URBHI – URBAN FLOOD RISK AND POLLUTANT RELOCATION AS A RESULT OF GLOBAL CHANGE

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Introduction

Global changes (i.e. combined climate and land use changes) are expected to induce significant alterations in climate and hydrological regimes in urban areas, producing flash floods with important impacts in terms of damage to property and even loss of human life, and significantly alter the transport and fade of pollutants. These flash floods occur mainly in small urbanized catchments. When added to global climate change, urbanization produces particularly intense changes in climate over towns and cities, which will aggravate climate change tendencies. The impact of this process on extreme rainfall events is still not well understood.

This poster presents the project URBHI – Urban flood risk and pollutant relocation as a result of global change – which is investigating the urban heat island impact on rainfall, with particular emphasis on extreme rainfall events. In addition to climate change, the project is studying how urban hydrology is influenced by alterations in land use, particularly increased urbanization. Land use changes considerably alter the connectivity of water fluxes between different catchment compartments and therefore have a significant impact on water fluxes and process thresholds. The ultimate URBHI objective is to provide guidelines for risk management and to propose a re-think of plans policies and programmes with the aim of alleviating the flash flood and pollutant hazard and improving risk management and mitigation strategies.

Covões catchment

The project URBHI is concerned with the Covões experimental catchment. Covões is a small (6.2 km^2) catchment located in the centre of mainland Portugal. The catchment is mostly covered by forests and farmland, with a significant presence (21.4%) of urban areas. It has experienced significant urbanization in recent years as a result of its proximity to the city of Coimbra. Figure 1 shows the evolution of urbanization in the catchment from 1990 to 2008, occupying what used to be farmland in the eastern part of the catchment. This trend is expected to continue, with new urban areas planned and under development.

The area is characterized by a humid Mediterranean climate, with an average annual temperature of 15 ^oC and total rainfall of 980 mm in an average year, with strong seasonal and interannual variability. In 2005, the runoff coefficient was 4.0% (Figure 2), showing a significant potential for a rise in runoff due to further urbanization. Nevertheless, a number of extreme rainfall events led to significant peak runoff rates in the catchment's outlet, with a major flood occurring in late 2007.

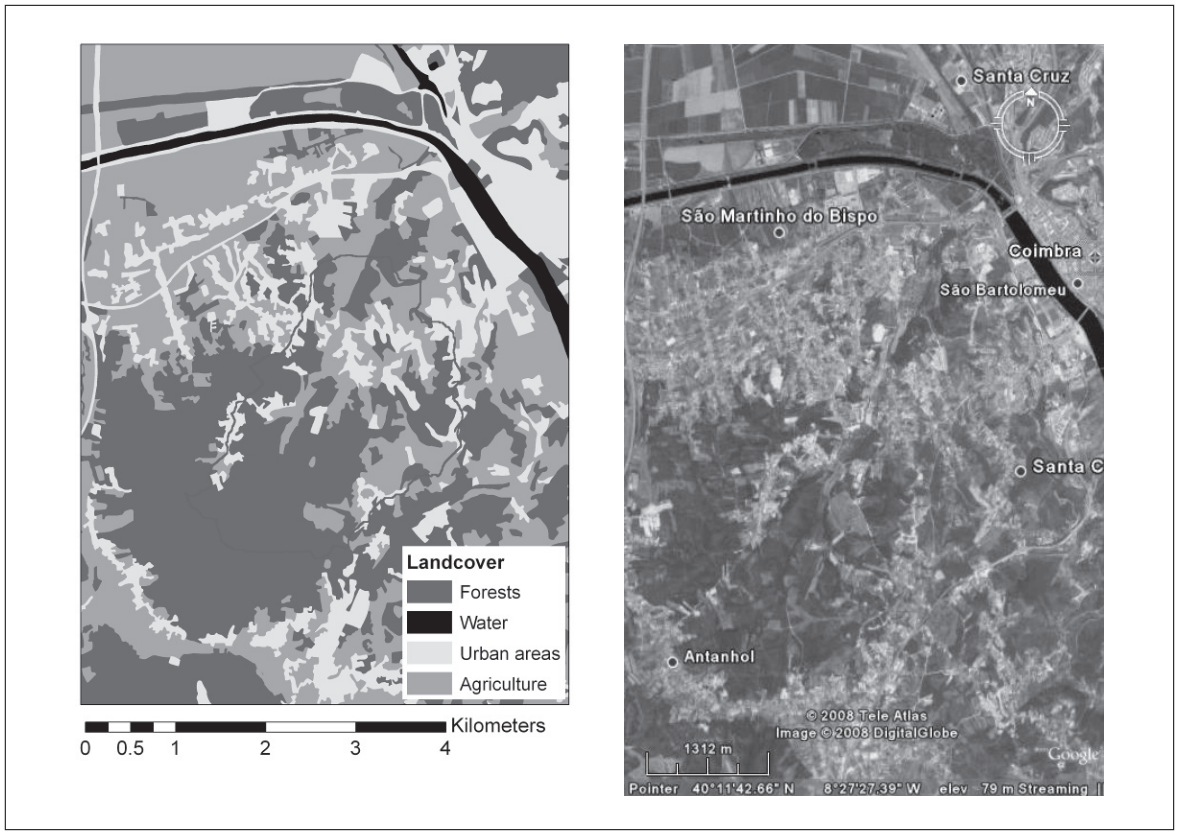

Figure 1. Map of the Covões catchment in 1990 (left) and air photo in 2008 (right)

The main processes requiring spatial and temporal monitoring in the catchment are: rainfall and streamflow (with high precision), to analyze rainfall-runoff processes under different storm patterns; infiltration and soil moisture patterns, to assess the importance of soil saturation for runoff generation processes on non-impervious areas of the catchment.

Monitoring program

The Covões catchment is being monitored and one weather station has been working for several years. Two other rainfall measuring sites will be shortly installed inside the catchment to assess the spatial distribution of rainfall characteristics (Figure 2). The impact of the specific urban climate on the nearby city of Coimbra and surrounding rural areas is also being assessed for different synoptic conditions.

Land use is being surveyed through the use of high resolution remote sensing data. A GIS database of land-use evolution in the past 50 years is also under construction, based on existing cartographic information and aerial photography.

Runoff response in the catchment is being monitored using hydrometric stations. One water level recorder is already installed at the catchment's outlet; another is being installed upstream of the main urbanized areas (Figure 2). This will enable the impact of urbanization on runoff response to be measured. A network of soil moisture probes is also installed in the catchment (Figure 2).

Monitoring results are currently being used to assess the impact of urbanization on the hydrological processes of the catchment. This information has also been used to feed, parameterize, calibrate and validate a physically based, spatially distributed hydrological model – MEFIDIS; Figure 3 shows a sample rainfall event used to validate the model. This model is being used to simulate the impact of climate and land use change on flash flood response, and of several planning strategies to mitigate flash flood impacts.

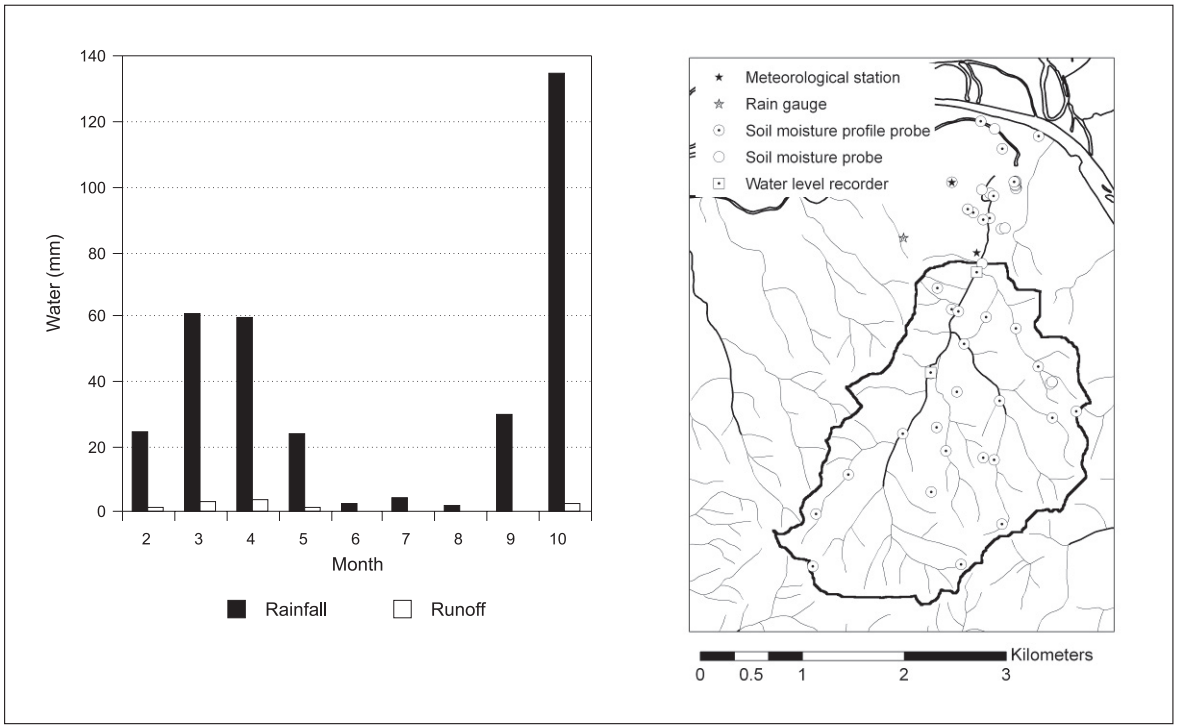

Figure 2. Monthly water balance in the Covões catchment for 2005, during the monitoring period (left). Map of current and future monitoring equipment (right)

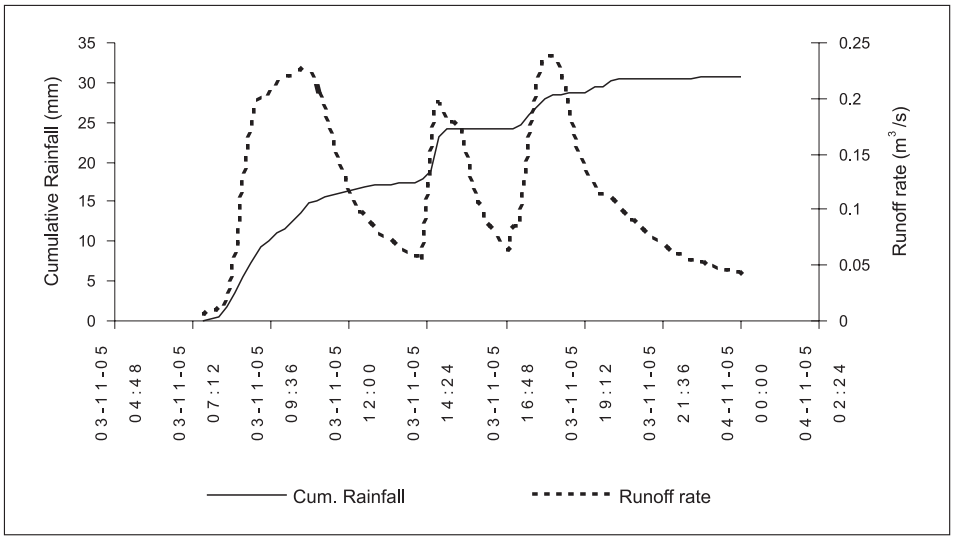

Figure 3. Cumulative rainfall and corresponding hydrograph for a selected storm

Further work

Project URBHI aims to further monitor the Covões catchment, especially in terms of transport processes:

- Several potential pollutant sources will be surveyed. Samples will be taken at selected points in the catchment during extreme rainfall events to assess the transport of pollutants.
- The relationship between climate, land use and pollutant (i.e. heavy metals, fats, oil and grease and hydrocarbons) transport and fade will be assessed using lysimeters, which will replicate the different types of non-impervious surfaces that are subject to different climate conditions.
- Sediment export at the outlet will be monitored to assess slope/channel erosion rates and sediment transport processes.

Furthermore, the project aims to contribute to the mitigation of flash flood and pollutant mobilization in urban areas by developing management tools based on a participatory approach. This approach will study how stakeholders and key actors perceive the problem. Key actors will then be exposed to the simulations for different global change scenarios and the implications of different planning strategies. Their views on how to solve the problem will then be incorporated into a spatial decision support system which will be made available to all key actors and stakeholders.

Conclusions

URBHI will study the interactions between climate and land use change, and provide knowledge useful to forecasting the magnitude and frequency of future peak flows. Processes to be studied include the impact of urban sprawl on:

- local climate, particularly in terms of frequency and intensity;
- soil and slope hydrological processes;
- the connection between soil and slope hydrology and small stream responses.

URBHI also aims to evaluate which land uses can be used to more efficiently adapt to the impact of increasing soil imperviousness caused by urbanization.

Furthermore, URBHI will develop a detailed monitoring network for the Covões catchment. This network will be maintained and improved upon in follow-up research projects, fulfilling the catchment's potential for becoming a fully-fledged experimental urban catchment.

Acknowledgments

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