Urban Green and Open Spaces under Pressure: The Potential of Ecosystem Services Supply and Demand Analysis for Mediating Planning Processes in the Context of Climate Change

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1 ABSTRACT

Climate change is a phenomenon which is discussed to be affecting cities and urbanising societies to a great extent. Thus, land use management of green and open spaces in the direction of climate protection and climate mitigation is an important aspect of sustainable urban and regional planning. However, land use planning holds the potential of causing conflicts between different stakeholders from administration, politics and civil society. The analysis of the demand of ecosystem services may therefore be a useful indicator to identify the interests of different stakeholders. Besides the demand, the analysis of the supply of ecosystem services might help to derive potential offers of climate relevant system functions and to support the planning processes of the areas of interest. Until now, the results of the analysis of ecosystem service supply and demand have been applied predominantly in regional or national contexts. For sustainable urban planning, the local level of observation thus seems to be more relevant.

This study presents results of the interdisciplinary research project GREIF (Karlsruhe Institute of Technology and University of Heidelberg, Germany). It aims at identifying ecological and socio-cultural potentials of local urban green and open areas in the Rhine-Neckar metropolitan region, Germany, using an ecosystem service supply and demand approach. Thereby, six ecosystem services of the categories provisioning, regulating and cultural services are analysed for three predefined urban areas. Furthermore, the demand of ecosystem services of local residents as direct users of these areas is determined by conducting comprehensive surveys. The study focuses on the comparison of quantitative supply and qualitative demand data in order to identify discrepancies between supply and demand of ecosystem services. The results will be communicated to administrative bodies and political authorities of the region to enable the integration of additional knowledge into planning decisions.

Preliminary results indicate that there are particular differences between the supply and demand of ecosystem services that affect the local residents in a direct way. Where the demand of the ecosystem services food provision and biodiversity is always higher-rated than the supply implies, the ecosystem service demand of climate regulation or renewable energy sources is always lower-rated than the supply indicates. These findings suggest that by incorporating the perceived demands of further stakeholders like planners or politicians, potential conflicting interests between ecosystem service demand and supply might become even more evident. Using this additional knowledge in the early stages of planning processes in the context of climate change might thus help to mitigate conflicts between different stakeholders.

Keywords: supply and demand analysis, ecosystem services, urban planning, climate change, urbanisation

2 INTRODUCTION

2.1 Motivation

In the context of climate protection and climate mitigation, sustainable land use management practices for green and open spaces are an important aspect of urban and regional planning (Jenks and Dempsey, 2005; Kenworthy, 2006; Peter and Swilling, 2012). However, land use planning has the potential of causing conflicts between different stakeholders from administration, politics and civil society. An analysis of the ecological potentials of areas of interest is hence a useful tool to identify climate relevant system functions and to assess the interests and perceptions of different stakeholders (Fisher et al., 2009). This paper makes use of an ecosystem services (ES) analysis to address the question of how ecological potentials can be used for mediating planning processes in the context of climate change.

Recently, ecological knowledge is gaining increasing acceptance in urban planning processes (Niemelä et al., 2010; Ahern et al., 2014; Rössler, 2015). However, it is rather discussed in research than implemented in practice (Hansen et al., 2015). Furthermore, ecological potentials are predominantly determined on a regional

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scale (e.g. Tyrväinen et al., 2007; Hansen et al., 2015) and monetized rather than distinguished between supply and demand (e.g. Nedkov and Burkhard, 2012; Gómez-Baggethun and Barton, 2013).

In this study, an analysis of urban green and open spaces is conducted on a local scale. It uses an approach that highlights the supply as well as the demand side of ES for the specific study site. It thus reveals matches and discrepancies between the ecological potentials of an area and the requirements and desires from other stakeholders. By combining methods from natural and social sciences, the paper responds to recent calls for the implementation of different knowledges about ecological potentials of urban spaces in planning processes (Castree et al., 2014).

2.2 Background

The concept of ecosystem services was introduced as a result of the increasing demands of humans on the limitied resources of the earth (Grunewald and Bastian, 2012). It aims at illustrating the relevance and meaning of the environment for society (Ehrlich and Mooney, 1983).

After Daily (1997), ecosystem services "are the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life." According to the Millennium Ecosystem Assessment, initiated by the UN, ecosystem services can be divided into four categories: provisioning services such as timber and food production, regulating services as flood protection or climate regulation, cultural services as recreational or aesthetic values and supporting services as soil formation and nutrient cycling (United Nations (UN), 2015).

2.3 Study Site

The three selected study areas are based in the Rhine-Neckar metropolitan region in south-western Germany. The areas are located in three different cities (Heidelberg, Mannheim and Weinheim) distinguished by size and socio-economic profile. In this paper, only the study site in Heidelberg will be considered. This area is situated at the north-western fringes of the city between the district Heidelberg-Wieblingen and the adjacent municipality of Edingen-Neckarhausen. It covers approximately 410 ha and is framed in the north by the river Neckar, in the west by residential areas and in the south and east by highways (see figure 1).

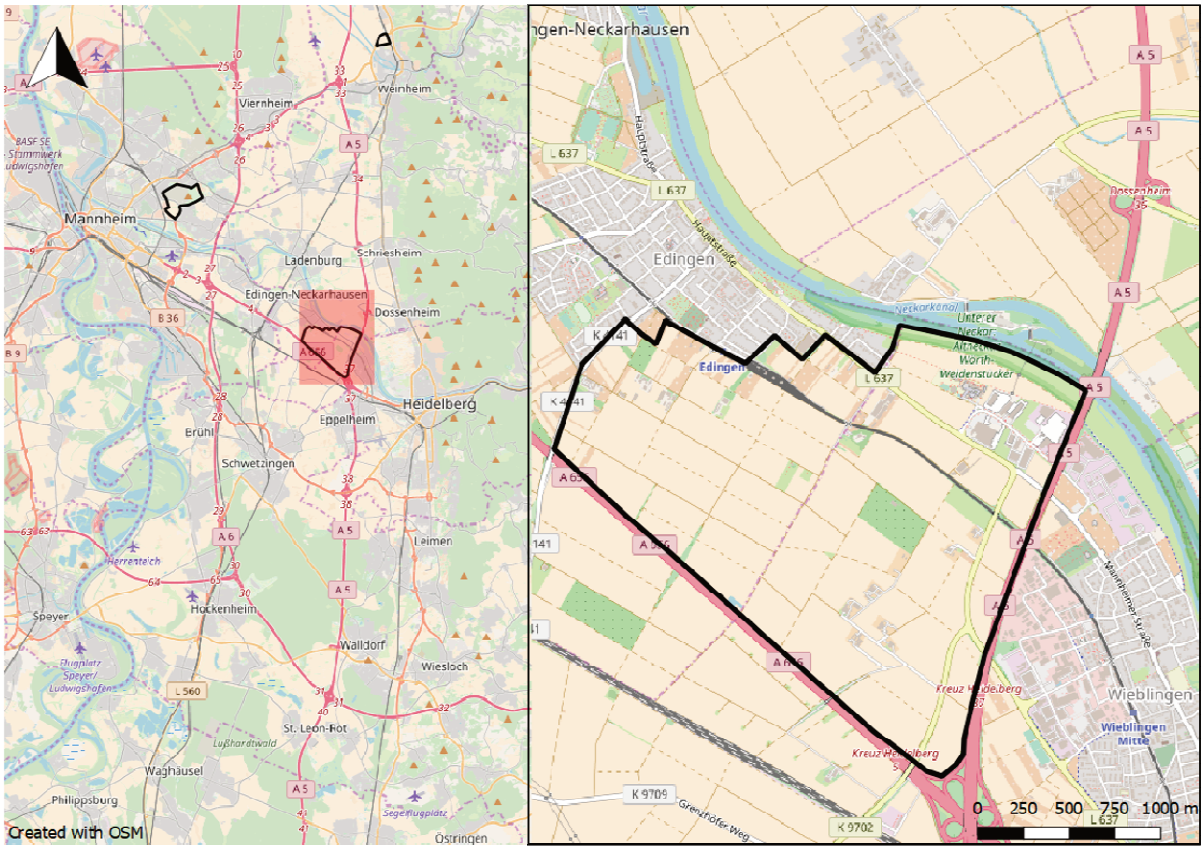

Fig. 1: Investigation areas of Mannheim, Heidelberg and Weinheim (left) and study area of Heidelberg (right).

3 METHOD

3.1 Ecosystem services - matrix analysis

Landscapes consist of different ecosystem structures depending on natural conditions and anthropogenic use and therefore hold differing capacities to offer ecosystem services (Burkhard et al., 2010). Due to changing land use forms, geographical population distributions and other socio-economic conditions, there are also differing demands for ES. These differences in supply and demand of ES can be represented with the matrix analysis. This approach is based on an evaluation matrix where relative and not monetized ES capacities and ES demand intensities of different land use forms can be put into relation (Grunewald and Bastian, 2012). Supply and demand of ES can be visualized in form of a budget matrix where the X-axis represents the chosen ES and the Y-axis the existing land use forms of the area of interest.

For this study, the following six ES were chosen:

Category provisioning services:

- Food and crops
- Renewable energy sources

Category regulating services:

- Climate regulation
- Biodiversity

Category cultural services:

- Aesthetics
- Recreation

3.2 Supply of ecosystem services

The supply of ecosystem services was analysed for the occurring land use forms in the study area. These were derived from Urban Atlas data that provide pan-European land use and land-cover data of urban regions. Urban land use forms have a minimum mapping unit (MMU) of 0,25 ha (= 50 m x 50 m), rural land uses a MMU of 1 ha (= 100 m x 100 m). They are based on Earth Observation Data (EOS), Open Street Map Data (OSM) and data from topographic maps (European Union, Copernicus Land Monitoring Service and European Environment Agency (EEA), 2018). The ecosystem services for the different land use forms were evaluated with categories ranging from 0 (= no relevant capacity to provide the ES) to 3 (= maximum relevant capacity to provide ES). The evaluation is based on general available literature data (Koschke et al., 2012) and field data. Additionally, literature data were adapted in case of available site-specific data (e.g. harvest data for crops). To ensure comparability, the selected ES were evaluated for the whole area by weighting them in relation to the size of the land uses. Subsequently, they were averaged and re-categorized into the defined evaluation categories from 1 to 3.

3.3 Demand of ecosystem services

For the analysis of the demand of the selected ES, a household survey was conducted to explore uses and perceptions of the study area (Yeh, 2016; see figure 2). Thereby, residents directly neighbouring the investigation area in Heidelberg were interviewed face-to-face using a paper and pencil questionnaire. The interviewees were asked to individually evaluate the ES of the study site according to a categorization from 0 (= not important) to 3 (= very important). All in all, 129 households were surveyed in Heidelberg. For evaluation, the mean value for each ES was calculated and re-categorized into the evaluation categories from 0 (= no relevant demand for ES) to 3 (= maximum demand for ES).

4 RESULTS

4.1 Supply of ecosystem services

Figure 2 shows the existing land uses for the area of Heidelberg derived from Urban Atlas.

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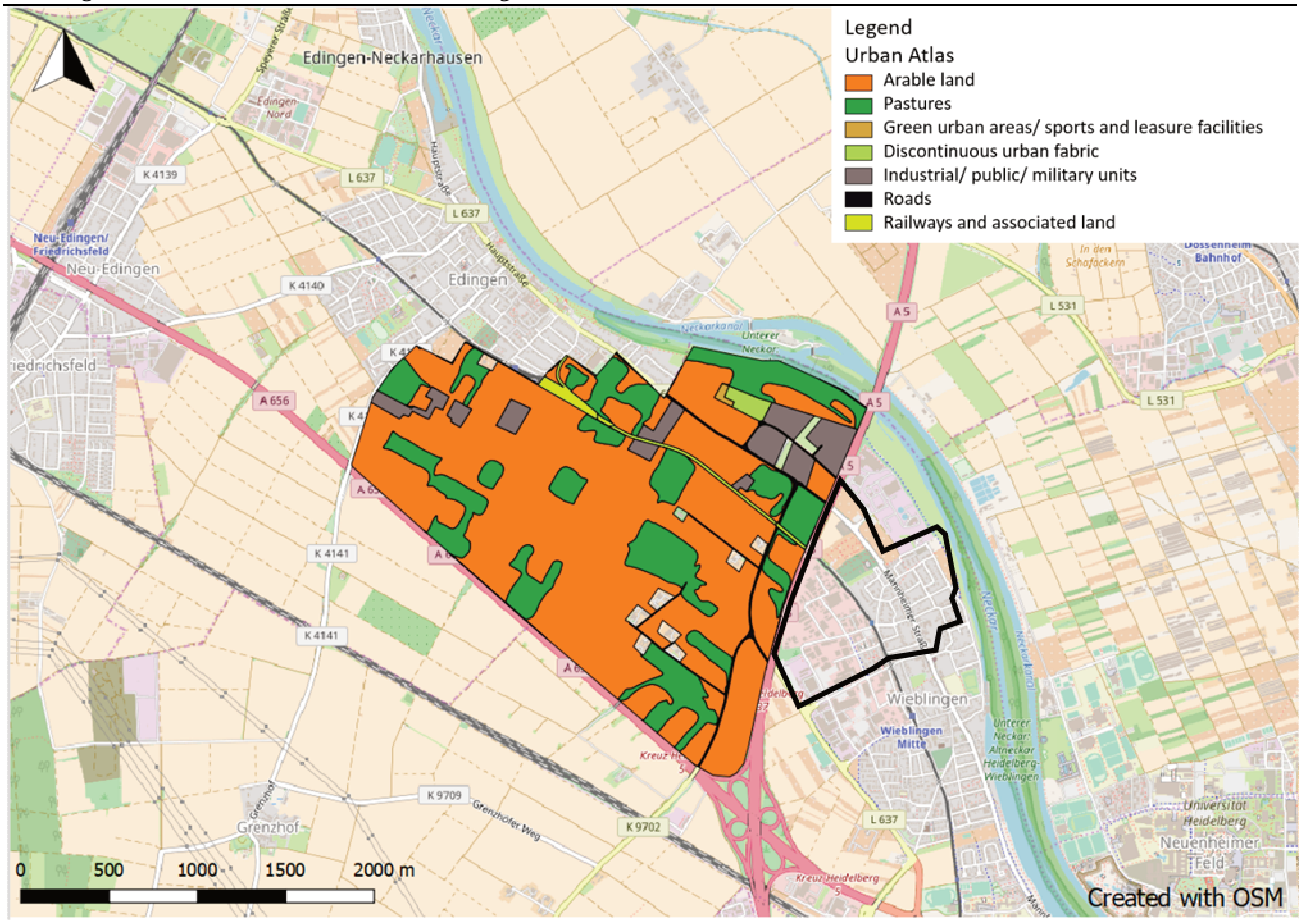

Fig. 2: Study site in Heidelberg with identified land use forms after Urban Atlas (European Union, Copernicus Land Monitoring Service and European Environment Agency (EEA), 2018). Outlined in black, the area of inquiry for the household survey is highlighted.

Most of the area consists of arable land (approximately 70 %) and pastures (approximately 20 %). There exist some industrial units, railways and roads (approximately 9 %) and with a very low share, discontinuous urban fabric and sports and leasure facilities which comprise a school and a nursery garden (approximately 1 %). In figure 3, the weighted supply matrix for the selected ecosystem services is shown.

Supply matrix

3	maximum capacity
2	high relevant capacity
1	relevant capacity
0	no relevant capacity

	Provisioning ES	Food and crops	Renewable energy sources	Regulating ES	Climate regulation	Biodiversity	Cultural ES	Aesthetics	Recreation
Arable land (69 %)		1	3		3	0		2	1
Pastures (21 %)		1	0		3	0		2	2
Greer urban areas/sports and leasure facilities (0.5 %)		0	0		1	0		2	2
Discontinuous urban fabric (0.5 %)		0	0		0	0		1	1
Industrial/public/ military units (6 %)		0	0		0	0		0	0
Roads and rai ways (3 %)		0	0		1	0		0	0
Sum of capacity after weighting and averaging		1	2		3	0		2	1

Fig. 3: Supply matrix for selected ES for the study site in Heidelberg.

The matrix shows that the area has a maximum capacity to provide the ES “climate regulation”. This ES is measured by the area’s capacity to produce and to circulate fresh air. As the site is predominantely under agricultural use, the density of wind-inhibiting obstacles is low what may explain this evaluation. This ES is followed by the ES of “renewable energy sources” which is evaluated by the harvest amount of rape in the area, and the cultural ES “aesthetics”. No relevant capacity can be found for the ES “biodiversity”, measured by the number of vascular plant species that do not occur in the investigated area.

4.2 Demand of ecosystem services

Figure 4 illustrates the demand matrix for the selected ES. The ES “biodiversity” is the most requested by the citizens, followed by the ES “climate regulation”, “aesthetics”, “food and crops” and “recreation”. The lowest demand was found for the ES “renewable energy sources”. It becomes clear that especially those ES, which affect the citizens directly, are evaluated with a high category. The low importance of the ES “renewable energy sources” may be due to the fact that the personal advantage of this ES is not obvious for the respondent, as renewable energy sources need to be transformed before they can actually be used (directly or indirectly) by the consumer.

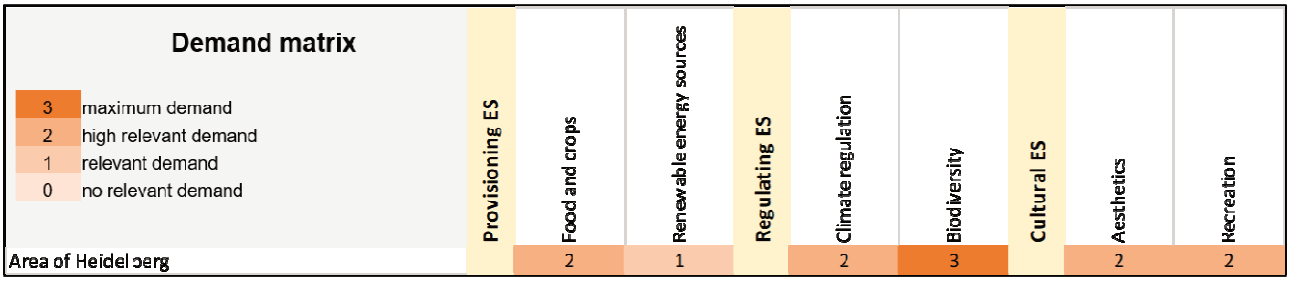

Fig. 4: Supply matrix for selected ES for the study site in Heidelberg.

4.3 Budgeting supply and demand of ecosystem services

The supply of ES can be compared with the demand for ES using a budget matrix (see figure 5).

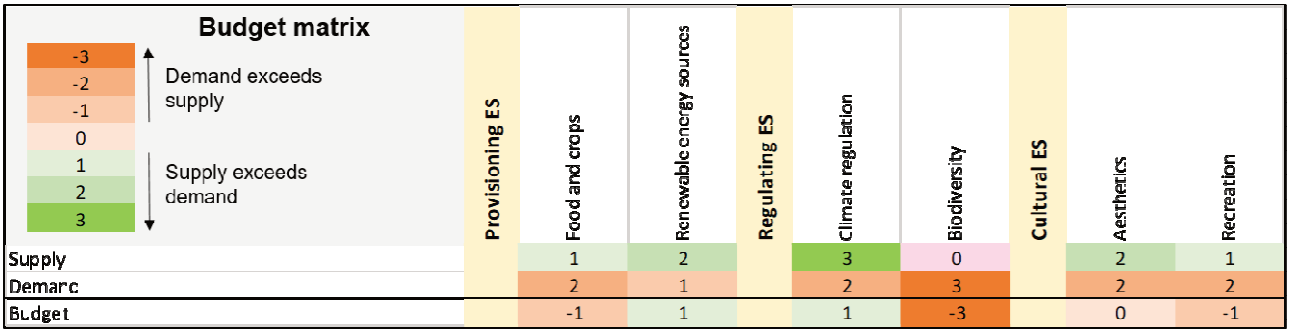

Fig. 5: Budget matrix for selected ES for the study site in Heidelberg.

It shows that there is a clear difference between the services the area offers and the demand of services from the citizens. Where the demand of ES exceeds the supply, values of the budget matrix are negative, as recognizable for the ES “food and crops” as well as “biodiversity” and “recreation”. Where the supply exceeds the demand, values of the budget matrix are positive, visible for the ES “renewable energy sources” and “climate regulation”.

The budget matrix reveals that those ES having an immediate effect on the life of the citizens and are thus assigned to a high evaluation category, cause negative values in the budget matrix. The demand for food (ES “food and crops”) as basic need of human beings as well as the demand for recreational space (ES “recreation”) are reflected in the matrix. A considerable difference between supply and demand can be detected for the ES “biodiversity”. The preservation of nature proves highly important for the well-being of citizens but can not be provided by the study site at all. In contrast, the ES “renewable energy sources” can be provided with “high relevant capacity” but is not as relevant to the citizens.

5 DISCUSSION AND OUTLOOK

This study focussed on the analysis of ES of green and open spaces on a local scale. The analysis of supply and demand of ecological services highlights, which ES are provided with which capacity by the study site. Moreover it reveals, with which priority these ES are demanded by the citizens. Thus, the matrix analysis exposes to what extent supply and demand differ for the study site. It showed for example that the ES „climate regulation” could be offered with a high potential by the area and was also highly demanded by the citizens. For urban planning processes, this result could indicate for example, that construction projects delimiting this capacity should be negotiated between planning authorites and citizens.

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These findings suggest that by incorporating the perceived demands of further stakeholders like planners or politicians, potential conflicting interests between ecosystem service demand and supply might become even more evident. Using this additional knowledge in the early stages of planning processes in the context of climate change, might thus help to mitigate conflicts between different stakeholders. In the further progress of the project, planning, administration and political authorities will be incorporated in the analysis to gain a differentiated picture of the stakeholders' interests in the area. These interests should again be analysed under use of the matrix analysis and results be communicated at a round table conference and discussed with the individual stakeholders. Thereby, a sensitization for ecological subjects may be fostered, what could lead to an adaption of land use planning to the actual ecological potentials of areas of interest.

6 FUNDING

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