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Landscape liveability spatial assessment integrating ecosystem and urban services with their perceived importance by stakeholders

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ABSTRACT

In recent years, landscape liveability has become a leading objective in policy and strategic planning. In the anthropocentric view of landscape, ecosystems fulfil important societal needs similarly to urban systems. Urban systems can meet a variety of such needs through Urban Services, which are historically and typically provided within cities. In this view, Ecosystem Services (ES) and Urban Services (US) influence landscape liveability in a comparable manner, so that liveability assessments based on both ES and US can be effective for landscape planning and policy-making purposes. As liveability is strongly dependent not only on objective landscape features, but also on the subjective perception of stakeholders, their involvement becomes essential for a coherent liveability assessment. The present study aims to develop a LIveability Spatial Assessment Model (LISAM) capable of considering both the local accessibility of services and their perceived relevance as expressed by stakeholders. To this end, a conceptual framework to detangle the spatial relationships between service sources, sinks, and delivery points was developed. From this base, consistent and comparable ES and US indices were calculated using GIS spatialisation techniques and then aggregated hierarchically through a Spatial Multicriteria Decision Making Analysis approach. Results include relevant maps showing explicit spatial indices of liveability that integrate, at various hierarchical levels, the local accessibility of ES and US, along with their local perceived relevance. By calculating complex indices able to highlight both the agri-natural and urban system roles on landscape liveability and by taking subjective and objective aspects into account, the model proved to be effective for spatial decision-making. In future applications, indicator and weight uncertainties should be considered and adequately analysed to assess reliability of the final output. The integration of ecosystem and urban disservices would also be relevant for including those landscape factors that reduce the overall level of place liveability.

1. Introduction

1.1. Ecosystem services in landscape planning

Landscapes maintain many important functions that provide numerous goods and services to society. In recent decades, research and technical efforts have been undertaken for the development of decision-making tools aimed at pursuing sustainability objectives in landscape planning. One of the most significant challenges has concerned the optimization of land-use spatial patterns, and the management of the services they generate, in view of social, ecological, and economic objectives (de Groot et al., 2010). In this context, the ecosystem services approach has been recognized as very promising for the development of sustainable policies and instruments that can more effectively integrate ecological perspectives into social and economic policies to improve their sustainability (Haines-young and Potschin, 2013; McLain et al., 2013; Müller et al., 2010). Ecosystem services (ES) can be considered as structural and functional ecosystem contributions to human well-being that occasionally occur in combination with other anthropogenic inputs (Burkhard et al., 2012). ES are primarily public services (e.g., air purification, groundwater recharge, or erosion prevention), but can also be private services (e.g., crop production). They are normally generated from natural resources, even though in several environmental systems the ecological processes and assets must be managed to deliver valuable services to humankind (Burkhard et al., 2014). Consequently, human inputs to natural resources (e.g., fertilizing, seeding, power plant construction) become an inseparable part of the ES supply process (Burkhard et al., 2014; Kroll et al., 2012). A wide number of studies have suggested new ways

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to integrate ES in landscape planning and management processes (e.g. Lebel et al., 2015; Plieninger et al., 2015) while also involving the local population in policy making (see e.g. Jeong et al., 2014; Norouzian-Maleki et al., 2015; Plieninger et al., 2015). In this regard, different authors (e.g. Hein et al., 2006; Muhamad et al., 2014; Orenstein and Groner, 2014) underscored that, for a more effective ES integration, explicit local demand for a wide set of services from a broad range of stakeholders should be considered.

1.2. Landscape liveability: conceptual background

Liveability standards are becoming a leading objective in policy and strategic planning (de Haan et al., 2014). The concept of liveability has traditionally referred to urban spaces (Howley, 2009; Pacione, 2003; Ruth and Franklin, 2014); however, it could become a key approach in the analysis and planning of the entire inhabited landscape. Liveability theory assumes that the perceived quality of life is dependent on both subjective characteristics of persons and objective qualities of landscapes (Costanza et al., 2007; Pacione, 2003; van Kamp et al., 2003). Veenhoven (1996) defined liveability of a nation as "the degree to which the provisions and requirements fit with the needs and capacities of its citizens". Capacities, in particular, are those personal abilities that allow people to deal with environmental or socio-economic features (which translate into requirements) of the place where they live. Thus, human needs and capacities are largely subjective, as influenced by human culture and personality, while provisions and requirements are objective, depending on the place of living. Veenhoven's definition can be easily adapted to the landscape liveability concept, determining that (1) liveability is dependent on the needs and capacities of inhabitants living in the environment, who should consequently influence the liveability assessment; and (2) liveability depends on the environmental characteristics, in particular services (provisions) and dis-services (requirements) provided by the environment. Focusing on environmental provisions (services), urban systems are traditionally able to deliver services for the fulfilment of human needs (de Haan et al., 2014) via the provision of urban services (US), which can be defined as public services and facilities that are historically and typically provided in cities (Tallon and Bromley, 2004; WAC 365-196-320, 2016). US are provided by society and include basic provisions such as sanitary sewer systems, domestic water systems, fire and police protection services, public transit services, recreational facilities, schools, and so on. For our purposes, ES can be distinguished from US at the local scale, since the latter can be provided independently from ecosystems within the area under investigation (even though their provision may sometimes depend on natural or urban system processes outside the local area). Evidently, US address human needs similarly to ES, which are widely recognized as influencing the liveability of places (Millennium Ecosystem Assessment, 2005; Norouzian-Maleki et al., 2015). In this view, liveability analysis based on the integrated assessment of both US and ES at the local scale provides a valid framework for planning and management purposes, since it can more effectively integrate natural resource management objectives with social and economic objectives (Antognelli and Vizzari, 2016).

1.3. Perceived importance of services

Various authors have highlighted that human preferences play a key role in the definition of liveability (see e.g., Leby and Hashim, 2010; Niemelä et al., 2010; Viegas et al., 2013). The European Landscape Convention indicates that the perception of a local population plays a key role in landscape analysis (Council of Europe, 2000). However, including stakeholder experiences in liveability characterization and quantification appears quite challenging since human preferences vary among individuals and groups of individuals (Norouzian-Maleki et al., 2015; Pacione, 2003; Shamsuddin et al., 2012). For this reason, the use of a liveability assessment method based on the integration of stakeholder preferences is highly recommended (Norouzian-Maleki et al., 2015). The perceived importance of ES and US to stakeholders concerning the overall landscape liveability has been previously assessed using a LIveability Assessment Model (LIAM) (Antognelli and Vizzari, 2016). LIAM development was based on a hierarchical classification, that included ES and US, derived from the Common International Classification of Ecosystem Services (CICES; Haines-Young and Potschin, 2013). Service weights on liveability were calculated using pairwise comparison matrices according to an Analytical Hierarchical Process (AHP, Saaty, 1980). The analysis of services that greatly influence the living experience and are provided by landscapes in diverse living places (Leby and Hashim, 2010) could thus give interesting views on landscape liveability in light of the weights resulting from LIAM.

1.4. Service mapping: background concepts and conceptual model

In mapping services for liveability assessments at a local scale, the spatial relationship between the place of production (the source), the place where services are delivered to the final consumer (the delivery point), and the place where services are used (the sink), must be considered (Bagstad et al., 2014; Gulickx et al., 2013). Since the spatio-temporal dimension of liveability can be identified in the human-environment interaction and the "here and now" notion (van Kamp et al., 2003), local availability and usability of services can be linked to the location of their *delivery points*. In recent ES literature, the concept of "service flow" was introduced to describe the spatial connection between ES sources and sinks (Bagstad et al., 2014; Fisher et al., 2009; Serna-Chavez et al., 2014). This concept assumes the possibility of spatially mismatched service sources, sinks, and, occasionally, delivery points. To better define the most common spatial relationships between source, sink, and delivery point, we considered the four types of ES demand described in a study by Wolff et al. (2015) (Fig. 1). According to this study, services can be *desired* or *used.* If they are *desired*, they are usually used indirectly, often without a real awareness, and they can be *desired for risk reduction* or simply *preferred*. Regulating services, such as flood regulation, are typically desired for risk reduction. However, the quantity of risk reduction provided at the delivery point is commonly related to local and complex spatial relationships between service sources and delivery points that are still unexplored. This makes the delivery points of regulating services difficult to map in most cases, despite the frequent overlap with sinks (i.e. for flood protection the service is delivered and used where the flood probability is reduced). *Preference* is typical of some cultural services, and characterizes mainly global services whose position of delivery points and sinks is not easy to define, since the use of this service is related to an intellectual perception rather than to a real use (e.g. the conservation of rare plant species or endangered wildlife). In this case, the definition of the service delivery points and sinks are often not univocal and therefore difficult to spatialise. There are also services *used directly*, which can be consumed (and so, should be properly called *ecosystem goods*) or used (so that they are services sensu stricto). This category of services can be moved across space by human action, so that the flow is recognizable and traceable. For example, local vegetables are produced on a farm, sold in a market, and used in yet another place, such as the consumer's home. Conversely, in the case of directly used services (mainly cultural and social services), the delivery point usually overlaps with the ES source and sink. For example, the use of woods for cycling implies a cyclist going to the woods in order to receive a benefit from the envi-