Assessment of the role of green infrastructure in sustainable urban water management

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Introduction

Urban areas have significantly different land cover in different part of the city, so it is especially important to examine the processes of hydrology in different urban districts. Knowledge of district-level processes are also essential because most sustainable urban water management systems also focus on local level treatment. The mitigating effects of urban trees and other vegetation types are increasingly being recognized and used as a part of green infrastructure to reduce the negative impact of urbanization on the water cycle.

The main goal in our research was to examine urban districts with different land cover. For this part of the research, we used the i-Tree Hydro model, besides this in another element of our research, we modeled rainwater harvesting systems in public institutions (kindergartens) using the EPA SWMM model.

Methods

Hydro

The i-Tree Hydro model what we used in our study pays special attention to vegetation in urban environment, with the help of which the relationship between precipitation/runoff and vegetation can be examined. The results can provide data on surface runoff (and its distribution on different surfaces), vegetation processes (interception, evaporation) and infiltration.

The model consists of three main input categories:

- Meteorological data
- Land cover category data (eCognition 9.1: segment-based classification) (Fig. 1)
- Soil data

Swmm

We used the EPA SWMM model for the rainwater harvesting simulation. SWMM is a highly complex tool for investigate surface runoff, evaporation and infiltration. It includes LID module that can be used to model rainwater harvesting solutions.

The model requires daily or hourly resolution of meteorological parameters (temperature, precipitation intensity, wind speed). Spatial data contain basic and specified spatial parameters (e.g. area, impervious/pervious surface ratio, slope etc.). The model uses a subcatchment system, thus modeling processes take place within a small watershed.

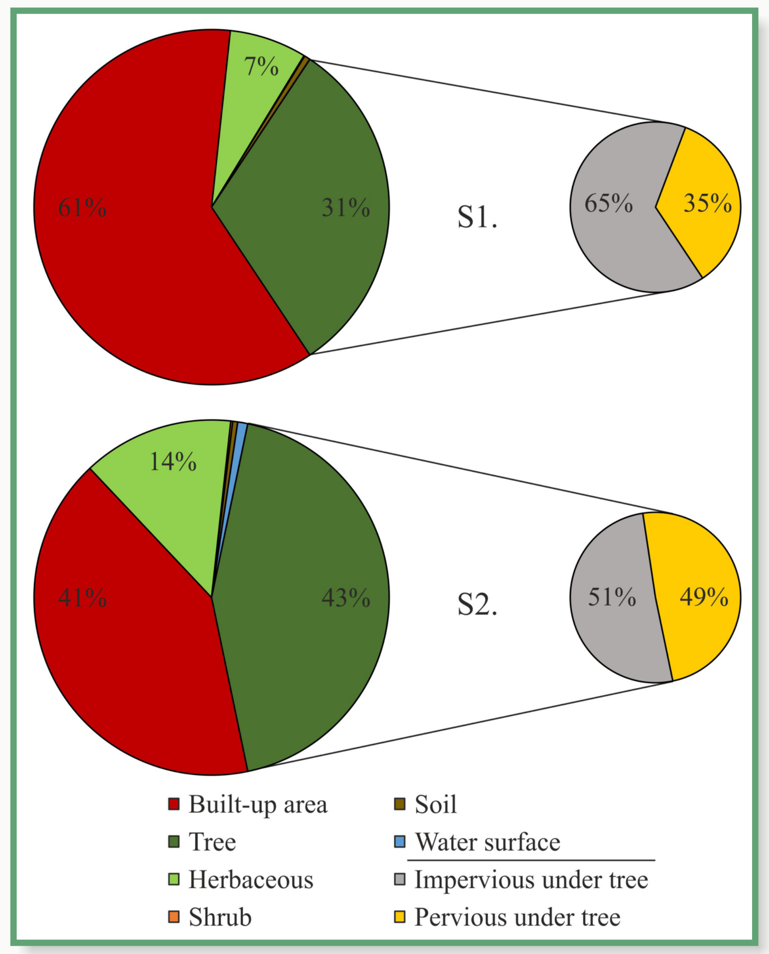

Fig. 1 Land cover ratio for i-Tree Hydro

Study areas

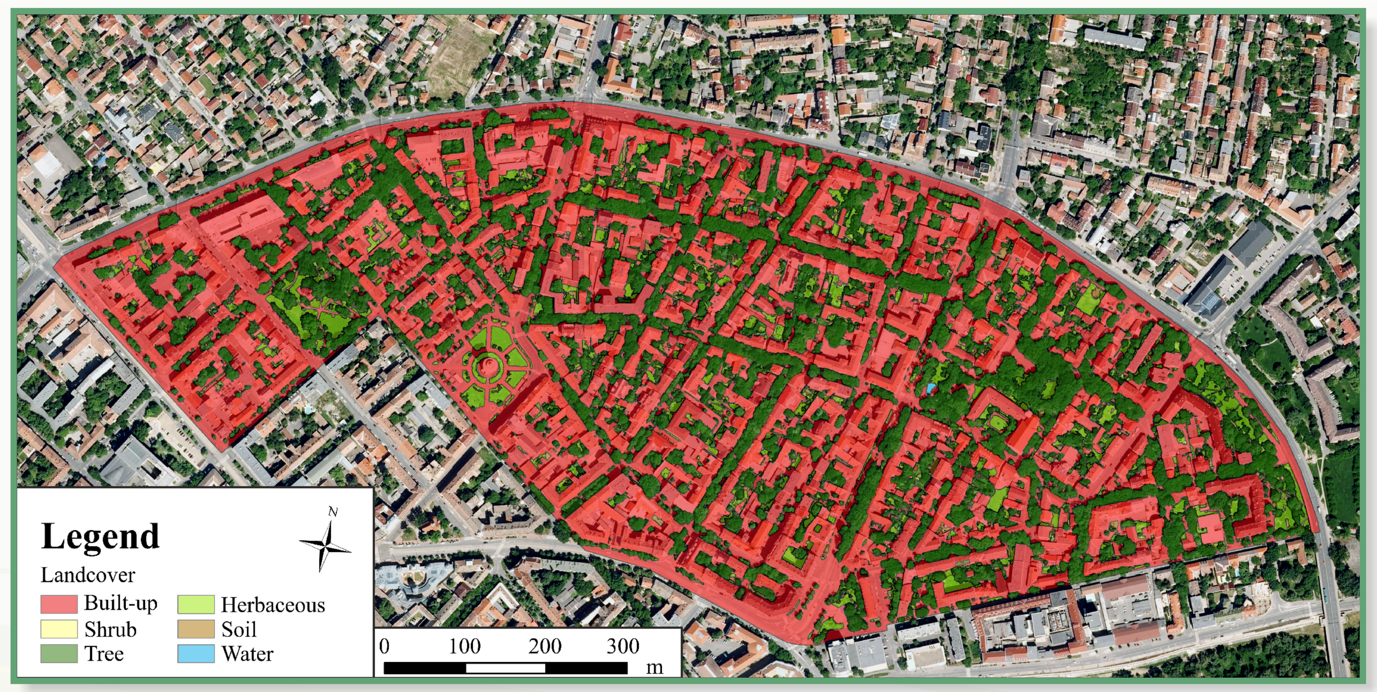

Fig. 2 Area of S1

Fig. 3 Area of S2

Hydro

Our study was examined in Szeged, Hungary. Our specific study areas characterize two different parts of the city. The first is in the significantly built-up downtown (Hereafter: S1. It is characterized by dense mix of low-rise buildings (Fig. 2), while the second study area is located in an outer, housing estate area of the city (Hereafter: S2. The S2 is characterized by open spaces and midrise buildings (Fig. 3).

SWMM

The kindergartens, which included in our study (also in Szeged) have different areas and rainwater collecting surfaces, but the elements of the rainwater harvesting system (underground rain barrels: volume 12 m³, height 1700 mm) are the same. The collecting surface of Kindergarten 1 (hereafter K1) is 348 m². In contrast, the collecting surface of Kindergarten 2 (hereafter K2) is 271 m².

Results

Hydro

The Hydro results were grouped into two main categories: runoff-related and vegetation-related results. The surface runoff of S2 is 14% less than the runoff of S1. In addition, due to the higher proportion of the pervious surfaces, compared to S1 the infiltration in S2 is 17% higher. Due to its high impervious surface ratio, the S1 has a significant surface runoff, the vast majority of which flows on impervious surface (Fig. 4). In the housing estate (S2), the volume of runoff is lower compared to S1 (Fig. 5). Thus, according to the preliminary assumptions, the hydrological conditions in S2 are more favorable from the point of view of urban water management.

The volume of interception is 10 502 m³ (3.84%) in S1 and 14 759 m³ (5.4%) in S2. Basically, the larger extent of tree canopy cover allows more efficient interception (Fig. 6). Thus, the green surfaces of the housing estates have a fundamentally higher green infrastructural value than the green surfaces of the downtown areas.

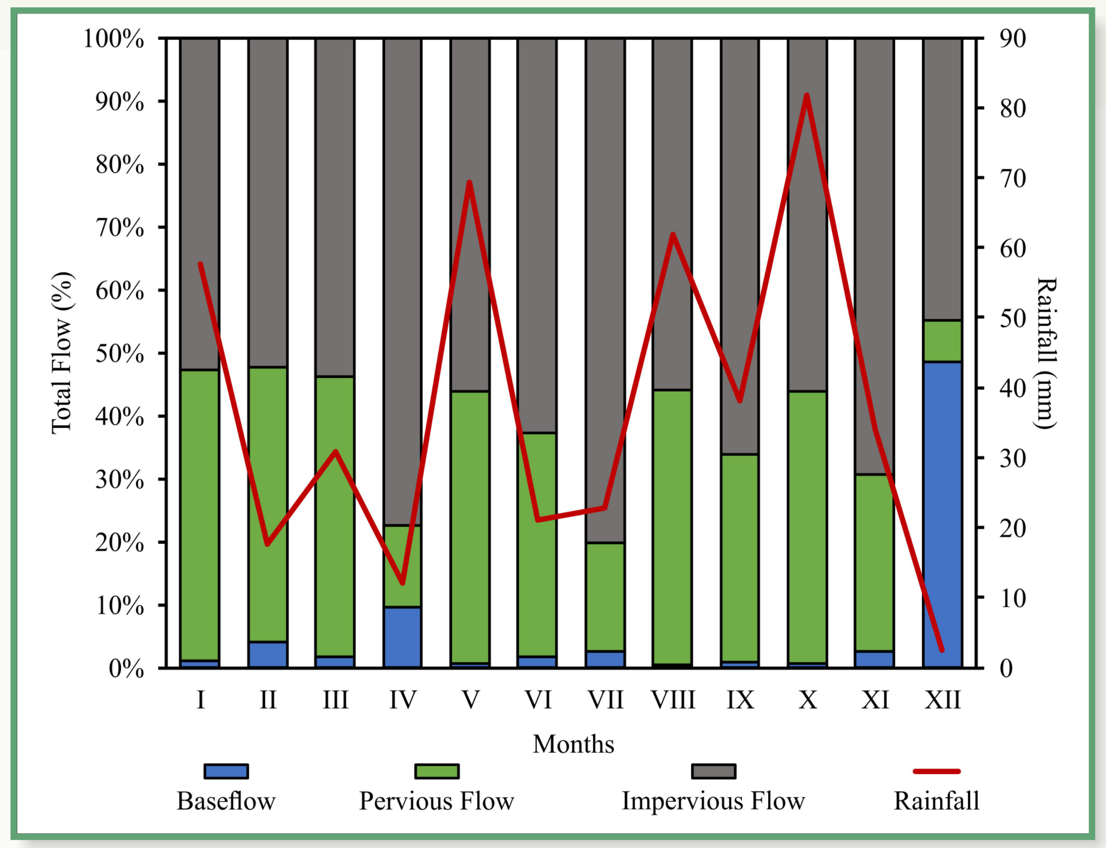

Fig. 4 Flow ratio of S1 per months

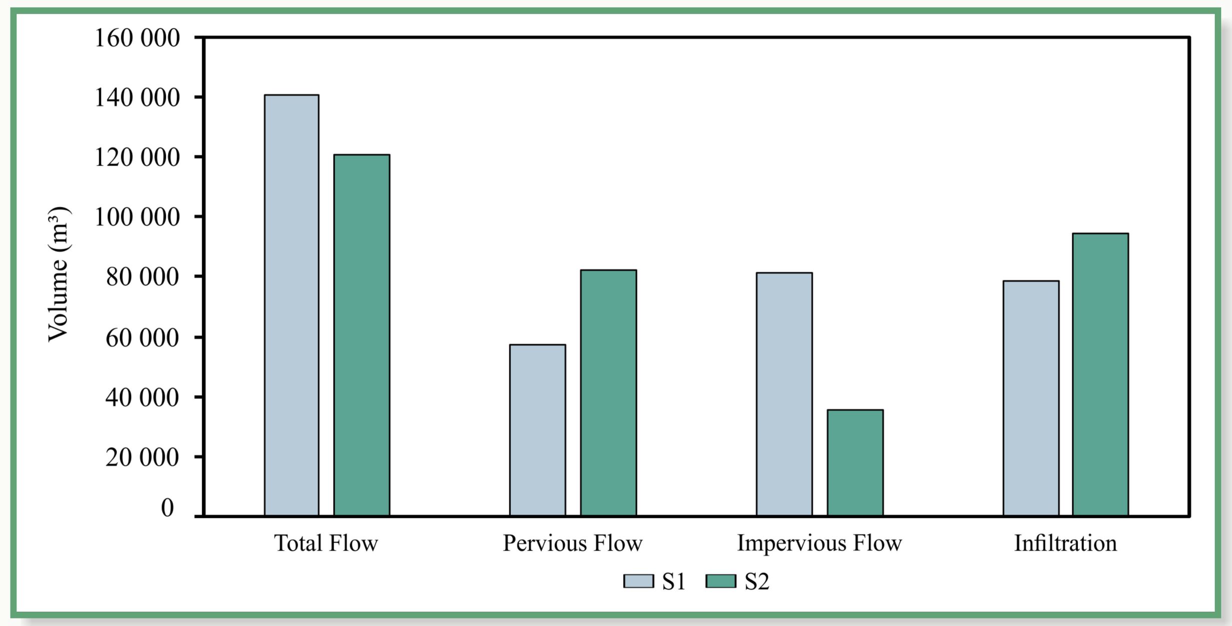

Fig. 5 Comparing flow of the study sites

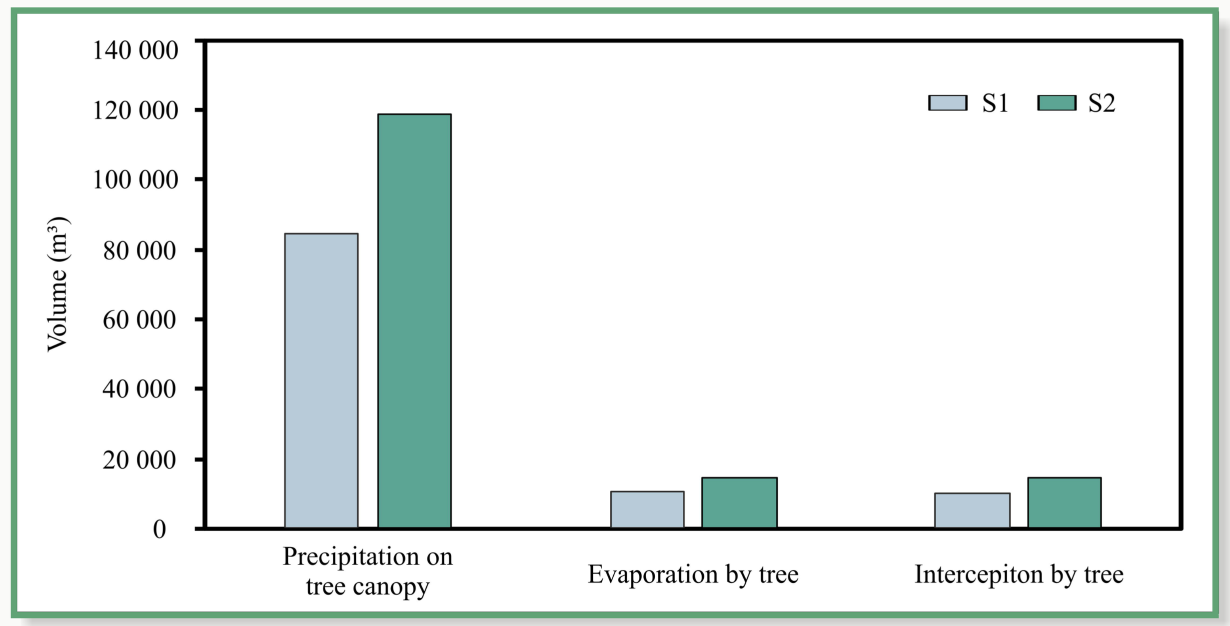

Fig. 6 Comparing vegetation-related results of the study sites

Swmm

Based on the results, it can be seen the processes in the two kindergartens have different quantities. Despite the same rainwater harvesting system, the two study areas differ significantly due to the difference of the collecting surface area (Fig. 7). The results of K1, it is almost double that of K2, with the exception of the volume of collected rainwater, which is limited by the size of the rain barrels.

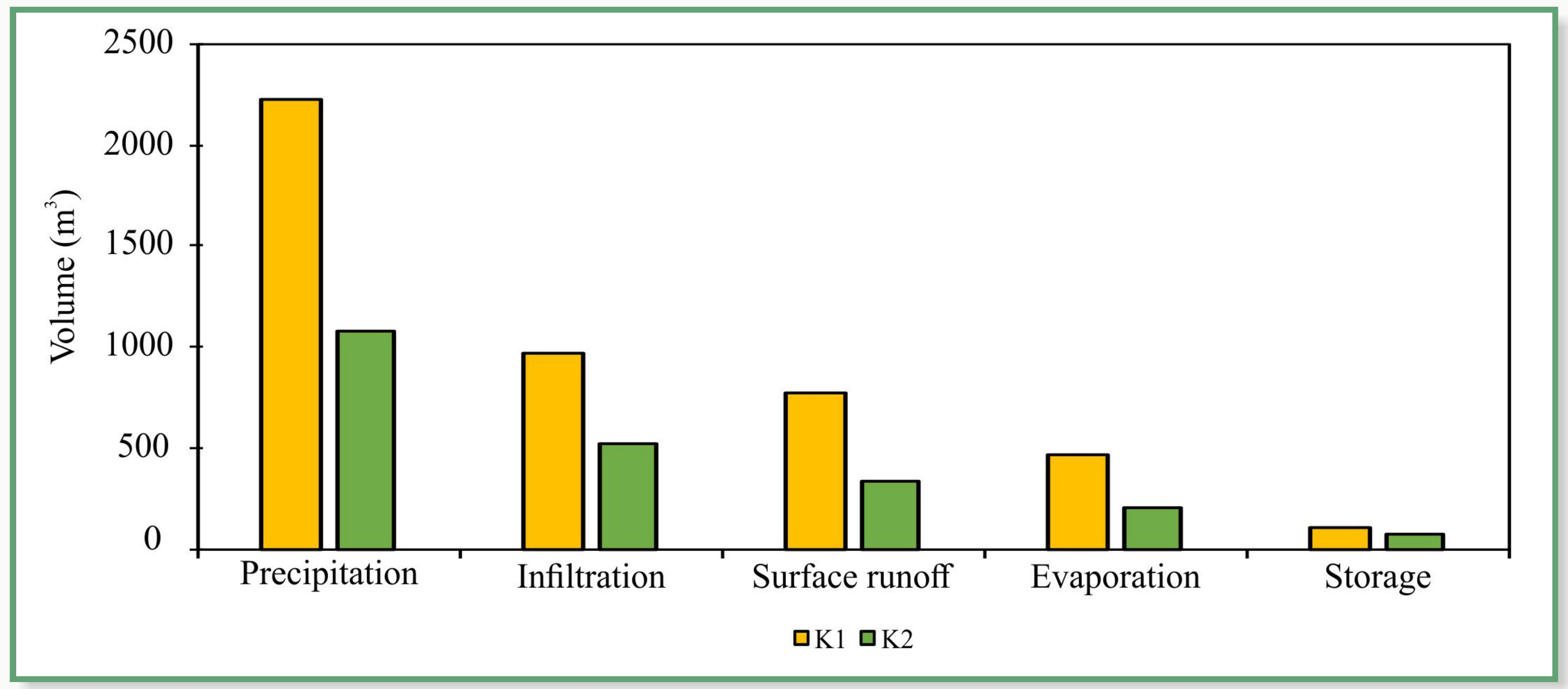

Fig. 7 Comparing results of the kindergartens

Conclusion

The undesirable effects of climate change will cause significant problems in the changed urban environment in the near future. We can prepare for these unwanted effects by making the city's water management more sustainable, which can only be done with proper knowledge of the effects of green and blue infrastructure. One of the key elements of sustainability is to examine the processes and problems together in an urban scale. But the solution of the problems and the management of the processes need to be solved at the local level.

Differences due to land cover can significantly affect the volume of surface runoff and infiltration. In the city center which characterized by high built-up ratio, the surface runoff is significantly higher than in the outer housing estate part of the city. In S2 woody vegetation contributed significantly to the lower value of surface runoff with help of interception. The district-level data provided by the model can be used in urban planning processes. With this information, we can quantify the surface runoff of the city districts and the vegetation contribution to runoff reduction. With the help of the results of rainwater harvesting examination, we can get a picture about the efficiency of the systems. The collected water can be used to irrigate green surfaces, which is linked to our district-level research. In the following part of our research, our goal is to expand the sample areas of these two researches. Besides this we would like to combine these two researches in order to get a picture of the available waters and the irrigation needs.

NATURE 4 CITIES

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