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# Green strategies for flood resilient cities: The Benevento case study

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**Abstract**

Over the past 50 years, cities experienced a rapid and uncontrolled growth that caused the loss of numerous permeable soils. Soil-sealing reduced soils' ability to absorb rainwater, compromising cities' capability to manage the impacts of rainstorms triggered by climate change, and consequently increasing floods' risk.
The research work focuses on the key role of green infrastructures for urban adaptation to climate-related events. The analysis of the flood that hit Benevento in October 2015 led to the definition of a nature-based strategy designed to achieve three main goals: to reduce impervious surfaces in the compact city; to prevent further soil sealing; to recover the fluvial ecosystem.


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## 1. Climate change, urbanization and flooding risk

Climate change is one of the primary challenges of our century. The phenomenon exposes human and natural ecosystems to numerous threats that have been extensively analyzed by IPCC's Working group II[1]. Europe is affected by heterogeneous climate-related impacts (higher temperatures, rising sea levels, extreme rainfalls), even though the European Environmental Agency has identified river flooding and wind related storms as the most significant impacts in Europe in terms of economic loss[2].

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Intense and sudden downpours are becoming in fact more and more frequent, by inducing floods whose increasing severity depends on several interrelated factors, such as changes in climatic systems, in land-use and land-cover, in population size and development and in soil sealing due to current urbanization patterns[3]. Soil sealing, defined as the coverage of natural soil surfaces with impervious materials[4], implies both the loss of permeable natural soils and the fragmentation of the natural environment. The main consequences of these phenomena are, besides the increase of flood risk, the depletion of biodiversity, the intensification of global warming, the loss of valuable and fertile territories as well as of soil itself[5]. The latter is indeed more and more largely recognized as a non-renewable resource that provides numerous ecosystem services: it represents the physical support for plants, animals and human infrastructures being, meanwhile, an important reservoir of biodiversity that contributes to climate regulation[6]. Hence, soil sealing significantly interferes with the natural balances of ecosystems, seriously affecting their capacity to deal with climate-related events.

In urban areas the increasing rate of impervious surfaces and the lower and lower capacity of water storage have significantly compromised the potential for detaining rainwater and controlling superficial run off. Meanwhile, the decrease of humid areas due to the urbanization of floodplains has further intensified the risk of rivers' overflows. These phenomena, which can be respectively identified as pluvial and fluvial flooding, may act in a complementary manner, causing a significant increase in the flood risk levels. Pluvial flooding, due to the heavy downpours, largely depends on the increasing amount of impervious surfaces that cause higher and faster flows of surface runoff, which overload the urban sewage system[7]. Fluvial flooding is often the result of both intense rainfalls directly flowing into the water body and of the urban sewage's system discharge that, from the neighboring urban areas, pours into the water bodies. The consequent rivers' overload causes their overflow over areas that used to be floodplains, but are most likely urbanized by now[7]: despite the deployment of land-use regulations aimed at avoiding flood plain risks, indeed, "commercial pressures or inadequate implementation in some countries" have significantly reduced their efficacy[8].

So far flood prevention was entrusted both to land-use regulations, often ineffective, and above all to grey measures: "physical interventions (…) to make buildings and infrastructure essential for the social and economic well-being of society more capable of withstanding extreme events"[2]. Nevertheless, grey measures represent in many cases high-regret options: although very expensive, they are sized to respect the most likely flooding events, and are often inadequate to cope with the increasing uncertainty related to climate change. The latter indeed, by inducing changes in hazards' features as well as in cities' characteristics, might result in an "escalation of impacts" and a multiplication of hazards' consequences[9].

Hence, numerous scholars as well as institutional reports have recently emphasized the need for a change in current approaches to flood prevention. This change should be addressed to: shift from defensive action against hazards towards natural management techniques, capable to "work with natural hydrological and morphological processes"[10]; consider flood prevention not limited to the most likely flood events but also to rare events[11]; favour flexible adaptation policies in order to deal with uncertainty. Flexible strategies "can be helped by (…) implementing a combination of 'grey' (i.e. technological and engineering solutions), 'green' (i.e. ecosystem-based approaches) and 'soft' (i.e. managerial, legal and policy approaches) adaptation options (…)"[1].

Moreover, the European Flood Risk Directive issued in 2007 has highlighted the urgent need for Member States to introduce flood risk management plans, providing prevention and protection measures and favoring, above all, "sustainable land use practices, improvement of water retention as well as the controlled flooding of certain areas in the case of a flood event"[12]. Thus, the Flood Directive has encouraged the widespread of "natural catchment-based approaches to runoff control and flood generation" that go beyond traditional engineering solutions; moreover, the Directive devotes "greater attention on sustainable and adaptive flood abatement measures (…) aimed at protecting and restoring natural ecosystem services, and realizing multiple co-benefits, whilst providing a socially-acceptable degree of flood protection and minimizing social, environmental and economic costs"[13]. It is worth reminding that such a paradigm shift has been clearly remarked also by the Sendai Framework for Disaster Risk Reduction 2015-2030, adopted during the third UN World Conference in March 2015. It has clearly emphasized, indeed, that the strengthening of the sustainable use and the integrated environmental management of ecosystems represent key strategies towards a more effective disaster risk reduction strategy.