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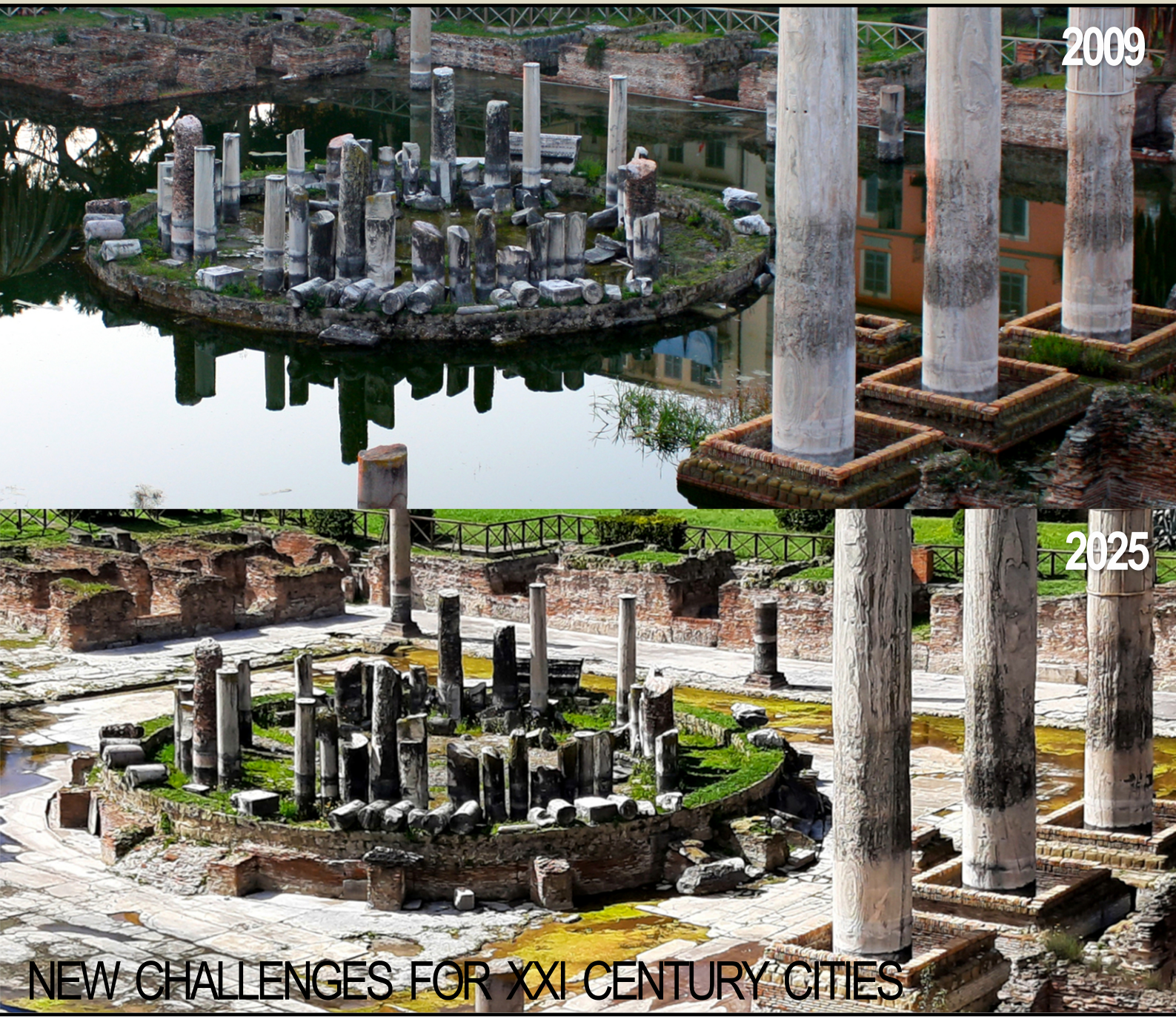

NEW CHALLENGES FOR XXI CENTURY CITIES

Multilevel scientific approach to impacts of global warming on urban areas, energy transition, optimisation of land use and emergency scenario

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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 2025 volume of TeMA Journal propose articles that deal with the effects of Global warming, reduction of energy consumption, immigration flows, optimization of land use, analysis and evaluation of civil protection plans in areas especially vulnerable to natural disasters and multilevel governance approach to adaptation.

TeMA is the Journal of Land Use, Mobility and Environment and offers papers with a unified approach to planning, mobility and environmental sustainability. With ANVUR resolution of April 2020, TeMA journal and the articles published from 2016 are included in the A category of scientific journals. The articles are included in main scientific database as Scopus (from 2023), Web of Science (from 2015) and the Directory of Open Access Journals (DOAJ). It is included in Sparc Europe Seal of Open Access Journals, and the Directory of Open Access Journals.

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The cover image shows a composition of two photos of the Temple of Serapis in Pozzuoli (Italy). Giuseppe Mazzeo took them in January 2009 and March 2025. At the top, the 2009 image shows the temple flooded, with the pavement not visible. In the down, the 2025 image shows the temple’s pavement dry and exposed. The Temple of Serapis is one of the leading visual indicators of the bradyseism phenomenon in the Phlegraean Fields. The bradyseism phase, highlighted by comparison, started in the first years of this century, as shown by the data published by the National Institute of Geophysics and Volcanology (INGV) on the website dedicated to the phenomena (https://www.ov.ingv.it/index.php/il-bradisismo).

TeMA - Journal of Land Use, Mobility and Environment offers researches, applications and contributions with a unified approach to planning and mobility and publishes original inter-disciplinary papers on the interaction of transport, land use and environment. Domains include: engineering, planning, modeling, behavior, economics, geography, regional science, sociology, architecture and design, network science and complex systems.
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REVIEW NOTES
Urban Practices

Competitive climate adaptation. Italian startups leading the way to climate change adaptation in cities

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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 five 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 role that innovative climate startups can play in fostering climate adaptation in cities while promoting urban competitiveness, and the strategic support that these entities can provide in managing urban and territorial transformations. The nature of these entities and the role they can play in the governance of urban transformation is outlined, and a brief review of Italian cases is carried out. Finally, the results are discussed, highlighting the potential that these economic constructions have in urban climate adaptation and urban competitiveness, but also the challenges they face. Three significant case studies of startups promoting climate adaptation in urban areas are presented, showing the relevance of the topic and its potential role in the urban adaptation discussion.

Keywords
Climate change; Adaptation; Urban practices; Competitiveness; Climate startups.

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1. Introduction

The Intergovernmental Panel on Climate Change's sixth Assessment Report states it clearly: without proper adaptation strategies, some regions and natural systems could reach unrecoverable states of alteration and degradation, the so-called tipping points (IPCC, 2021). The reaching of these critical thresholds within the Earth's climate system can trigger large-scale, irreversible changes in key Earth system elements (ocean currents, glaciers, forests, ecosystems, etc.) critically impacting natural and human systems, posing a risk to communities around the world (Lenton et al., 2019).

Despite the widespread awareness of these global risks, adaptation goals are still far from being met. To cite some data, the UNEP Adaptation Gap Report 2023 reports that financial needs for adaptation in developing countries are 10 to 18 times greater than current international public financial flows (UNEP, 2023), highlighting the significant imbalance between funding needs for climate change adaptation and the funds actually available. Moreover, according to the report "Global Landscape of Climate Finance 2024" published by the Climate Policy Initiative (CPI), most global financial flows for climate are aimed at mitigation (89%) while only 5% targeted adaptation (CPI, 2024), illustrating its lower priority.

The disparity in the availability of funding for mitigation and adaptation stems from the fact that, over the years, mitigation strategies have given rise to actual markets. Technologies such as electric or hybrid vehicles, renewable energy systems, and even CO_2 emissions—through mechanisms like carbon emissions trading—have become tradable assets with tangible economic value. In contrast, adaptation measures are often perceived as riskier investments, as they typically lack clear revenue streams and offer limited short-term financial returns, making them less attractive to private investors.

In this context, there is a growing need to diversify and expand funding sources for climate adaptation. This could be achieved either through the establishment of new international financial instruments or by fostering the development of a market for adaptation-related solutions, which could help mobilize private sector investments. Encouraging private finance for adaptation is particularly urgent given the persistent gap in public funding. As the UNEP notes, "there is an urgent need to scale up adaptation finance from both public and private sources to meet growing climate risks" (UNEP, 2023). Similarly, the OECD emphasizes the importance of creating enabling environments for private investment in adaptation, including through blended finance and risk-sharing mechanisms (OECD, 2023).

A crucial dimension of the concept of adaptation, by its definition, is that it can drive transformative shifts in social and economic systems, besides merely reducing potential physical damages. It can enable climate-resilient development by addressing structural vulnerabilities and creating new opportunities (IPCC, 2021), and it can spur innovation and economic diversification (OECD, 2023).

The transformative potential of climate change adaptation inherently links it to processes of research, innovation, and economic growth, positioning it as a key paradigm for fostering the resilient development of urban systems. Notably, the concept of adaptation closely aligns with that of urban competitiveness, a multidimensional concept (Gargiulo & Sgambati, 2022) which has been defined as "the ability of a city to meet future challenges" (Sgambati & Gargiulo, 2022), with climate change representing one of the most pressing among them.

Contemporary challenges and uncertainties expose cities and local communities to multiple and non-linear risk factors that require a spatial planning approach to integrate the dimensions of complexity and unpredictability (Beltramino et al., 2022). To address the complexity and multidimensionality of today's challenges, it is essential to adopt a systemic approach, conceiving cities as complex systems formed by a set of elements and the relationships between them that define their organization (Papa et al., 2021).

Addressing climate change requires indeed rethinking urban systems in their physical, social, and economic dimensions. This involves not only reducing vulnerabilities, but also turning threats into opportunities, redirecting climate investments as catalysts for resilient urban growth and enhanced quality of life for citizens.

2. Competitiveness and climate adaptation: the role of startups

In the context of urban climate adaptation, startups emerge as agile and innovative actors capable of accelerating the transformation of urban systems toward greater resilience and competitiveness.

Broadly defined, startups are newly established, innovation-driven companies that aim to scale rapidly by offering disruptive solutions, often leveraging technology and novel business models (Blank & Dorf, 2020). Their flexibility, risk-taking capacity, and ability to prototype and iterate solutions at high speed make them particularly well-suited to respond to complex and evolving challenges such as those posed by climate change.

In urban adaptation, startups can play a crucial role by developing nature-based solutions, climate risk analytics, early warning systems, or resilient infrastructure technologies. They can help translate scientific knowledge into scalable solutions, foster public-private collaboration, and unlock new investment channels for adaptation, including through green fintech, insurtech, or adaptive urban planning tools.

Moreover, by embedding adaptation into market logic, startups can create new economic opportunities, enhance urban competitiveness, and support a shift from reactive to proactive strategies. In this sense, they act as catalysts of both climate resilience and economic regeneration, particularly in cities seeking to position themselves as innovation hubs.

According to the OECD (Koirala, 2019), fostering startup ecosystems aligned with climate goals is key to "stimulating inclusive and sustainable growth while addressing climate vulnerabilities". Also in the European context, startups are increasingly being recognized and included in EU policy frameworks – such as the New European Innovation Agenda – as strategic actors in advancing the twin green and digital transitions, including the adaptation dimension. The transition of cities is a top priority in academy and policy (Moraci et al., 2024).

Startups are thus being recognized worldwide as a powerful alternative to innovate the economic landscape while confronting the world's biggest challenges, and this evolution is supported by data. According to the MIT Technology Review, investment in this area exceeded $70 billion in 2023, a 50% increase over the previous year. Analysis by the company PwC shows that in the first three quarters of 2024 about 28% of climate tech deals supported startups working on adaptation and resilience (A&R) offerings (Baber, 2024).

Italy is also keeping pace with the growth of investment in climate tech startups. Research conducted by Net Zero Insights reports that €241 million were invested in climate tech startups in Italy in 2023, and equity investment in the sector increased from €79 million in 2022 to €215 million in 2023 (Buratti, 2024).

For both climate techs dedicated to mitigation and adaptation technologies, the impact of the solutions is strongly projected on the territory and in urban systems. From the implementation of renewable energy, energy efficiency in buildings, transportation and sustainable mobility to the use of AI for disaster risk reduction, water resource management, or climate monitoring and data analysis, all topics of interest have a direct impact on land use, the implementation of urban structures and infrastructures, and the organization and monitoring of urban data. The strong alignment between the innovation agenda of climate startups and the core priorities of the digital and ecological transition in urban systems positions territorial-impact startups as key players in current debates on urban adaptation and competitiveness.

3. Italian climate tech startups, a review

Along with many of the world's industrialized countries, Italy is also keeping up with investment in climate techs. Research by Medium reported the existence of about 350 climate tech startups active in Italy in 2023, 2.5% of the total (14,000), a lower-than-average number but still significant for the size of the country.

All Italian regions see the presence of climate tech startups, but with a clear prevalence in Lombardy, followed by Lazio and Piedmont, confirming Milan, Rome and Turin as the core hubs of the Italian climate tech ecosystem, representing 37.1% of the total climate tech startups. The geographic distribution of climate tech startups does not directly reflect the geographic distribution of funds, with Lombardy always in first place,

Piedmont second, Emilia-Romagna third, Trentino-Alto Adige fourth, and only Lazio fifth (Massa & Cuppoloni, 2023).

Most relevant to the parallelism with climate change adaptation and the governance of urban and land transformation are the sectors identified by Massa and Cuppoloni as among the most addressed by Italian climate tech startups:

- Agriculture, Forestry & Food;
- Energy;
- Manufacturing & Industry;
- Transportation & Mobility;
- Water, Waste & Remediation;
- Construction & Real Estate;
- Carbon Neutrality;
- Climate Monitoring.

The identification of these categories of action is of great interest to the discourse on climate change adaptation in Italy, given the climate risks to which the Mediterranean peninsula is most susceptible to. Beyond the more traditional key sectors for mitigation, such as energy and mobility, we find startups focused on the theme of Water Management, a crucial issue in Italy due to both the threat posed by flood risk and drought risk (Guida & Pennino, 2022), also recalled by the Agriculture, Forestry & Food category. The Construction & Real Estate sector also incorporates a reflection on the built environment, the need to update it in design, integrated technologies, and resilience shown in response to extreme weather phenomena. Emerging as a major theme in both the literature and technology solutions developed for the construction market are Nature-Based Solutions, technologies and actions that harness natural green or blue elements and ecosystem services to increase the capacity of urban areas to respond to the effects of climate change (Mazzeo & Polverino, 2023).

In addition, although last in terms of spread, the Climate Monitoring category stands out. To support planners in enhancing sustainable urban land use planning, there is a need to understand how human impacts may affect urban land cover (Dinç & Gül, 2021). Therefore, innovative sensor technologies, monitoring, drones, satellite modeling, and the use of AI, among others, are cutting-edge technologies critical to refining the ability to analyze climate risk on the ground, and to prepare appropriate responses in the necessary timeframe.

The interest of venture capitals, funds, and investors in supporting these innovative economic entities working on issues of absolute priority for climate change adaptation is an aspect of strong potential to increase funds and efforts to adapt urban systems to the challenges of climate change and should be given more attention by institutions that are materially involved in promoting adaptation on the ground nationwide.

To provide an example of the spatial impact that some of these climate tech startups have on urban systems, 3 italian startups that promote urban climate change adaptation practices were selected as case studies. These address in a systemic way several of the "hottest" issues in terms of adaptation to climate change in urban areas, including two of the most prominent at the European and global level: temperature extremes and urban flooding (Pennino, 2024a; Pennino, 2024b; Pennino, 2024c).

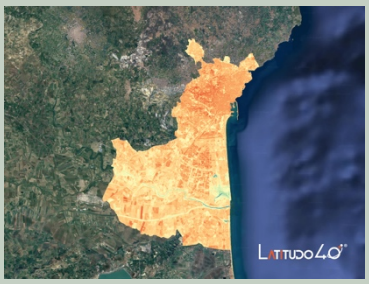
The first case study is an exemplary case of using the latest AI, machine learning and satellite imagery technologies to spatially map climate hazards and provide public administrations with a detailed reference for urban planning. This startup's work takes climate monitoring a step further by integrating analyses related to various climate indices, from air pollution to the heat island phenomenon, with the ultimate goal of effectively implementing Nature-Based Solutions and green areas in an integrated way to reduce emissions, improve air quality, and make urban environments healthier and more resilient.

The second startup presented aims to address, with the most advanced technology available, one of the central climate risks for the Italian peninsula: urban, coastal, and riverine flooding. The startup integrates geospatial, satellite, climate data and AI-based models into a cloud computing environment providing highly

accurate and precise simulations of flooding phenomena in urban, river and coastal areas. These models are then used to provide technical support to administrations, as was done in the collaboration with the Metropolitan City of Venice to map the risk of urban flooding.

The last case study combines reforestation and reduction of atmospheric CO_2, with climate change adaptation in terms of crops and soil resilience to drought and hydrogeological disruption of soils. While implementing this territorial resilience transformation, the startup pursues a parallel social goal, involving social communities in the reforestation projects and reintegrating in the working environment individuals who are in vulnerable situations.

1.1 Latitudo 40. Identify risks, support decisions



Latitudo40 is an Italian innovative startup based in Naples that develops urban environmental monitoring solutions by integrating satellite data, artificial intelligence, and predictive modeling.

The company's core mission is to support cities, public authorities, and private organizations in understanding and managing the impacts of climate change at the urban scale, providing tools for sustainable and resilient planning. Through a proprietary platform, Latitudo 40 processes high-resolution satellite imagery and geospatial data, combining them with machine learning models to generate dynamic environmental indicators, including impervious surface extent, vegetation indexes, urban heat islands, and localized climate risk. Their technology enables temporal analysis of urban areas, continuously mapping how territorial and climatic changes affect buildings, infrastructure, and populations. Latitudo 40's data-driven approach is designed to inform strategic decision-making by local governments and to foster effective interventions for climate adaptation, urban regeneration, and ecological transition, in line with the objectives of the 2030 Agenda and the European Green Deal. Among its key projects are collaborations with Italian and European cities such as Turin, Helsinki, and Barcelona, within smart city and urban sustainability initiatives.

One of its most relevant contributions to climate resilience and urban innovation is the project Urban EVOLUTION (Earth obserVatiOn and nature-based soLUTions agaInst urban pollution), a multidisciplinary research initiative addressing critical urban environmental challenges such as air pollution and the urban heat island effect. The project leverages cutting-edge remote sensing technologies, artificial intelligence, and Nature-Based Solutions (NBS) to assess pollution levels and evaluate the effectiveness of ecological interventions in mitigating CO_2 emissions, particulate matter (PM), and temperature rise. Piloted in Naples, Catania, and Perugia—three Italian cities characterized by diverse urban morphologies and climatic conditions—Urban EVOLUTION aims to develop scalable, adaptable models tailored to Mediterranean urban environments and applicable globally. Through a multi-stakeholder, 12-month collaborative framework involving universities, research institutions, and public authorities, the project supports data-informed policymaking for sustainable land use and urban planning. Urban EVOLUTION is aligned with the Paris Agreement's targets, aiming to reduce emissions by 50% by 2030 and reach climate neutrality by 2050, emphasizing the strategic potential of urban green spaces to offset up to 40% of emissions and improve air quality. Latitudo 40's advanced geospatial analytics are central to translating environmental data into actionable insights, thereby enhancing cities' capacities to design healthier, more resilient urban ecosystems.

Startup page: https://www.latitudo40.com/

Project's page "Urban EVOLUTION": https://www.latitudo40.com/uses-cases/urban-evolution

1.2 SaferPlaces: Global Platform. AI-based Digital Twin Solution for Flood Risk Intelligence

SaferPlaces is an Italian climate-tech startup specializing in flood risk assessment and climate adaptation planning through the integration of Earth observation, hydrological modeling, and artificial intelligence. The company was established with the goal of making high-resolution flood risk intelligence accessible and actionable for public administrations, urban planners, and infrastructure managers. Their flagship solution is a cloud-based platform that provides rapid, cost-effective simulations of pluvial, fluvial, and coastal flooding under current and future climate scenarios. Designed to align with the principles of the EU Floods Directive and the Paris Agreement, SaferPlaces empowers local authorities to design resilient, data-driven adaptation strategies and infrastructure interventions.

By leveraging satellite imagery, digital elevation models, and local land use data, the platform can map hazard exposure at the parcel level, helping cities identify vulnerable assets and prioritize green and grey infrastructure responses.

One of SaferPlaces' most notable case studies is its collaboration with the city of Venice, a globally recognized urban center facing increasing risk from both sea level rise and extreme rainfall events. In this context, SaferPlaces supported local authorities by modeling multiple flooding scenarios to evaluate the effectiveness of planned and existing protection measures. The platform's simulations incorporated tidal dynamics, rainfall patterns, and storm surge projections to provide a comprehensive picture of the city's vulnerability. The results informed updates to emergency planning protocols and long-term urban development strategies, especially in critical areas such as the historic city center and the surrounding lagoon. This case exemplifies SaferPlaces' capacity to provide tailored, location-specific insights that are essential for heritage cities exposed to complex climate threats.

Startup page: https://saferplaces.co/

Project's page "SaferPlaces Helps the Metropolitan City of Venice to Fight Pluvial Flooding": https://saferplaces.co/saferplaces-helping-the-metropolitan-city-of-venice-to-fight-pluvial-flooding/

1.3 ZeroCO2. Fighting the climate crisis with high social impact reforestation

ZeroCO2 began as an Italian social and environmental impact startup, founded with the aim of fighting climate change through reforestation with high social impact.

Founded in 2019, the company started by operating mainly in Latin America (Guatemala in particular), and then expanded its activities to Peru, Argentina, Tanzania and Italy.

Their business idea combines:

- Environmental sustainability: they plant trees to offset CO_2 emissions.
- Social impact: they collaborate with local communities, farmers and social cooperatives.
- Innovation: they use tree tracking technologies and make the process of growth, location and impact transparent.

From a socially focused innovative startup (SIAVS), it is now a certified B Corp Benefit Society developing natural solutions to address climate change, protect ecosystems and support rural communities.

In Italy, the company is carrying out the project "Italy resisting climate change." Active in all regions of Italy, the initiative works with more than 45 social agricultural cooperatives, educational farms, and agribusinesses to

promote reforestation projects based on sustainable agricultural practices that incentivize social support. Key objectives include educating people about sustainable agriculture, improving the resilience of soils and crops, and supporting local communities by promoting job placement for socially disadvantaged individuals. In fact, social agriculture projects deal with sociotherapy, rehabilitation, housing, and work integration to promote social agriculture at the local level, generating welfare for territorial communities and the Italian social fabric.
Moreover, to pursue the main goal to fight climate change, zeroCO2 promotes the sustainable management of Italian lands and forests to preserve existing ecosystems. Their tree planting projects improve soil quality, absorb CO_2, and provide habitats for local wildlife. Collaborating with agricultural cooperatives across Italy, the organization implements solutions to combat desertification, drought, and hydrogeological instability. Rather than reforestation, zeroCO2 focuses on making land more climate-resilient and empowering local communities through low-impact, sustainable farming practices that help conserve biodiversity and mitigate climate change.

Startup page: https://zeroco2.eco/it/

Project's page "Italy Resisting Climate Change": https://zeroco2.eco/it/progetti/supporto-alle-cooperative-agricole-sociali-in-italia/

4. Considerations from case studies

With each fraction of a degree of temperature increase, the effects and consequences of climate change become more intense and dramatic (IPCC, 2021). The answer to impending climate risks is adaptation to climate change, and increasing the resilience of physical, economic, and social systems (IPCC, 2022). Building resilience to contain the risks for inhabitants, businesses and infrastructures deriving from the impact of climate change represents a challenge for local planners and public decision-makers (Palermo et al., 2024).
To make this transformation viable, optimizing investments that directly impact cities, engaging diverse social and economic actors, and promoting technologically innovative solutions is of utmost importance.
In this multi-stakeholder scenario, examples of organizations that carry out business activities with the objective of developing, producing, and commercializing innovative products or services, such as innovative startups, assume a strategic role. These economic organizations, given their strong vocation toward innovation, often start from groups of young students, researchers or innovators, catalyzing the potential of young minds and creating value on the territory, revealing themselves as powerful tools for cultivating social capital locally. Furthermore, the territorial impact that some startups have makes them a potential tool to support public administrations in making the challenges posed by urban planning more effective and smarter and suggests possible citywide implementation of these cooperations.
The three case studies—ZeroCO_2, Latitudo 40, and SaferPlaces—illustrate the diverse and complementary roles that climate-oriented startups can play in enhancing urban resilience to climate change.
ZeroCO_2 exemplifies how nature-based solutions and socially inclusive afforestation projects can contribute to local ecosystem restoration while engaging communities in adaptive land management. Latitudo 40 demonstrates the power of geospatial intelligence and AI in monitoring environmental dynamics and guiding urban greening interventions, as showcased by their Urban EVOLUTION initiative. Meanwhile, SaferPlaces provides a data-driven approach to flood risk assessment, offering crucial support to municipalities like Venice in managing climate-related hazards.
Together, these startups highlight how technological innovation, environmental insight, and participatory planning can intersect to support climate adaptation at the city scale. Their contributions underscore the importance of integrating flexible, scalable solutions into urban planning processes, particularly in

Mediterranean and climate-vulnerable regions. As local governments strive to meet adaptation goals, partnerships with such innovation-driven actors can help bridge data gaps, accelerate implementation, and promote more adaptive and inclusive planning frameworks.

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