visual Impact Assessment (LVIA) emphasizes on the influences of change on landscape itself and visual amenity. Since the 1990s, European Landscape Convention (ELC) commits to formulating common standards and principles by means of Landscape Character Assessment (LCA) to guide regional and national landscape decision-making process. As a mapping tool, LCA mainly via landscape character maps, typologies and indicators is widely used for monitoring and evaluating landscape features and has already applied in various aspects (Wascher, 2000; 2005). These approaches contribute to the assessment of spatial quality, but also reflects on the significance of capturing spatial and visual characteristics for landscape policy.

### 2. 3 Visual landscape research in academia

Inspired by the establishment of the second national memorandum which puts landscape characterization and visual landscape research into planning and management agenda, a number of scholars and researchers in different universities, organizations and institutes are absorbed in classifying and mapping rural landscape through spatial and visual landscape aspects and techniques. There are four main themes over time can be divided, which are the development of visual landscape concepts, computational methods and tools, perception approaches and GISc in landscape architecture.

(1) Visual landscape concepts

From the design perspective, visual research primarily develops to measure visual impacts of architectures in urban areas or in landscape domains and explore visual perception in built environment, represented by several case studies in Rotterdam, Antwerp and Delft (Wentholt, 1968; Steffen and Van der Voordt, 1978; Prak, 1979; Bouwman, 1979; Korthals Altes and Steffen, 1988; Steenbergen, 1985, 1990). In addition, De Veer and Burrough (1978) do the only English review to introduce and summarize the initial development of Dutch physiognomic landscape (visual landscape) mapping techniques in the years between 1966 and 1976, exemplified by the work of Schuurmans and Van Schie (1968), Vrij et al. (1976), Smit (1976), De Veer et al. (1977), Van der Ham et al. (1970), Kerkstra et al. (1974), Koster and De Veer (1972) and Maarleveld and De Lange (1972). Case study and potential users’ survey are used to achieve and compare different methods applied for defining landscape classification and describing spatial and visual characteristics for landscape design, planning and management.

(2) Computational methods and tools

From the 1980s, computer-assisted approaches show flexibility and specificity to meet diverse demands and provide consolidated methods on visual landscape researches. Applications of computational techniques are introduced, such as Burrough et al. (1982), Van den Berg et al. (1985), and Dijkstra (1985). Meanwhile, GIS techniques come into use in landscape researches, as by Buitenhuis et al. (1986), Piket et al. (1987). Since the 1990s, Palmer and Roos-Klein Lankhosrt (1998) develop a series of measurements and models for spatial and/or visual related landscape indicators, which aim to identify and investigate landscape characteristics in a more explicit way.

(3) Landscape perception approaches

In the late 1980s and early 1990s, based on the psychological theories, a vast amount of researches on landscape perception are joined in the visual landscape studies by the work of Boerwinkel (1986), Coeterier (1987, 1994, 1996), Van den Berg (1999).

(4) GISc and environmental psychology in landscape architecture

The past decades have demonstrated it is indispensable to do visual landscape researches for describing landscape characteristics and assessing landscape quality in order to guide landscape decisions in the Netherlands. However, as academic interest, visual landscape studies are developed to merge specific aspects like geographic, environmental, spatial, human and social issues together, through theories, methods and technologies to find solutions to balance the artificial structures and nature. Since the 1990s, some scholars have deliberated the possibilities of combining and merging GISc and environmental psychology into landscape architecture approaches, and proposed to use indicators to describe landscape characteristics more precisely, as by Alphen et al. (1994), Palmer (1996), Palmer and Roos-Klein Lankhorst (1998) and Dijkstra and Van Lith-Kranendonk (2000). Specifically, De Veer and Burrough (1978) propose and define three approaches to map the visible landscape: the compartment, the field of view and the grid cell approach. The compartment approach considers the visible landscape as a set of concave compartments that can be characterised by size or shape, the type of border and their content. The field of view approach is based on measurements of fields of view and mapping sightlines from the observer’s position in the landscape. The grid cell approach samples the landscape by a tessellation of (mostly square) grid cells, for which one or more variables are measured and used to classify the cell density and complexity or to assign a type to it (De Veer and Burrough, 1978; Palmer and Roos-Klein Lankhorst, 1998).

## 3 Methodology

The main objective of this paper is to present a methodological review of the literature centred on quantitative mapping methods and tools of spatial and visual landscape spaces more inter-subjectively. In order to achieve it, relevant research articles on visual landscape research were viewed after searching Scopus, Web of Science and Google Scholar database in March 2017. The literature has been selected using five filters. First, articles focusing on 1) landscape character assessment, 2) computational landscape methods and tools, 3) landscape perception approaches, 4) GISc-based landscape research and 5) environmental landscape psychology are selected based on the content of their abstracts, title and keywords, which result in a total of respectively 102 and 91 articles. Subsequently, these articles are filtered by subject area (environment science), year (after 2012), source type (journals), document type (article), and language (English and Chinese), resulting in 45 and 39 articles respectively. Finally, these articles have been read in depth and only, articles are selected that provided specific quantitative methods and tools of mapping landscape spatial and visual characteristics.

Based on the related articles, the last decennia, the number of processing methods and techniques to map the visual landscape increased, new algorithms were developed allowing the determination of new indicators for the visual landscape. Important are stereometric three-dimensional (3D) analyses that complement the planimetric two-dimensional (2D) ones. Referring to the Dutch academic context, the following groups of methods and techniques can be categorised as six main groups: grid cell analysis, landscape metrics, viewsheds, isovists and virtual 3D-landscapes, eye-tracking analysis.

(Section 4 will be the result of this paper describing the above six different mapping methods and tools with case study in detail.)