Indicator-based Landscape Assessment Matrix for Defining Land Use Priority Zones in the Salzburg FUA

Günter Gruber[1], Johanna Schmitt[2], Thomas Prinz[2]

[1]RSA iSPACE, Salzburg/Austria · guenter.gruber@researchstudio.at
[2]RSA iSPACE, Salzburg/Austria

Abstract: This paper presents GIS-based methods that help to make ecosystem services measurable and show the distribution and the supply of green spaces with different qualities in the functional urban area (FUA) of Salzburg by introducing natural recreation as an example of cultural ecosystem services. It displays the variety of services in a landscape assessment matrix and elaborates on innovative approaches to prioritize conflicting land use zones.

Keywords: Green infrastructure, spatial indicators, landscape assessment, GIS

1   Introduction

Green infrastructure provides ecosystem services that can be assigned to the categories "supporting" (e. g. nutrient cycling, soil formation), "provisioning" (e. g. food, fresh water), "regulating" (e. g. climate and water regulation), and "cultural" (e. g. aesthetics, recreation) (MA 2005). For the assessment of these services and the quality of green areas, the use of indicator systems has established itself as a valuable technique during the last years (cf. e. g. BURKHARD et al. 2009 or DE LA BARRERA et al. 2016). Several approaches of quantifying ecosystem services in rural or urban environments have been developed for studies at regional or national scale (DERKZEN et al. 2015) and various initiatives focusing on provisioning and regulating services, e. g. programmes to reduce land degradation in North Africa, were undertaken. However, cultural services have been neglected by most of these initiatives because they require different scientific methods (TENGBERG et al. 2012) and most of the few existing studies in this field only point to indicators for the assessment of *urban* green areas (e. g. VAN HERZELE & WIEDEMANN 2003) or tourist destinations (e. g. CHHETRI & ARROWSMITH 2008). Based on the concepts of geodesign (cf. GOODCHILD 2010), which use GIS potentials to supplement traditional planning techniques, this paper bridges this gap by providing an indicator-based approach for the assessment of the recreational value at a broader scale from an urban core to rural hinterlands and introduces a matrix to determine zones of recommended land use with respect to a balanced supply of services.

2   Methods

This paper refers to a GIS-based green space assessment framework developed within the scope of the transnational project *Urban Green Belts*. It includes five thematic pillars that present an increasing thematic depth and analytic complexity from maintenance to fair supply (cf. Figure 1). Project partners in several Central European countries use it for green space assessment, monitoring, and development based on their local challenges. All of the pillars

contain specific basic to key spatial indicators to analyse the variety of ecosystem services. For this paper, the implementations in Salzburg have been added to the overview, which now represents two green quality indices and their comprised indicators. The study area is characterized by a high share of green and covers a part of the functional urban area (FUA) Salzburg, which includes the city itself and ten municipalities located in its commuting zone. The city of Salzburg has approx. 150,000 inhabitants and consists of an urban core and rural fringes, while most other municipalities have a more provincial character.

The presented approach uses indicators assigned to the sustainability and attractiveness pillars that help to evaluate the different qualities of green spaces in terms of their recreational attractiveness and ecological value. These indicators are applied to 4,488 public green spaces from the national cadastre that belong to different categories like recreational areas, forests, or agricultural areas. The indices are used for the identification of high quality green. They are calculated in a GIS as equally weighted overlay of the single indicators using mainly input data from the Salzburg State GI System (SAGIS).

Thematic pillars				
Maintenance	**Sustainability**	**Attractiveness**	**Profitability**	**Fair Supply**
Dimension Inventory of various green space types and deduction of effort and costs for conservation	Support of a well-balanced supply of natural green space functions	Configuration and satisfaction of users as contribution to livability	Economic potential in terms of agriculture & forestry and tourism	Balanced fulfillment of the demand for green space services
Targets Monitoring and management support for public authorities	Analysis of natural functions for authorities and ecologists	Acceptance studies for planners and socio-psychologists	Capitalization options for developers and business people	Demand and competition analyses for regional planners and developers

Implementations in Salzburg
Data on green space inventory only used as input for other analytical steps
	Landscape Index
	
	- Relief diversity
	- Presence of water
	- Tree cover density
	- Quality of ecosystem services provided by land cover
	- Share of protected areas and biotopes
	- Noise zones
	- Wildlife corridors
	- Attractive forests
		Recreational Index
		
		- Path density
		- Number and variety of infrastructural elements like
		  • Playgrounds
		  • Sports fields
		  • Picnic sites
		
		To be complemented by users' perceptions
			Identification of high quality soils and productive forests for cultivation	**Near-distance supply of high quality green for residents**
				
				Matrix to identify priority and potential conflict zones

Fig. 1: Pillars and application potentials of green space assessment (own representation)

As a next step, for all green spaces achieving high values, buffer zones are calculated. In the case of green with a high recreational value, a threshold of 400m as an average walking distance for all demographic age groups is used. For areas with a high landscape quality, on the other hand, a threshold of 1000m is applied. These service areas are used to calculate the near-distance supply for residents. In this case, we decided not to use road network-based service areas since the results do not differ considerably at this spatial resolution.

For a solid delimitation of land use zones (e. g. settlement cores with high quality green supply in walking distance or interconnected green corridors of high ecological value in a certain distance to human activities) as defined in the Salzburg regional development concept (cf. AMT DER SALZBURGER LANDESREGIERUNG 2003), service areas of recreational areas and

ecological protection buffers are used. However, the results derived by this approach together with the economically relevant areas display conflicting zones of land use and demand the conceptualisation of a landscape prioritisation matrix. Both indices serve as input data for defining priority zones and are based on a standardised scale between 1 and 5 with 3 as medium and 4-5 as high value. Table 1 shows the criteria for indicating zones for recreation, close-to-nature recreation, and habitats. Recreation refers to an intensive recreational use supported by different types of infrastructure as taking place in areas like parks or playgrounds, while nature-oriented recreation refers to green spaces that still have some infrastructure, but are attractive mainly because of their natural beauty. Additionally, some other criteria are applied to specify recreation zones of outstanding value to the local residents, although they do not achieve the highest quality level. Other baseline data are used to define risk prevention and agriculture & forestry zones referring to the provisioning and regulating functions of green. The prioritisation of areas at first is made by individual decision of preferences in the form of a recreation scenario. In a next step, local policies are included to produce a more realistic and detailed result with regard to a well-balanced supply of different ecosystem services and local planning strategies and guidelines.

Table 1: Criteria for the definition of landscape priority zones

Priority zones	Criteria		Service area	Specifications
	Recreation	Landscape		
Recreation	High	Neutral	400m	None
	Medium	Neutral	400m	> 1000 residents affected
	Medium	Neutral	400m	Singularity in community
Close-to-nature recreation	Medium	High	400m	None
	Present	Medium	400m	> 500 residents affected
	Present	Medium	400m	Singularity in community
Habitat	Not present	High	1000m	None
Risk prevention	Hazard zones and forest with protective function			
Agriculture & forestry	High soil quality and forest with economic function			

3   Results

This paper supports the identification of well-supplied and undersupplied regions in terms of recreational areas and points to the demand of defining priority areas of settlement development, economic use, and nature conservation. Fig. 2 represents green spaces with high recreational and landscape value together with their buffer zones and the share of residents per municipality living within these zones. This map covers a part of the study area, which comprises the city of Salzburg and the transition zone to rural areas. The results show that most areas with a high recreational value are located in the city of Salzburg, whereas green spaces with a high landscape value are more equally distributed. This highlights the lack of "classic" public recreational areas like parks or playgrounds in the more rural environment. In the city of Salzburg, 60% of the residents are supplied with green spaces with high recreational value,

which is by far the highest share in the whole study area. Many municipalities with more rural characteristics like Elsbethen, Puch, or Grödig, on the other hand, profit from the presence of large areas with a high landscape value, which are located in close proximity to the mountains and the river Salzach. In addition, in the southern communities only few well-equipped recreational areas can provide a great benefit to the residents. This refers to considerable upgrade potentials that become evident particularly for the central municipalities in the study area.
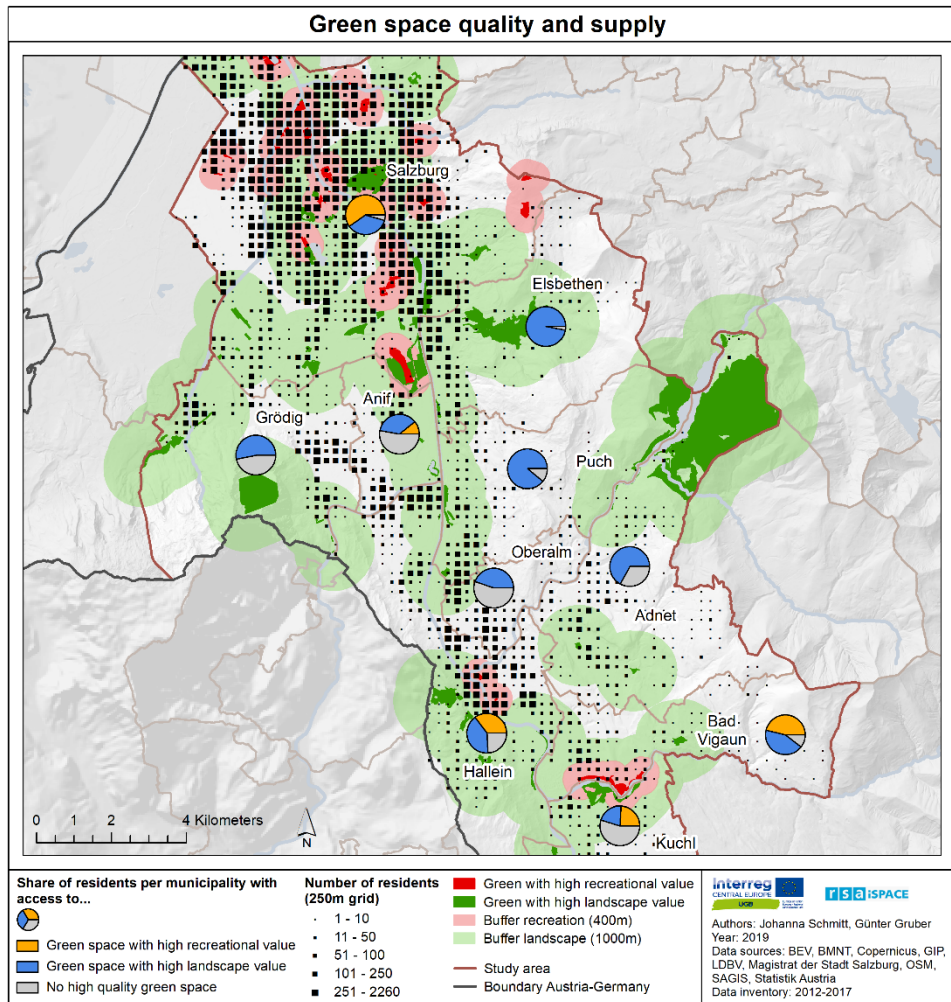

Fig. 2: Distribution of high quality green and green space supply per municipality

Figure 3 displays the various priority zones as result of the landscape matrix (cf. Table 1). The map on the left serves as an overview of five different main green space functions in the study area, while the smaller maps show detailed local analyses, which comprise a prioritisation of recreational areas and a settlement growth scenario. The matrix allows an individual
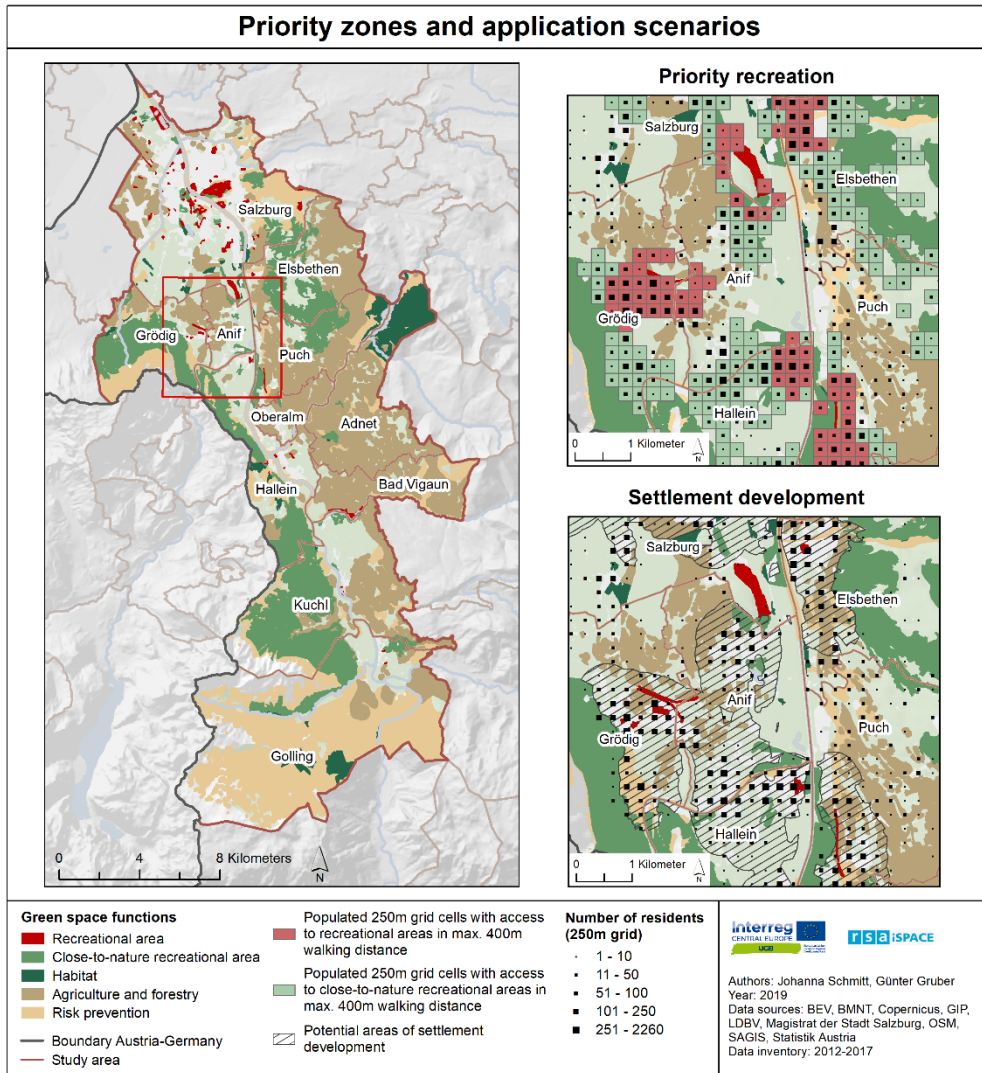
Fig. 3:   Priority zones of green space functions and application scenarios

prioritisation of land use zones, which results in different cartographic outputs. A focus on the habitat function e. g. can point out the cross-valley green belts. In this example, however, *recreation* is favoured over other uses. The service areas of recreational areas and the reached inhabitants are added to highlight the importance of certain green spaces. In the selected example region, most residents have access to recreational areas or close-to-nature recreational areas, but also some undersupplied zones, which are mainly located outside of agglomerations, can be identified.

The different recreational values and even the combination of close-to-nature recreation with habitat function or risk prevention in most cases do not raise many conflicts. It is rather the

question of finding solutions for the conflicts caused by the economic use of land and the future settlement development in this area of high demographic pressure. The *settlement growth scenario* illustrates these challenges. It is based on current settlement cores, which are determined by existing residential building areas with a sufficient infrastructure. Based on the increasing settlement pressure in the smaller municipalities near the city of Salzburg, we assume the boundaries of these cores to extend by 400 m respecting the area of permanent settlement that is available for agriculture, settlement, and traffic. The increase of the population and the resulting growth of agglomerations could lead to a demand for new building land, but also to densification activities in the existing settlement cores. The map shows that now other areas with an undersupply of basic green services provided by recreational areas occur, which becomes obvious especially in the municipalities Anif and Puch. These developments require a re-application of the assessment circle and optionally a new prioritisation of desired land use, which of course results in different results for the supply map.

The question of how to deal with zones of conflict is part of the evaluation at local level. It requires the identification of areas in which certain services are indispensable or underrepresented and, therefore, the preservation or upgrading of green spaces providing the required services is essential. In this context, community involvement is a promising technique as it helps to display the requirements and wishes of potential green space visitors. Another option is to envisage interconnected spaces of similar qualities to create landscape corridors. This paper presents approaches and exemplary results as decision support tools for local authorities and planners.

4   Discussion and Outlook

The presented approaches are useful as foundations for the elaboration of planning guidelines contributing to regional strategies in the study area since the clear delimitation of priority development zones has been an ongoing concern for many years. The applied methods support the identification of well-supplied and undersupplied regions in terms of different green qualities and the derivation of local upgrading actions. A parallel identification of conflicting areas due to population and economic pressure underlines this urgency and leads to the elaboration of priority zones. In certain areas, the designated land use seems to be obvious, while some other green spaces are subject to conflicts, e. g. between settlement development and the preservation of valuable green or between agriculture and recreational areas. The priority matrix offers foundations for future spatial development by depicting areas that are essential for a long-term supply of all functions and green spaces that may be evolved into interconnected green belts or new construction grounds.

We still see potential for amendments, especially with regard to the indices and their input indicators. The delimitation of habitats for example could be more realistic with an adjusted indicator system as the landscape value comprises many aspects of scenic beauty, which are only relevant for human green space visitors. We currently upgrade this approach in terms of concepts and flexibility. A grid-based web tool for the Salzburg State Government as part of a local roadmap allows users to display the different, partly conflicting green values and prioritise land use on their own. The presented scenarios serve as recommendations and templates.

At the same time, the concept is easily transferable to other regions if appropriate data are available. The local view on challenges and suitable actions in accordance with strategic goals is a helpful element in this process. The international project consortium works on community involvement and multi-stakeholder governance methods that support us with bringing the present solutions of the spatial analyses and GIS modelling into practice. This includes the discussion and definition of development goals on administrative level and de-mand analyses and application options in the field. These methods also help to examine and reflect the expectations of local target groups like residents or businesses in the conflict so-lution process, which is an essential part of the geodesign concept.

With regard to the pillar model, there is still potential for adapting and specifying the defined assessment indices by including biological data or qualitative data regarding people's per-ceptions and satisfaction, which will improve the determination of recommended priority zones. The overlay of planning-relevant data at small scales such as population forecasts, zoning plans, or housing densification potentials will support the derivation of more detailed action plans. Results may be integrated into regional development concepts or have an impact on residential subsidies to ensure a high-quality living environment in the long-term future.

Acknowledgement

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