7.3.1. Mapping urban ecosystem services

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Introduction

Globally, more people live in urban areas than in rural areas, with 54 % of the world's population living in urban areas in 2014. As the world continues to urbanise, sustainable development challenges will be increasingly concentrated in cities. The UN Sustainable Development Goals well summarise this concept with goal 11: "Make cities inclusive, safe, resilient and sustainable".

Maintaining functioning, healthier and equally accessible urban ecosystems and services is thus an essential point for future urban policies and planning.

Urban ecosystems can be defined as an integrated ensemble of connected built (sharing built or paved infrastructures) and green infrastructures (GI). The tangible integration of GI in urban policies requires awareness-raising amongst planners, stakeholders and citizens as well as tools to monitor progress of policy objectives and to support local planning.

Nevertheless urban environments are very peculiar and a general framework for the mapping of urban ecosystem services (ES) cannot be directly adopted.

This chapter illustrates how urban ES can be mapped according to a tiered approach (see Chapter 5.6.1). This chapter introduces a selection of ES particularly relevant in cities. Next it provides concrete examples on mapping urban GI and urban ES applying a tier 1 approach, based on Urban Atlas landcover data provided by the European Environment Agency and local data. The chapter presents two tier 3 models, for mapping regulating and cultural services. Finally a web-based tool for an analysis of urban ES is introduced.

Ecosystem services relevant in cities

Trees, parks, gardens and (peri-)urban forests help improve the quality of the air, reduce noise and mitigate extreme summer temperatures or peak flood events. They also provide non-material benefits, such as recreation, education, cultural and aesthetic values and contribute to social interactions. Table 1 presents a list of key urban ES. Cities also depend on ecosystems beyond city limits and, in this case, we refer to indicators described in other sections of this book.

Mapping urban ecosystems and urban green space as the base layer for assessing urban ES

A detailed map of urban GI can serve as the basis for mapping urban ES supply and

Table 1. Key urban ES organised according to the CICES classification.

CICES Section	CICES Class
Provisioning	Cultivated crops
	Surface water for drinking
	Groundwater for drinking
	Surface water for non-drinking purposes
	Groundwater for non-drinking purposes
Regulation & Maintenance	Filtration/sequestration/storage/accumulation by ecosystems
	Global climate regulation by reduction of greenhouse gas concentration
	Micro and regional climate regulation
	Mediation of smell/noise/visual impacts
	Hydrological cycle and water flow maintenance
	Flood control
	Pollination and seed dispersal
Cultural	Physical and intellectual use of land-/seascapes in different environmental settings
	Scientific/ Educational
	Heritage, cultural
	Aesthetic

demand. This requires detailed spatial data for identifying the service providing units of GI. Depending on the context and purposes of the study, the analysis can cover a variety of spatial extents (from large metropolitan areas to small compact cities) and can be based on different data sources.

In Järvenpää, Finland, GI was identified and a typology of GI was created based on fairly detailed spatial data (municipal biotope data) and areal units, including even the smallest green spaces. All permeable surfaces were considered as areas potentially providing ES. Therefore, the land use and land cover data were masked by all sealed areas including mainly streets, railroad, other traffic areas, landfills and buildings. This was undertaken by using several national and municipal spatial datasets. At the final stage, the most recent available aerial photographs were used to check the validity of the digitised features.

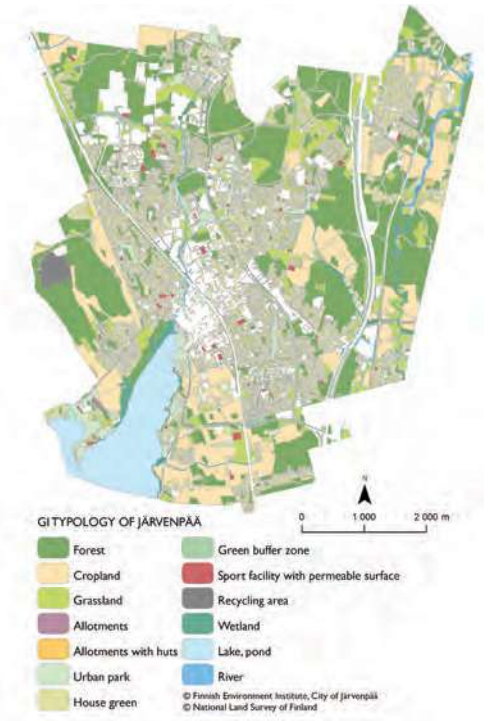
The final outcome of the spatial representation of the GI typology in Järvenpää is presented in Figure 1.

GI was classified according to land cover and land use type. Public and private land were both considered as potential service providing units for urban ES provision. In fact, private yards and gardens can be very important for provision of regulating and cultural services (e.g. stormwater retention, pollination and adding to aesthetics of an area). Public green and blue areas, on the other hand, are very important from an environmental justice point of view. The benefits delivered by these areas should be available and accessible easily and evenly to different population groups to improve the well-being of residents.

In Leipzig, Germany, the Urban Atlas land cover data set, provided by the European Environmental Agency, was used to show

spatial patterns of urban ES indicators and their performance[1] .

[1] (http://www.eea.europa.eu/data-and-maps/data/urban-atlas).



Urban ES values for carbon storage and recreation services for the 20 different Urban Atlas land cover classes were derived from empirical studies. For the assessment of recreation, the per capita green space in 63 districts of Leipzig was used as proxy. Population data reflect the district population in 2014.

The results are urban ES performance maps based on the different land cover classes. Figure 2 shows the resulting map for carbon storage and per capita green space for the city of Leipzig.

The use of secondary land cover and population data may limit the opportunities for statistical analysis. Using land cover data always means generalisation but this provides an overview of city-wide urban ES performance.

Figure 1. Map of green infrastructure in Järvenpää for the assessment of urban ES provision. Built-up areas are shown in white.

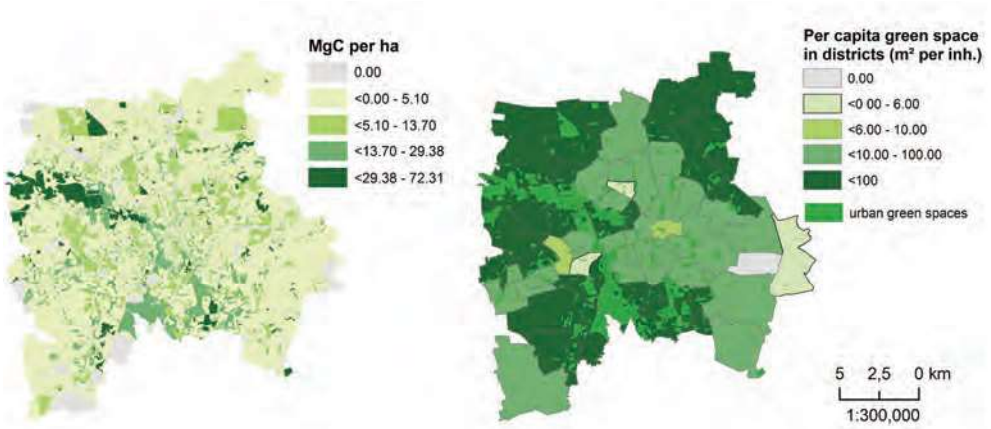


Figure 2. Carbon storage in Leipzig (left) and per capita green space in the districts (right). Carbon storage is highest in the riparian forest areas in Leipzig. The per capita green space is highest in districts near the floodplains and in the southern, north-western and north-eastern districts near the city border where the population number is comparatively lower than in the inner city districts.

Mapping regulating and cultural services: A tier 3 approach

Assessing the cooling capacity of urban GI

Assessing the urban ES provided by GI is often too data-demanding for being routinely conducted in urban planning. A method, based on literature data, has been developed to assess the cooling effect provided by GI. This method can be employed by planners to support the design and management of these infrastructures. First, the main functions involved in the cooling capacity of GI were identified: shading and evapo-transpiration. These functions were assessed individually and then combined in order to estimate the overall cooling capacity of GI. The assessment of the shading function was based on an analysis of the tree canopy coverage which is one of the key elements influencing the shading effect. The assessment of evapo-transpiration considered soil cover, tree canopy coverage and climatic area of the GI which are the three main components involved in providing this function. Each function was classified into categories and the categories were then combined into an overall cooling capacity value which also considered the size of GI. This capacity was then classified into six classes from "E" to "A+", adopting the European Union Energy Label classification, where A+ represents the highest cooling performance. Finally, decay models were also applied to assess the effect beyond the boundaries of GI. The overall purpose was to provide planners with a relatively simple model to predict the cooling capacity of GI and to support their design and inclusion in urban plans. Figure 3 provides an example of cooling capacity assessment in the city of Trento, Italy.

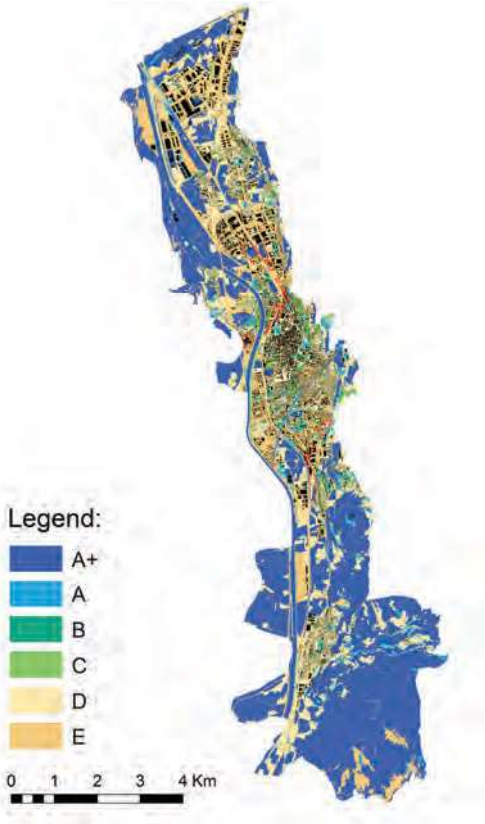


Figure 3. Map of the cooling capacity of the urban GI in the city of Trento. Cooling capacity is expressed in classes from A+ (highest capacity) to E (lowest capacity).

Assessing the social value of public parks and playgrounds

Public parks and playgrounds are key resources for urban citizens since they provide recreational, cultural and educational opportunities. Nevertheless these opportunities are not only related to the amount of public green surface per capita but also to other aspects, for example, type of facilities available or the presence of bicycle paths to reach the park. This problem was addressed by developing a model to estimate the amount of

service provided by urban parks. The model consists of two parts: 1) it estimates the Social Value of Public GI (SVPGI); 2) it calculates a potential accessibility measure which accounts for user's characteristics (the age). Figure 4 presents the structure of the model; Figure 5 shows the amount of service potentially available in Padua (Italy) amongst the population younger than 11 years old.

Planning for green infrastructure in cities: The "Nature Value Explorer for Cities" tool

The online Nature Value Explorer tool[2] aims to value the impact of nature development projects on ES. The tool is currently being extended with an urban version. The purpose of this version is to support cities, administrations and planners in providing an equal and adequate supply of urban GI, paying attention to the quality and the functions of the GI and the trade-offs between different urban ES. Users can estimate the effects of the existing and planned GI on reaching different sustainability goals. The urban context requires a specific typology of urban green and valuation methodologies specifically suited for urban environments. Urban ES which can be valued include urban farming, air pollution and urban heat stress reduction, carbon sequestration, water retention, health and wellbeing.

The maps below (Figure 6) are produced for the city of Antwerp (Belgium) and represent the actual demand, supply and potential for green vegetation to reduce urban heat impacts. Demand maps are based on population density. The urban heat map for Antwerp is a combination of UrbClim model simulations with in-situ validation and satellite images, whereas

[2] www.natuurwaardeverkenner.be

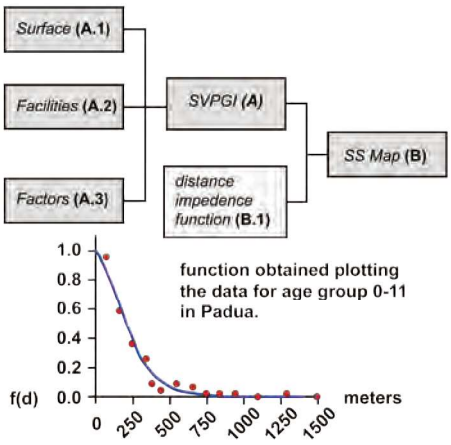


Figure 4. Overview of the structure of the model. The SVPGI (A) depends on the green area surface and the presence of playgrounds-sport-recreational facilities (A.2) and key contextual factors (proximity to bicycle paths, safety) (A.3). To calculate the social services map (B), the SVPGI is allocated amongst all citizens (or amongst defined user groups), giving each one an amount proportional to a distance decay function (B.1). The parameters of the function can be adjusted, according to the users' age or other characteristics. The distance can be estimated through the local road network.

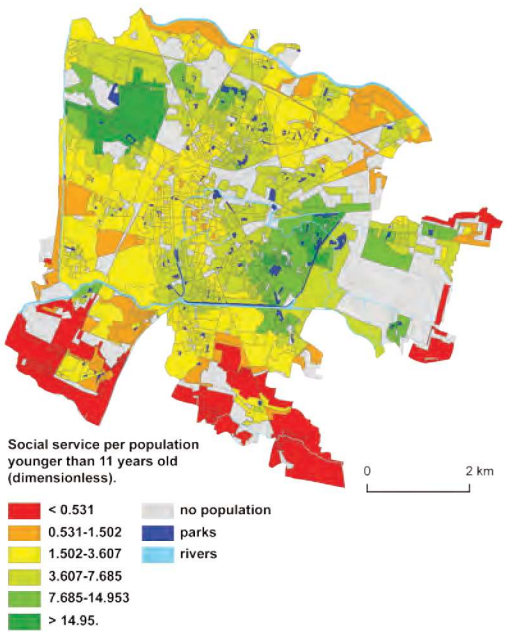


Figure 5. The estimated social service per population younger than 11 years old.

the supply maps represent the cooling effect of the existing vegetation and water system. The potential for additional trees to reduce urban heat impacts depends on the mismatch of supply and demand, the impact of trees on urban climate and the spatial boundary conditions for additional trees (we assume trees cannot replace existing buildings).

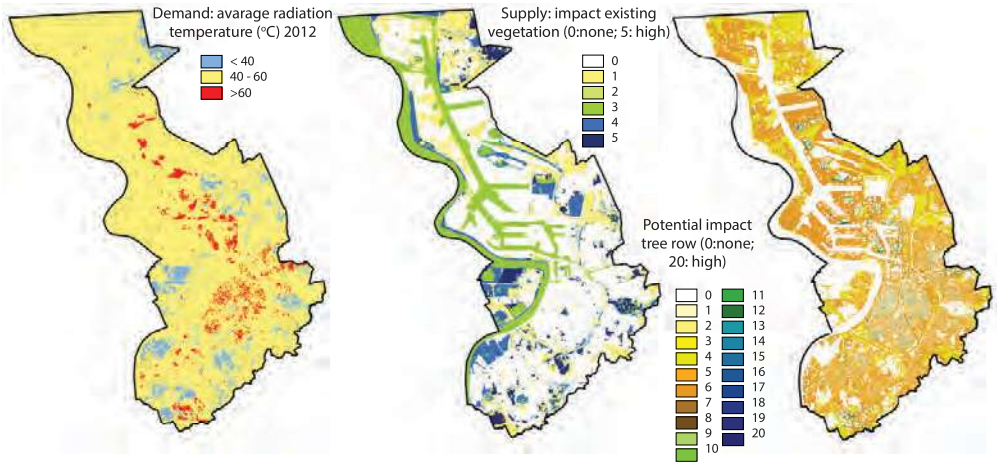


Figure 6. Urban ES maps for heat stress in Antwerp. Supply from existing vegetation and water is scored from zero (0) to maximum (5). Based on a heat map of the city and population densities, the demand is mapped leading to zones with varying degrees of impact vegetation. Taking into account the current supply and demand, the potential for green measures is calculated and scored from no potential (0) to maximum potential (20).

Further reading

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