Towards a Water Sensitive City: an integrated approach to test the effectiveness of green infrastructure adoption in Northern Italy.

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Highlights

- Water Sensitive City is not an arrival point but a path to be taken and pursued.
- Integrated approach based on sharing knowledge and interests that aims to encourage a collective engagement.
- Spatial suitability assessment framework for WSUD, as a basis for new planning tools.
- Incorporation of ecosystem services into suitability framework for green stormwater systems.

Introduction

Urbanization, population growth and climate change are world-wide phenomena which are putting a strain on the efficiency of urban water systems (Ashley et al., 2005; McGrane, 2016).

Our cities are experiencing the pressures of these phenomena and they are facing many economic, social, health and environmental challenges even more exasperated by an increase in frequency of urban floods. Conventional centralized water infrastructures, especially pipe networks, which have a long-life span, are frequently classified as highly unsuitable to address future challenges (Mikovits et al., 2013).

New water management strategies must be then developed.

The complexity of this challenge calls for the integration of knowledge from different disciplines and collaborative approaches. Furthermore, although the population remains generally unaware of the economic and environment impact of this phenomena the contribution of the people living in the affected site is essential to find new adaptation strategies (Ashley et al., 2005).

As such, the shift toward more integrated approaches to urban water management is being recognised as a challenging but necessary direction to take (McGrane, 2016). While some places are still grappling with the delivery of essential services like water supply and sewer pipes, others are struggling to address and overcome some of the vulnerabilities inadvertently created by their existing water management systems (Morita, 2014). For both developed and developing cities, the concept of Water Sensitive Cities represents one of the starting points for developing new techniques, strategies, policies, and tools to ensure a better liveability, sustainability, and resilience of the cities.

The process of transition from a traditional city to a Water Sensitive City requires a radical change in the way of thinking about run-off water which must no longer be considered as wastewater but as a useful and precious resource (Bichai and Flamini, 2018). By treating all types of water as a valuable resource, new approaches and opportunities arise; both directly in terms of preserving the freshwater resource and obtaining climate resilience, and indirectly in terms of creating more liveable cities by linking the new water infrastructures to aesthetical and recreational benefits (Bichai and Flamini, 2018).

This study aims to apply this concept using the DAnCE4Water model (https://www.wsc-scenario.org.au/) to an Italian town that in recent years has faced severe water issues, Parma.

This model allows to evaluate the efficiency of new decentralized technologies (Water Sensitive Urban Design) and their integration with existing centralized technologies (water drainage network). In particular, the model creates complex interactions between the urban environment and the hydraulic network and simulates different scenarios of the development of the urban environment and water system (Urich et al., 2012; Urich and Rauch, 2014; Löwe et al., 2017).

This paper demonstrates application of this approach to an integrated research project that draws from social science, architecture, urban planning and environmental engineering to develop interdisciplinary insight into the opportunities for increasing local resilience to flooding and urban liveability (Turco et al., 2020).

Methodology

Case Study

The approach has been applied on Parma, a town in the north of Italy that extends on the southern area of the Po River flood plain, for a total extension of about 260.77 km^2 with a population of 193.315. The city of Parma in the last century has been affected several times by intense flood events, and at the same time it has faced a drought emergency in 2017. In the last seventy years it attended almost a doubling of the resident population, and in recent years it has launched projects aimed at redeveloping its urban drainage system.

Modelling and analysis

A computational decision-support tool was used to analyse interactions between urban forms and flood risk for adaptation options, aiming at flood mitigation through stormwater management solutions and innovative urban designs, by testing their efficiency under different scenarios.

This testing was enabled by recent developments in scenario modelling, supported by DAnCE4Water's urban development algorithms coupled with the EPA SWMM modelling software that assesses flood risk in time. Testing mitigation measures for different potential scenarios is essential for the identification of robust solutions. As for the sewerage, the SWMM5 hydraulic and hydrologic modelling software was used to create a coarse combined sewer system model representing the sewerage system of the city. The sewer has been simplified into 110 drainage basins, 5399 nodes (manholes) and 6653 links (pipes).

Urban growth was modelled by splitting existing parcels and placing new buildings based on predefined preferences on location and building type, as well as on high level drivers such as population growth. Urban layout details were translated into the SWMM model as changes in impervious area, the pipe network, or the terrain. The flood risk assessment has been evaluated under four different scenarios: a first scenario, Business as Usual (BAU), representing the state of the art without implementation of any adaptation strategies, two scenarios with an implementation of adaptation strategies (Green Roofs and Porous Pavements) and a last scenario characterised by New Urban Development areas.

Dance4Water

DAnCE4Water is a strategic planning tool, modelling the complex interactions between the social system, the urban environment and the water system under different scenarios including climate changes, changes in the societal needs and urban development (Urich et al., 2014).

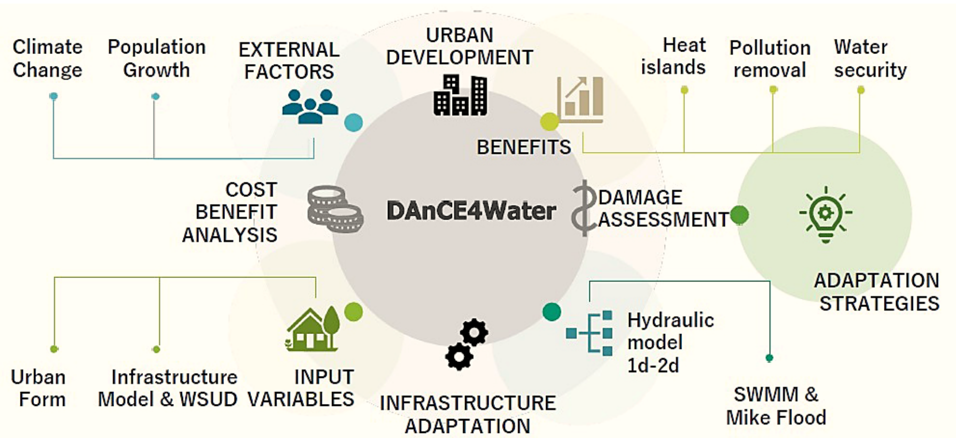

Figure 1. DAnCE4Water module overview (Urich, 2012).

Results and discussion

The results show how the application of porous pavement or green roofs can significantly reduce the surface runoff. The fourth scenario that experienced new urban development and an increase in population reported higher flooding values than the BAU scenario (existing situation). The table shows how the lack of interventions and a change in the current rainwater management policies can lead to a worsening of the situation, not only from the hydraulic point of view but also in relation to the surface temperature with a consequent increase in the heat island effect. On the other hand, due to a lack of data on sewerage and a low level of detail about the land use, the results are to be considered only as preliminary outcomes.

Table 1. Simulation results for each potential scenario

SCENARIO	Total Precipitation [mm]	Infiltration Loss [mm]	Surface Runoff [mm]	Final Storage [mm]
BAU	24,0	1,6	19,4	2,9
Porous Pavement	24,0	5,3	15,0	3,7
Green Roofs	24,0	5,8	14,9	3,2
New Urbanization	24,0	1,5	19,6	3,0

The integrated approach adopted for the case study represents an important innovation: it enables a city to benchmark its current water management practices and policies, it helps cities to identify their short and long term goals for water sensitivity, it allows to test and evaluate the effectiveness of various strategies through the use of a new modelling software, it provides an interesting perspective for more efficient and sustainable interventions and it can reveal city's strengths and vulnerabilities.

Conclusions and future work

Urban water managers have to cope with increasingly complex and multi-faceted challenges as societal expectations grow and natural resources reach the limits of sustainable exploitation.
Considering climate change and population growth challenges that cities are facing there is a critical need for strategic investment in solutions to deliver long-term sustainable outcomes. Despite the commitment of many Italian cities, especially in Northern regions, to become a water-sensitive city, the process is still at an early stage and there is a long way to go before the goal is reached. In many cases old sewer systems are now inadequate and adopting natural based solutions is not yet considered as a priority, even if fastered at many levels (Grossi et al., 2021). However, the adoption of green roofs and porous pavements is favouring an improvement in current conditions and a partial mitigation of some of the existing criticalities.

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