How Sustainable Drainage Systems may improve city resilience: Experimental insights, Urban design modeling and performance assessment at the catchment scale

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This research aimed at investigating the potential of Sustainable Drainage Systems (SuDS) in the mitigation of flooding risk in urban areas. In particular, the research activities featured an experimental part, held at the University of Salerno and focused on the technology of Green Roofs (GRs), and modeling studies, aimed at assessing SuDS benefits in the stormwater management at the catchment scale and carried out in collaboration with IRIDRA S.r.l. and the Technische Universität Darmstadt.

The study of the hydrological behaviour of GRs under Mediterranean climate allowed understanding how design and climate variables could affect the role of these infrastructures in the mitigation of urban flooding. Specifically, this stage of the research focused on the analysis of the variation of retention performances of two extensive green roofs test beds, different in the drainage layer and located in the Campus of University of Salerno, according to the rainfall characteristics and design parameters. Both, in fact, proved to be crucial for the definition of soil moisture content, a key parameter in the performance of such infrastructures. Several studies were carried out to evaluate also the effect of Grs ageing on the overall performance of these systems. Moreover, to test their performance under controlled rainfall conditions and to understand how their size and design could affect their behaviour, an indoor experimental site was set up with Plexiglas cases customizable for reproducing different kind of GRs.

To understand the role of different typologies of SuDS in the mitigation of urban flooding in urban contexts, modelling approaches were developed to assess the performance of these infrastructures in Sesto Ulteriano (Northern Italy), a catchment that experienced a fast soil sealing and is actually affected by several hydraulic and hydrological criticalities. EPA SWMM5 simulations and comparison of a hard-technology scenario, representing the actual configuration of the drainage network, with design and model-based SuDS retrofitting scenarios, helped to assess how climate condition, SuDS spatial distribution, retrofitting potential, feasibility and land use could somehow affect the behaviour of these systems in urban catchments. In addition, to investigate how climate change may challenge these systems, an analysis of historical rainfall (1858-2019) enabled the identification of trends in precipitation extremes for the design of potential climate scenario within a 30-year future time window. Again, simulations were performed to test SuDS modeling scenarios under continuous and event-scale potential future rainfalls.

As for the GRs analyses, results show an overall tendency of reduction of stormwater retention for large events (long duration, high cumulate depth and rainfall intensity) and mainly see the rainfall cumulate depth as the best predictor for retention coefficients. Drainage layer building practices and initial Soil Moisture Contents also seem to play a key role on the GRs retention properties.

Urban-scale studies highlighted the importance of the awareness of the actual retrofitting potential of catchments in the prediction of the effectiveness of SuDS projects for flooding risk mitigation. Strategical solutions based on fixed and unaware project retrofitting percentages, would inevitably result in unsuccessful interventions, unable to pursue city resilience. Overall, findings achieved so far suggest that these infrastructures are actually able to mitigate the effects deriving from urbanization and soil sealing. Although few are the retrofittable surfaces in developed urban context, such infrastructures are nevertheless a valid aid for traditional drainage systems in the management of stormwater, providing besides numerous additional benefits for human beings and nature. For sure, in planning such interventions, it must also be taken into account that the effect of climate changes seem to counteract their efficiency. Under future potential climate scenarios, in fact, slightly worse performances were registered, showing, at the same time, how SuDS can be valuable used to adapt to climate change conditions but that the resilience they provide in terms of stormwater management issue would be much more sensitive to climate input in the next future.

Partnerships

The research project, carried out at the University of Salerno, provided for a partnership with an Italian company, Iridra S.r.l. in Florence, and with a foreign university, the Technische Universität Darmstadt in Germany. Professor Antonia Longobardi oversaw the research carried out at the University of Salerno and supervised all the tasks. Professor Britta Schmalz, head of the Department of Engineering Hydrology and Water Management of the Technische Universität Darmstadt, was responsible for co-ordinating the work during the stage abroad from June 2019 to November 2019 (6 months) and was involved in other subsequent activities. Anacleto Rizzo, Ph.D. an hydraulic engineer, and Nicola Martinuzzi, mechanical engineer and chief executive officer of Iridra S.r.l., handled the activities during the stage (6 months) in the company and provided the case study.