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Effectiveness of green areas and impact of the spatial pattern on water infiltration within cities

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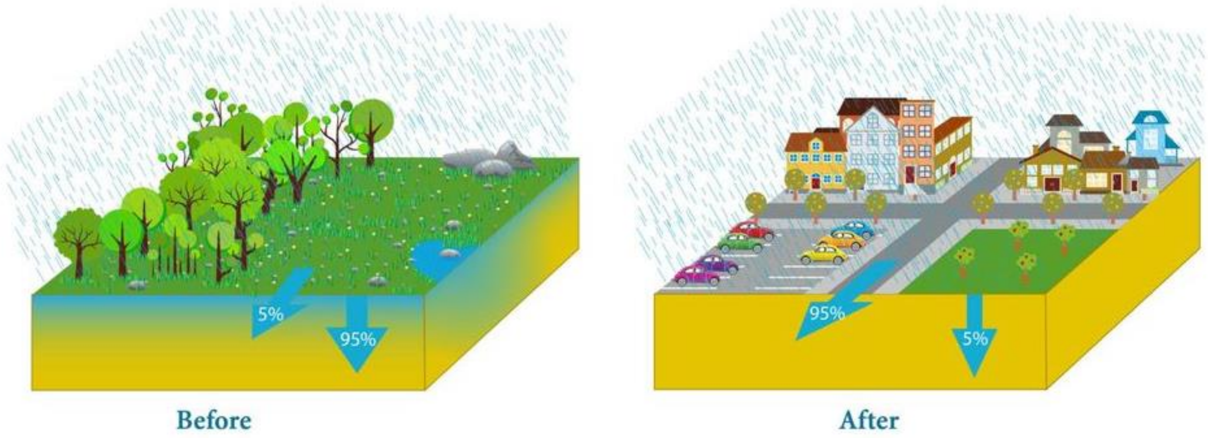
LAND4FLOOD
NATURAL FLOOD RETENTION ON PRIVATE LAND

Introduction

- Sealing, favoured by population growth and urbanization, is a major soil threat;
- Expansion of impervious surfaces decreases the ability of soil to provide ecosystem services, such as water regulation.



Built-up areas have grown at a higher rate than population!

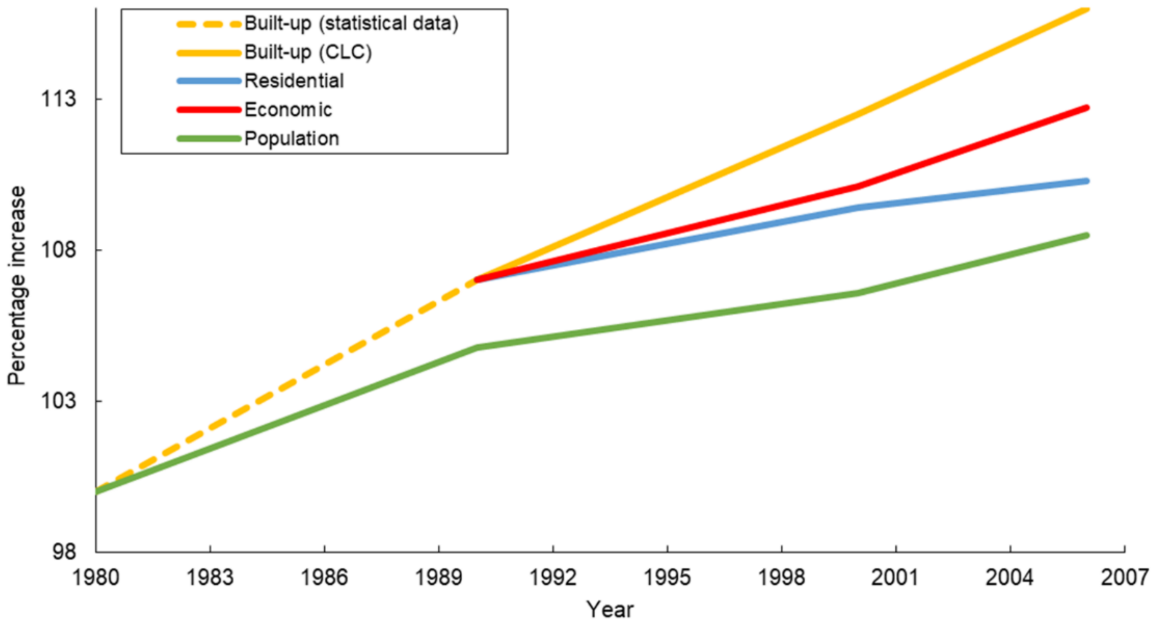


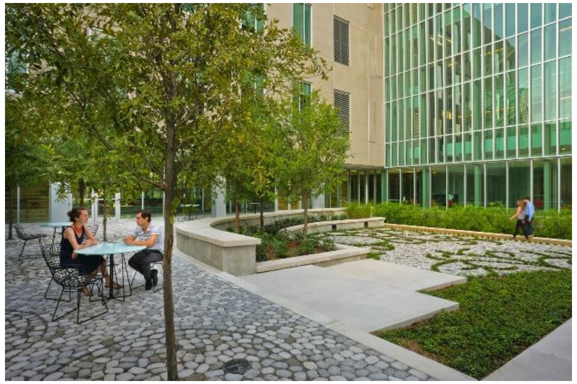
Fig. 1: Built-up area, including residential and those intended for an economic function (e.g. infrastructures), and population increase in selected countries (Ferreira et al., 2019).

A worldwide interest in greening the cities have been noticed among politicians and stakeholders. Green areas provide benefits for the urban water cycle, namely through reducing runoff and flood hazard.

Aim and Objectives

Investigate the impact of different spatial patterns of green surfaces within urban areas on surface runoff.



1) Assess the role of green areas inside the cities on runoff reduction;

2) Investigate rainfall-runoff processes in distinct spatial patterns of green and sealed surfaces.

Methodology

1) Assessment of the spatial patterns of green areas in Portuguese city centres crossed by rivers

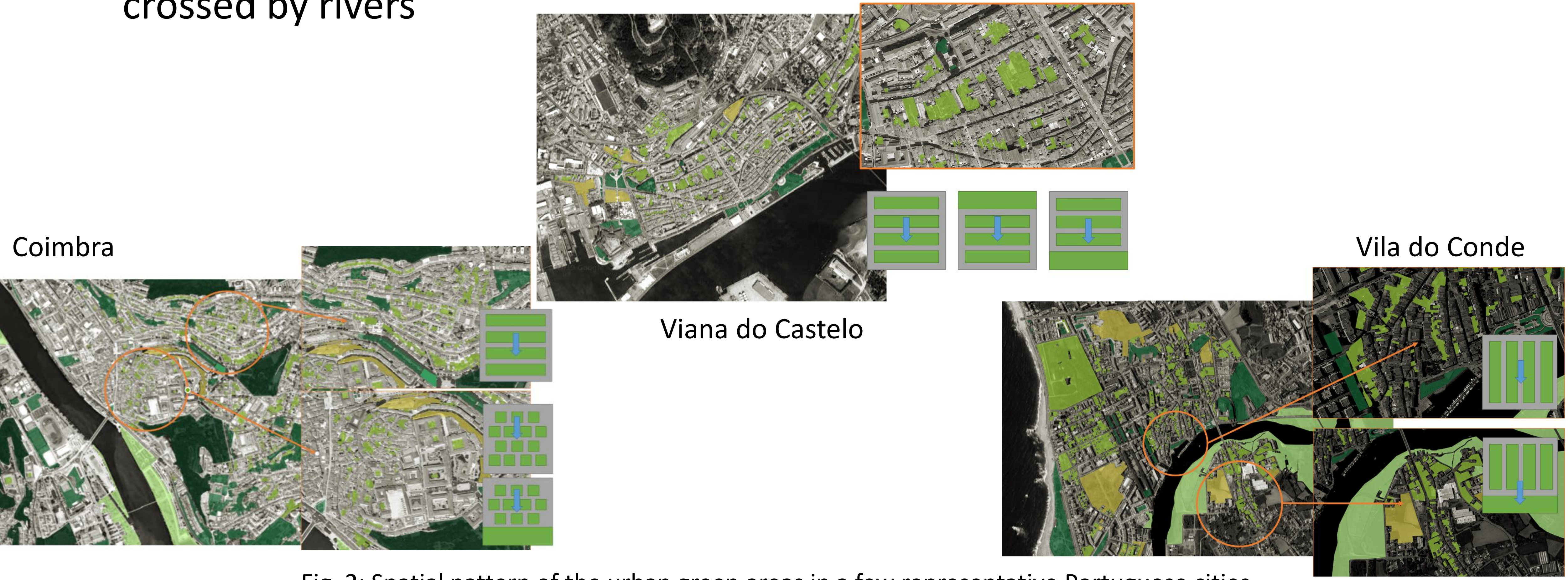


Fig. 2: Spatial pattern of the urban green areas in a few representative Portuguese cities.

2) Implementation of selected urban green patterns in lysimeter experiments
(0.78 x 1.60 m)

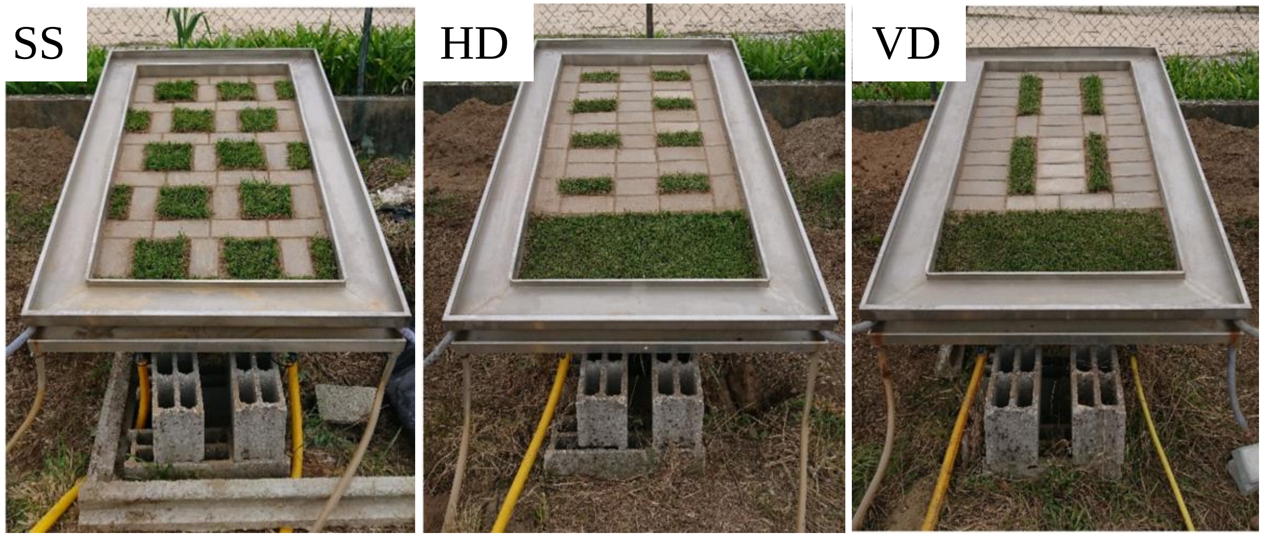


Fig. 3: Three spatial patterns investigated: dispersed gardens with a narrow green strip along the stream (SS), small gardens along contours, with a large green strip downslope (HD); linear gardens along the slope, with a large green strip downslope (VD).

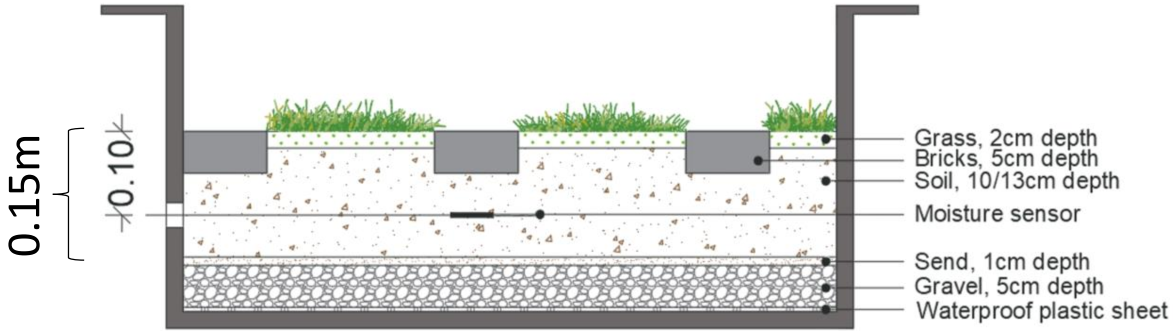


Fig. 4: Profile of lysimeter experiments, including different material layers and associated depths.

- **Surface cover**: 60% concrete blocks (to simulate sealed surfaces) and 40% turfgrass (to mimic gardens)
- **Soil properties**: sandy loam soil, 1.4 kg/m^3
- **Slope**: 13^o - 16^o
- **Installation date**: October 2019

3) Measurement of surface runoff and leachate volume after natural rainfall events

Fig. 5: Experimental setup, including two replicates per spatial pattern, one rainfall gauge, and runoff and leachate collection and storage systems.

Results: Rainfall pattern

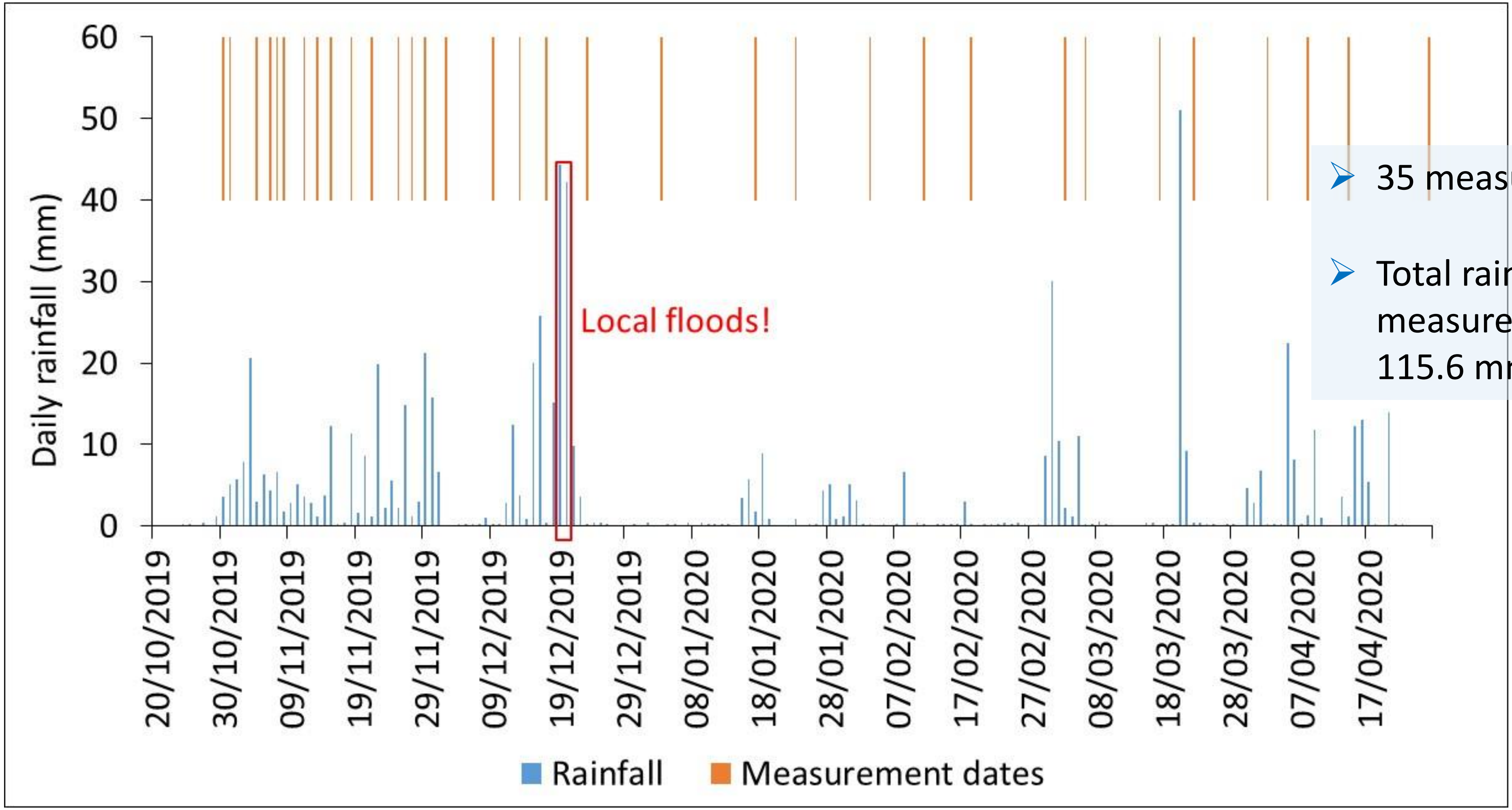


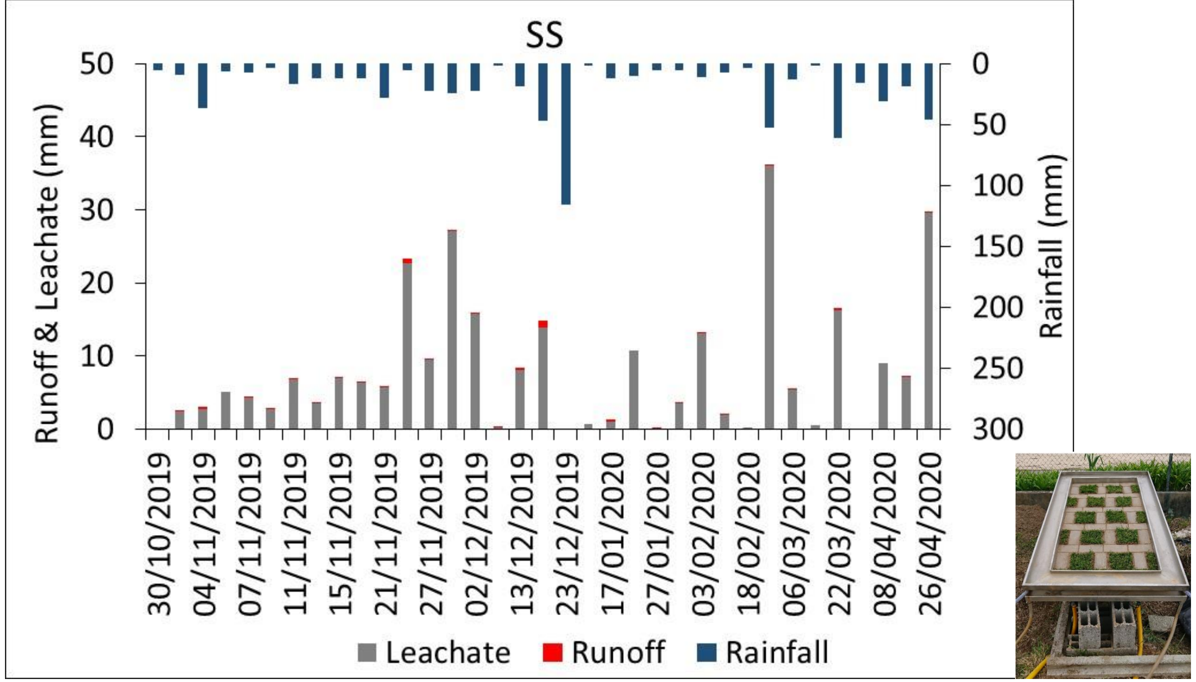
Fig. 6: Daily rainfall over the monitoring period.

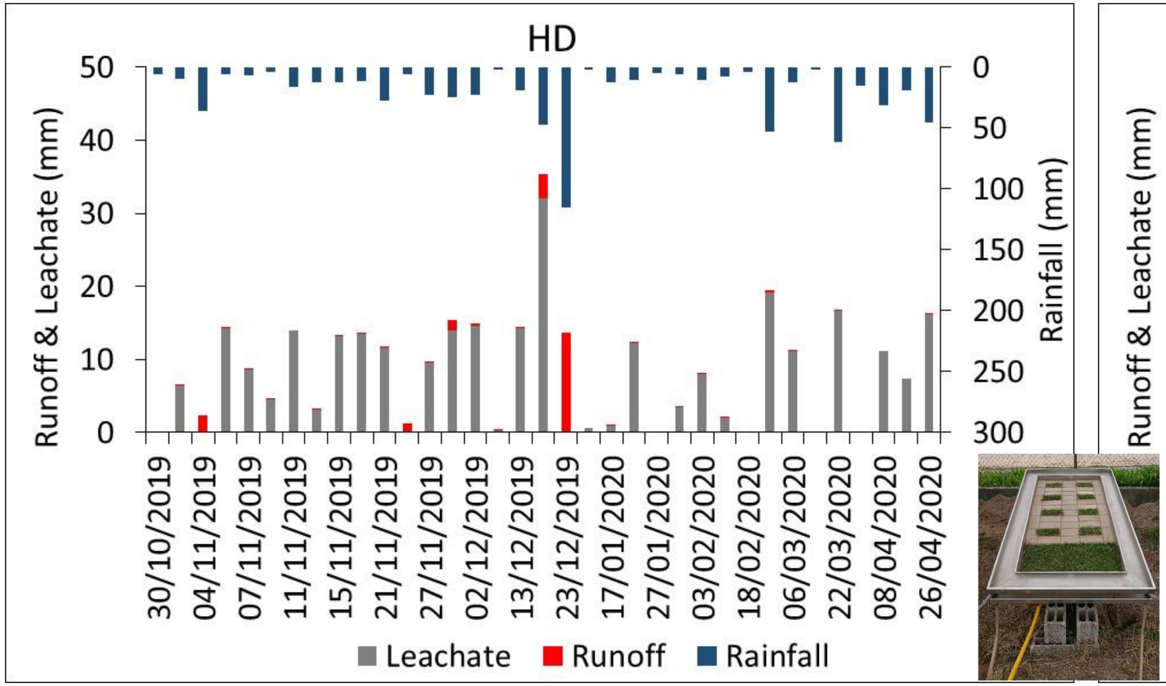
- 35 measurements performed
- Total rainfall between measurements: 1.5 mm to 115.6 mm

Results: Rainfall, runoff and leachate

- Under dry settings, the soil accumulates a relevant part of the water (runoff+leachate < rainfall);

- Slow movement of the water inside the soil leads to leachate stored in some of the subsquent storms (runoff+leachate > rainfall).





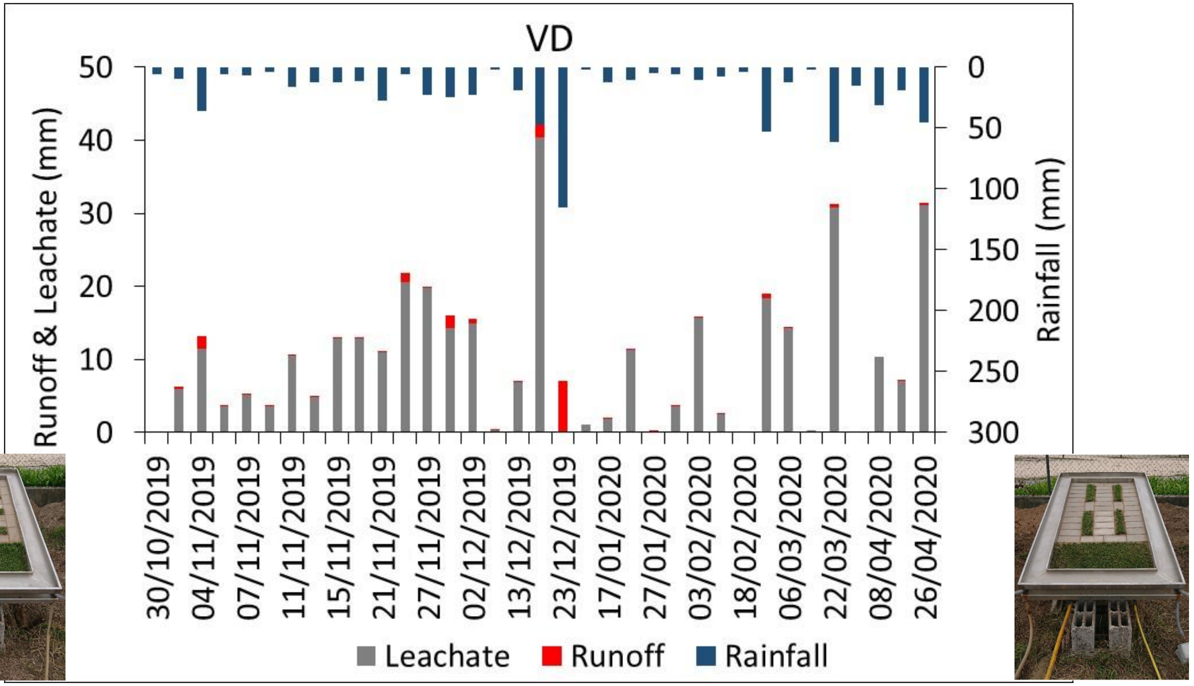
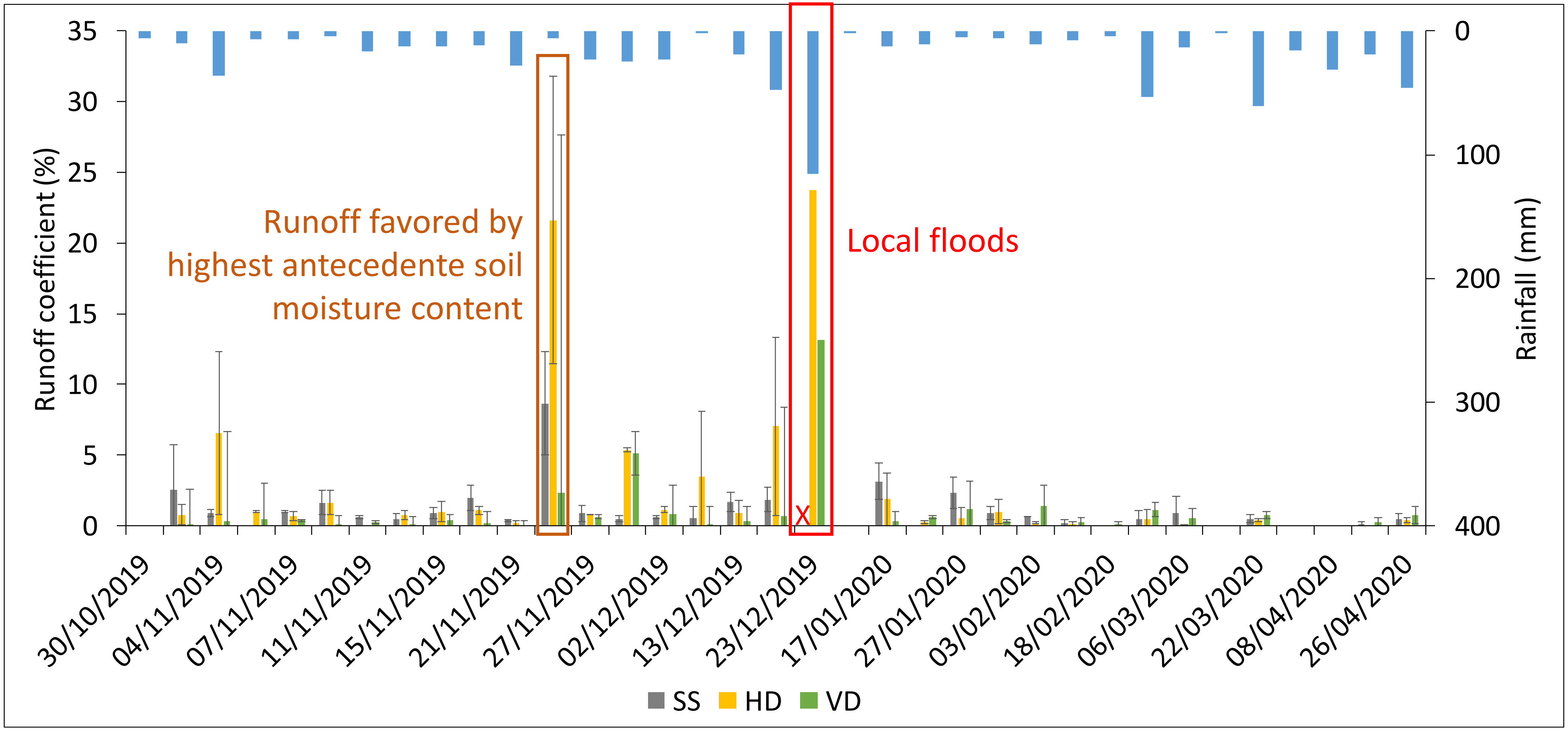


Fig. 7: Temporal variation of rainfall, and average runoff and leachate during the measurement periods.

Results: Runoff coefficient



Runoff coefficient (%) for the overall period

SS1 = 0.8% SS2 =1.0%

HD1 = 2.6% HD2 = 1.1%

VD1 = 2.5% VD2 = 1.1%

Conclusions

- Based on $1.24 m^2$ experiments, 40% turfgrass cover is able to cope with the majority of rainfall and runoff from upslope paved surfaces;

- Runoff coefficient is **typically <2%**, but can reach up to 25% under larger storms (44 mm/day) recorded in the wettest season;

- The **spatial green vs pavement patterns investigated did not show clear impacts on rainfall-runoff processes**, although dispersed gardens with a narrow green strip along the stream (SS) showed slightly lower runoff coefficient.

- **Turfgrass revealed effective to retain and infiltrate rainfall and runoff from paved surfaces**. It may provide an adequate solution to mitigate the impact of urbanization on the water cycle and flood hazard within cities.

- Further research will comprise (i) additional measurements to assess rainfall-runoff processes in larger rainfall events, and under distinct antecedent soil moisture conditions; and (ii) upscaling of the results.