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## NEW CHALLENGES FOR XXI CENTURY CITIES

Global warming, ageing of population, reduction of energy consumption, immigration flows, optimization of land use, technological innovation


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TeMA Journal was established with the primary objective of fostering and strengthening the integration between urban transformation studies and those focused on mobility governance, in all their aspects, with a view to environmental sustainability. The three issues of the 2024 volume of TeMA Journal propose articles that deal the effects of global warming, the ageing of population, the reduction of energy consumption from fossil fuels, the immigration flows from disadvantaged regions, the technological innovation and the optimization of land use.

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The cover image shows heavy damage from floods in the Valencia, eastern Spain in October 2024
(Source: t.me/beholdisraelchannel/43470?single). The cover image was elaborated on to improve the resolution quality using free AI software.

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**REVIEW NOTES – Urban Practices**

# Global warming or global warning? A review of urban practices for adaptation to urban floods

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**Abstract**
Starting from the relationship between urban planning and mobility management, TeMA has gradually expanded the view of the covered topics, always remaining in the groove of rigorous scientific in-depth analysis. This section of the Journal, Review Notes, is the expression of continuously updating emerging topics concerning relationships between urban planning, mobility and environment, through a collection of short scientific papers written by young researchers. The Review Notes are made of four parts. Each section examines a specific aspect of the broader information storage within the main interests of TeMA Journal. In particular, the Urban Practices section aims at presenting recent advancements on relevant topics that underline the challenges that the cities have to face. This note provides an overview of the challenges that global warming poses and the risks in terms of climate change that it generates for territories and cities, with a specific focus on the urban flooding phenomenon. The challenges that adaptation to urban flooding events commonly faces are outlined, and a brief review of international case studies is carried out. Finally, the results of the review are discussed highlighting some key threads of adaptation to urban flooding practices and three significant examples of adaptation in urban areas are reported, within a perspective of integration and sharing of know-how on the topic.

**Keywords**
Climate change; Adaptation; Urban practices; Case studies; Urban floods.

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## 1. Introduction

Extreme weather events are natural phenomena, occurring at considerable distances in time, and have always been part of human experience and people's historical memory. These events are characterized as rare at a particular place and time of year, with unusual characteristics in terms of magnitude, location, timing, or extent (World Metereological Organization, 2023). Over the past 10 years, we have become accustomed to witnessing these phenomena more conspicuously in terms of frequency and intensity, annually reporting at least one phenomenon that emerges on a global scale and connotes itself as "the phenomenon of the year," sometimes earning a familiar household name, such as Charon or Katrina.

The year 2024, however, from the beginning, heralded itself as the year when certain global thresholds would be crossed (World Metereological Organization, 2024). Flood-related disasters of rare severity have occurred in almost every region of the world, events that are expected to occur with a 100-year frequency but are challenging traditional forecasting techniques.

In May, one of the worst weather disasters in the country's history struck southern Brazil, particularly the state of Rio Grande do Sul (Pan American Health Organization, 2024). Images of the thousands of displaced people, whose homes were completely destroyed or washed away by the tumult of the water, shocked the world. The damage and impacts in terms of economy and human lives were already present in the collective imaginary, but thousands of people losing everything: housing, possessions, jobs and sources of livelihood, is a consequence that was not yet perceived as close.

Hurricanes and other phenomena typical of the earth's tropical area, such as cyclones and typhoons, are themselves natural phenomena, and it is not surprising to hear about them annually in the rainy season. These phenomena, however, have a natural origin, but they have consequences that are less and less natural and manifest other worrisome aspects of coastal flooding hazards. Hurricane Milton marked 2024 for the mass evacuation that affected more than 5 million people in Florida, in the southern United States (Mazzei & Taft, 2024), and caused total destruction, coming to cost over 34 billion in damages (Isidore, 2024).

Europe has also been the setting of disastrous and alarming phenomena. Spain has seen one of the most severe floods in the last 100 years, with more than 200 deaths and unprecedented images of stacks of cars submerged and stuck in urban streets, a glaring sign that the icons of modernity and contemporary security are nothing against the uncontrolled power of natural phenomena that should dictate the rules of our expansion and development (NASA Earth Observatory, 2024). The Spanish case is emblematic in that it embodies, on the one hand, the power that meteorological-climatic contingencies, in this case the cold drop phenomenon, can achieve in a context of climate change; but also, the severity of the effects that erroneous urban expansion choices and deficient prevention and civil protection measures can generate, especially in terms of human lives.

These epochal events, nevertheless, although surprising in terms of magnitude, do not come unexpectedly. With two months to go, it is almost certain that 2024 will be the hottest year on record since the pre-industrial age, with the global average temperature reaching +1.54 °C, even exceeding the limit identified as an extreme not to be surpassed in the Paris Agreements (World Meteorological Organization, 2024). As temperatures gradually rise, accelerated by the increase of greenhouse gases in the atmosphere, the oceans and seas are also warming, going on to alter the water cycle with tangible consequences in terms of precipitation and dynamics between aquifers, reservoirs and waterways.

## 2. Urban flooding and climate change

These phenomena have long been studied and are among the objects of the IPCC Assessment Reports. There are multiple ways in which rising temperatures influence the occurrence of flooding phenomena, and there are multiple types of flooding that can occur.

Warmer air holds more moisture, and wetter air leads to more abundant and intense rainfall. For every degree increase in global warming, about 7 percent more extreme daily precipitation is expected (World Meteorological Organization, 2024). Intense rainfall, occurring in contexts characterized by other phenomena such as: increased urbanization, soil sealing, and inadequate and backward urban drainage systems, leads to a first type of urban flooding: pluvial flooding, caused by extreme rainfall in urban environments and which can potentially occur anywhere as rainfall intensity increases. This phenomenon occurred in the recent flooding of the Valencia region, during which streets suddenly filled with water turned into actual rivers, dragging whatever was in the way.

Increased rainfall intensity and extreme rainfall patterns (alternating long periods of absence with intense events concentrated in a few hours or days), can contribute to the occurrence of fluvial flooding, flooding caused by the sudden increase in river flows that, combined with excessive and unnatural anthropization of river floodplains, subjects inhabitants and infrastructure to disastrous flooding. At a time when the effects of climate change were not yet so obvious, many cities that have sprung up along rivers have unabashedly increased urbanization and subsequent sealing along their banks, eliminating the natural river floodplains that are supposed to absorb the natural flooding phenomena that occur remotely over time. The anthropization of the banks has also caused a degradation of the natural ecosystems that helped absorb and manage rainwater, further reducing the resilience of urban areas to these phenomena (Rentschler et al., 2024). Fluvial floods are thus also potential types of urban flooding, often coupled with or dependent on related pluvial flooding phenomena, as was the case with the disastrous floods in southern Brazil.

In parallel, among the most obvious consequences of global warming is the melting of glaciers and polar ice caps, a phenomenon that contributes to sea-level rise. This phenomenon exacerbates coastal flooding that occurs in the case of storms and storm surges, as well as in the cases of typhoons, hurricanes and cyclones, phenomena whose intensity is in turn increased by the increased moisture in the air due to higher temperatures. This convergence of phenomena leads to an increase in the power of these increasingly extreme events, a prime example of which was Hurricane Milton in Florida. This type of flooding, referred to as tidal or coastal flooding, is in turn made more dangerous by the combination with other non-climate-sensitive urbanization phenomena, which has seen heavy coastal urbanization, with sealing of soils and often the failure to provide for warning, emergency, or infrastructure systems that can protect the built environment and the citizens from these phenomena.

Compared to the phenomenon of extreme heat, the subject of the previous review in this series (Pennino, 2024b), urban flooding has more tangible consequences and is now central to the concerns of the very citizens who witnessed it directly or indirectly this year, more than ever before. It is therefore an urgent priority to adapt urban environments to these phenomena that will continue to occur, and to make communities more resilient and ready to deal with them.

## 3. Adaptation to urban floods, a review of case studies

As the types of urban flooding are multiple, involve different causes and produce manifold effects, the strategies and interventions that can be put in place in terms of adaptation are also varied and differentiated. First, starting with the most normalized strategies in the current way of transforming the built environment, there is the need to implement, redesign and adapt gray infrastructure, that is, all the built infrastructure such as drainage networks, catch basins, and culverts that are integrated into urban environments precisely to manage stormwater runoff and its eventual accumulation during downpours. These infrastructures have often been built without considering climate change forecasts, and thus prove unsuitable for the increasingly extreme weather phenomena affecting our cities. It is therefore necessary to adapt the existing infrastructure, improve or enlarge it where required, so to adapt it to the new forecasts of weather phenomena caused by climate change.

A parallel strategy that has been emerging as a major player in recent years is that of replacing gray infrastructure or, more often, supplementing that with green and blue infrastructure. This strategy involves the creation of alternative infrastructures, based on natural elements such as tree cover, plantings, creation of natural basins, and the integration of ecosystems into the built environment, that help recreate the natural capacity of soils and plants to absorb and retain water and moisture, offloading the pressure put on gray infrastructure, and providing numerous additional benefits to citizen, such as a mitigation of surface and air temperatures, and a restoration of local ecosystems and biodiversity, as well as the pleasantness of urban environments.

These solutions are partly assimilable to another broad category of adaptation strategies, that of nature-based solutions (NBSs). This category, in fact, proposes the use of natural elements that perform the same function as gray technologies or infrastructure, and thus have a lower environmental impact as well as a lower cost of production and numerous additional benefits. These include, in addition to the aforementioned green and blue infrastructure, all those technological solutions that integrate natural elements centrally in solving climate challenges, including green roofs and walls, permeable pavements, rain gardens, and numerous others.

Preserving soil and ecosystems is intrinsically linked to safeguarding the urban and peri-urban landscape, which serves as a strategy for maintaining environmental characteristics while protecting the cultural and social value of natural spaces near urban areas. To effectively address the risks of urban flooding, control mechanisms for landscape variation should be designed to reflect local features and respond to emerging environmental challenges (Cialdea, 2023). This integrated approach would ensure resilience while balancing ecological preservation and the socio-cultural significance of these landscapes.

Solutions that include physical adaptation of cities, however, are not the only way and are not sufficient to adapt urban systems, which in addition to natural and built spaces are also composed of urban actors and functions. Indeed, strategies that rely on tools for monitoring and warning of these phenomena, enabling real-time analysis of phenomena and consequent early warning communications, are crucial. In parallel, evacuation and emergency plans and the appropriate training and preparation of the citizenry for these phenomena are fundamental, to coordinate the response of the population in these extreme situations while limiting damage and, above all, avoiding loss of life.

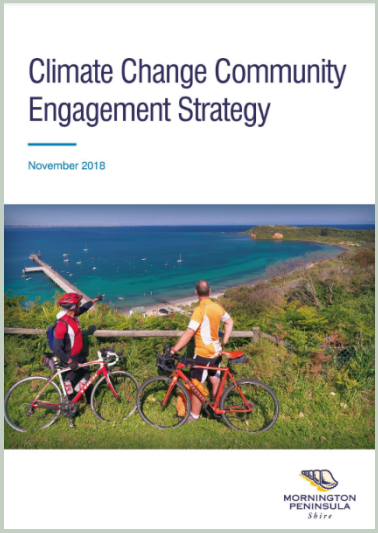
As summarized in the first paper in this series (Pennino, 2024a), adaptation to climate change is now a central issue in the international debate on climate change. As the issue is closely linked to cities, both as a problem and as a potential, the many guidelines provided by international organizations and the many successful cases collected in special repositories provide useful food for thought.

With reference to the topic of this paper, there are already many cities that have implemented urban flood adaptation strategies. In this review are reported three case studies of different types from three exemplary databases focused on this central issue in the climate change adaptation discourse:

- Climate-ADAPT, the Environmental Information platform which collects and makes available for consultation the European adaptation case studies, coordinated by the European Environment Agency under the aegis of the European Commission;
- The Climate Change Adaptation Resource Center of EPA, the United States Environmental Protection Agency, whose projects fit in the goal of the organization which involves urderstanding and addressing climate change to protect human health and the environment;
- CoastAdapt, an Australian online platform the National Climate Change Adaptation Research Facility (NCCARF) of the Department of Environment and Energy of the Australian Government, that supports communities in adapting to coastal climate change impacts with tools, case studies, and data-driven guidance.

Each of the case studies was carried out in a different geographic area and is a strategy for adapting to the three different types of urban flooding: coastal, riverine and pluvial.

### 2.1 Community conversations: building engagement to mainstream climate adaptation in Mornington Peninsula Shire Council




The Mornington Peninsula Shire Council developed a comprehensive coastal adaptation initiative to address the increasing risks of flooding by prioritizing community engagement and education. Recognizing that public participation is crucial for effective adaptation, the Council facilitated "community conversations" where they shared scientific insights about climate change impacts while actively listening to residents' experiences and concerns. This participatory approach not only built trust but also empowered residents to take ownership of adaptation strategies, ensuring that the solutions were both practical and relevant to local needs.

As a result, the Council integrated community perspectives into flood risk management plans and established policies that reflect the unique characteristics of the coastal environment. Their initiatives included the development of green infrastructure solutions, the protection of natural ecosystems, and the implementation of flood mitigation strategies that addressed specific vulnerabilities. The Council also prioritized collaboration with stakeholders, such as environmental experts, local planners, and community groups, to create tailored solutions that promote long-term resilience.

Moreover, the project emphasized the importance of maintaining cultural and social ties to the environment, ensuring that natural spaces retain their ecological and community significance. Educational campaigns and public workshops strengthened the community's collective awareness of climate risks and the necessity of adaptive measures. By prioritizing transparency, inclusiveness, and cooperation, the Council laid the foundation for a sustainable and resilient coastal area, ready to face the ongoing challenges posed by climate change and extreme weather events.

This case study serves as a valuable example of how participatory governance and community-centric approaches are essential in addressing climate adaptation. It highlights the importance of integrating local knowledge, scientific research, and practical interventions to build coastal resilience, protect the environment, and support the social fabric of Mornington Peninsula's coastal communities.

Organization: The Mornington Peninsula Shire Council

Source: CoastAdapt, National Climate Change Adaptation Research Facility; 2016

Retrieved from: https://coastadapt.com.au/case-studies/community-conversations-building-engagement-mainstream-adaptation-mornington-peninsula

### 2.2 Smart growth along the riverfront helps manage stormwater in Iowa City, Iowa

Iowa City was among the hardest hit communities from the 2008 Iowa River floods with extensive flooding along the riverfront. In 2009, EPA and FEMA worked with the state organization, Rebuild Iowa, to identify policy options to accommodate growth in the Riverfront Crossings District and add green infrastructure and open space to reduce flooding. Subsequent EPA assistance on brownfields redevelopment and green infrastructure helped the city develop a master plan to rebuild the riverfront while protecting the environment, promoting equitable development, and helping address the challenges of climate change. The Riverfront Crossings Master Plan aims to create a resilient riverfront community park through using flood mitigation measures and stormwater best management practices to protect against future flooding.

The plan would relocate vulnerable properties and infrastructure away from the floodplain and guide future development away from the most vulnerable areas. The Riverfront Crossings Master Plan promotes green infrastructure, vegetated buffer zones and public spaces along rivers and streams to reduce

flooding, runoff, and erosion. While this plan did not explicitly incorporate climate projections, it can help Iowa City better manage projected increases in extreme rainfall, stormwater runoff and flooding along the riverfront. The Riverfront Crossings Master Plan will help Iowa City transition a high risk flood prone area with critical community infrastructure into a public riverfront park that provides recreational amenities, and helps the community adapt to current and future high river flows.

Organization: EPA, FEMA and Rebuild Iowa

Source: EPA (United States Environmental Protection Agency) Climate Change Adaptation Resource center; 2024

Retrieved from: https://www.epa.gov/arc-x/smart-growth-along-riverfront-helps-manage-stormwater-iowa-city-iowa

**2.3 The economics of managing heavy rains and stormwater in Copenhagen — The Cloudburst Management Plan, Denmark**

Copenhagen experienced four major rainfall events in the period 2011-2016, resulting in severe damage that was expensive to repair. These types of events are expected to be more intense and more frequent as a result of climate change. The city has drawn out a Cloudburst Management Plan that aims to reduce the impacts of flooding due to heavy rains. The plan included an assessment of the costs of different measures (traditional versus new options including adaptation measures), the cost of the damage despite the measures and the resulting financial impact. The results showed that continuing to focus on traditional sewerage systems would result in a societal loss compared with the alternative solution. The alternative adaptation measures aim to store or drain excess water at ground level. The plan consists of four surface solutions as well as pipe-based solutions, including:

- stormwater roads and pipes that transport water towards lakes and the harbour, e.g. in the built-up area of central Copenhagen;
- retention roads for storing waters;
- retention areas to store very large water volumes, e.g. parks that could turn into lakes during flood events;
- green roads to detain and hold back water in smaller side streets.

The traditional sewerage system was estimated to cost DKK 20 billion (EUR 2.6 billion) compared with DKK 13 billion for the alternative solution. Despite capital investments in the traditional sewerage system, financial losses from flooding would remain high (net loss of DKK 4 billion). On the other hand, the chosen combined solution — consisting of expanding the sewer network and surface projects focusing on water retention and drainage — would result in a net saving of DKK 3 billion. The plan is also likely to contribute to a growth in property values, increased employment, upgrade of urban spaces and increased tax revenues. The Cloudburst Management Plan was developed during 2013 and includes 300 surface projects. The projects have started to be implemented at around 15 projects per year for the next 2030 years. The projects are prioritised according to the level of flood risk, a socio-economic assessment and the availability of co-benefits.

Organization: The City of Copenhagen Technical and Environmental Administration

Source: Climate-ADAPT, European Environment Agency; 2018

Retrieved from: https://climate-adapt.eea.europa.eu/en/about/climate-adapt-10-case-studies-online.pdf/@@download/file

## 4. Considerations from case studies

With the increasing trend of global warming, confirmed by the 2024 data, and the dangerous consequences this will have on water-related extreme weather events and their impact on urban areas, it is a top priority for cities to adapt to these foreboding phenomena. The discipline of urban planning is therefore central to

integrating these predictions and the responses provided through climate change adaptation into current and future transformations of urban systems. In recent years, driven above all by the great transformations that have affected contemporary society and the territory, this discipline has been forced to deal with a great many new factors, emergencies and problems, whose complexity and problematic nature have favoured the development of a great many research paths, empirical explorations and experiments (Savino, 2023). In this transitioning scenario, climate change intersects with unresolved issues from the previous century—such as housing emergencies, territorial imbalances, peri-urban expansion, unused properties, territorial risk, and urban regeneration—while also amplifying challenges like conflicts over space, water, raw materials, and land (Cutini, 2023). It further intensifies economic dynamics, such as the extractives economy, growing inequalities, and shifts in production, consumption, and income distribution, profoundly affecting urban planning practices and professionals (Cecchini, 2023). In dealing with these complex issues, it is necessary to be "conscious and critical" (Busi, 2023) in analyzing the complexity of these phenomena, and it is imperative to adopt multi-disciplinary approaches, both in research and in real-world implementation (Aurigi, 2023). It is therefore necessary not to give in to overly specific concepts and entrust them with the entirety of the solution, but rather to evaluate in detail the economic and social feasibility, applicability, usefulness, or side effects in different contexts on a case-by-case basis (Monti, 2023).

In the case studies reported, contingent climate risk, whether past, present or projected, was the opportunity that allowed for the implementation of integrated, multi-sectoral strategies that constituted a multifaceted response aimed, while adapting urban space, at strengthening communities and improving their provision of services and quality of life.

In the case of Iowa City, river flooding allowed administrations to rethink a city space, proposing a multifunctional master plan with a high impact on the urban fabric. The project design incorporated several of the most widely accepted adaptation strategies, from green infrastructure to stormwater management practices. The plan also explicitly considered the promotion of equitable development, and reclaimed a brownfield, giving back to citizens a valuable urban space in direct contact with the river. This case study highlights how planning to increase resilience means on the one hand protecting economic properties while protecting and preserving the environment, and at the same time providing citizens with better urban social spaces.

No written plan, however, is sufficient to prepare the city and its residents for extreme weather events. The Mornington Peninsula Shire Council case study embodies some of the most important principles for developing resilience in communities. It is an inclusive adaptation initiative that, in addition to scientific planning, has included a major commitment to public participation, education and outreach. Participatory approaches are crucial to trigger bottom-up adaptation initiatives from citizens themselves and to improve citizen response to adaptation actions implemented by government. Finally, collaboration among stakeholders and participatory approaches help maintain and strengthen social and cultural ties to the land and environment, and their community relevance.

The case study of Copenhagen, focusing on urban flood risk, conveys a concept as fundamental as it is not obvious: it is more effective to invest comprehensively in adaptation than to spend repeatedly on actions to repair damage caused by extreme weather events. Indeed, with the Cloudburst Management Plan, the city has equipped itself with valuable gray-green mixed infrastructure, improving the livability of urban spaces but also ensuring a prompt response to increasingly frequent and disastrous heavy rain events. Indeed, there are numerous co-effects of the plan, including increased employment and upgrading of urban public spaces.

All three cases presented help to gain a deeper understanding of the potential of comprehensive planning at the city level that incorporates adaptation to flooding, whether riverine, storm or coastal, into urban planning for the benefit of the community.

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## Author's profile

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