ISSN: 2977-814X
ISSUE DOI: https://doi.org/10.51596/sijocp.v3i2
Volume 3 Issue 2
journal.spacestudies.co.uk

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To cite this article:

Armocida, F. (2023). Cultural Heritage Resilient to Climate Change: Strategies for Microclimatic Adaptation of Public Spaces in Historic Centres. SPACE International Journal of Conference Proceedings , 3(2), 20–27. https://doi.org/10.51596/sijocp.v3i2.85

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Cultural Heritage Resilient to Climate Change: Strategies for Microclimatic Adaptation of Public Spaces in Historic Centres

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Article History:
Received May 5, 2023
Accepted June 23, 2023
Published Online December 29, 2023

https://doi.org/10.51596/sijocp.v3i2.85

Abstract

In the era of green transition, the processes of "adaptive manipulation" contribute, as highlighted in the latest report of IPCC (AR6 SYR 2023), to strengthening the response of cities to changes and climate hazards. Although the term heritage itself is used relatively rarely across all IPCC reports (ICOMOS, 2022), recent scientific literature shows that climate change has a negative impact on cultural heritage, its resilience levels, and its tangible and intangible entity. This emergency issue is central at the international level in line with many European reports (ICSM CHC White Paper III 2022, JPI White Paper 2022, Horizon Europe WP 8. Climate, Energy and Mobility and WP 5. Culture, Creativity, and Inclusive Society).

The state of the art related to the most recurrent experimentation on the topic concerns: user-driven climate adaptation strategies that include modelling processes and simulation of predictive climate scenarios, regenerative processes related to solutions based on the nature and use of adaptive devices capable of generating positive socio-economic and environmental impacts.

In this context, the objective of the contribution is to identify the main research experiences at the European level on strategies for microclimate adaptation and mitigation of public spaces in relation to the main climate hazards. The methodology is based on a critical review of research experiences to obtain useful data and characteristics for the testing of adaptive and technologically efficient devices with application in the public spaces of historic centres. In particular, the result, which is part of the study of ongoing PhD research, is focused on testing smart and user-driven technologies aimed at increasing urban resilience to climate change. The study will present partial conclusions from the ongoing research, highlighting open issues and future directions for investigation.

Keywords: Cultural heritage, urban resilience, climate adaptation, user-driven, hazard mitigation

1. Introduction

In relation to the current issues arising from extreme events linked to climate change, the common action line focuses on defining adaptation strategies that increase the resilience of cities and urban contexts. Currently, green transition processes represent a shared commitment in most

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international policies and intervention trajectories. In this sense, important scientific evidence emerged in the latest Evaluation Report of the Intergovernmental Panel on Climate Change (AR6 SYR 2023) where it was seen how cities and urban areas offer significant opportunities for reducing emissions through a necessary decrease in energy consumption in the building sector (IPCC, 2022). It becomes clear that the development of adaptive manipulation processes of cities can contribute to increasing the resilience to climate change of the entire urban apparatus, in line with goals 7 (Affordable and Clean Energy), 11 (Sustainable Cities and Communities) and 12 (Responsible Consumption and Production) of the Sustainable Development Goals (SDGs) of Agenda 2030. It is therefore essential to consider the impacts that these climate hazards have on cities, their cultural heritage and, above all, on the tangible and intangible entity that composes it, which refers, in this contribution, to the public spaces of historic centres in the Mediterranean area.

The intervention strategies focus on experimenting with climate adaptation actions for public spaces in vulnerable neighbourhoods, increasing the endowment of greenery, soil permeability, and social spaces to improve comfort and functionality through the adoption of adaptive, smart, and technologically advanced devices. These experiments, through user-driven approaches, result in community actions that promote public-private partnerships, including the integration of cultural heritage into future design scenarios. (European Union, 2022).

In this context, the following contribution aims to analyse the relationship between climate-change-related hazards and extreme events and the public spaces of historic centres in the Mediterranean area. The aim of the research is to identify, within the European landscape, a comprehensive picture of participatory, adaptive, responsive, technologically efficient, and nature-based solutions implemented in innovative devices capable of increasing the resilience of public spaces in historic centres to the upheavals linked to these changes.

1.1. The Effects of Climate Change on Historic Centres in the Mediterranean Area

The effects of climate change represent one of the most important global challenges, which are addressed through the adoption of adaptation strategies to mitigate its most extreme impacts on cities. It is precisely the Mediterranean area that is considered (according to IPCC, ARC.6; IPCC ARC.5; European Environment Agency, 2012) a “hot spot” region: an area identified as vulnerable to climate change, with urban areas particularly exposed to its effects.

Among the various causes of climate risk related to man-made climate hazards, Climate Adaptation Plans also report increased rainfall events with more intense, frequent rainfall and higher temperatures, which threaten the integrity of historic centres and their public spaces in both their material and immaterial forms. The criticalities related to these hazards are countless; for example, the increase in extreme rainfall events and temperatures, along with the alternation of soil wetting and drying, increases the risk of soil subsidence, while intense and frequent rainfall can cause harmful flooding with direct effects on historical settlements. According to studies carried out in relation to 2100, in the Mediterranean hot spot, the effects of high temperatures would pose a significant risk of material degradation of the elements that make up the cultural heritage considered. The same scenario suggests an additional risk associated with intense, sudden rainfall and extreme pluvial or fluvial flooding in areas with limited drainage systems (Kapsomenakis & Douvis et al., 2022). In this context, the processes of adaptation and mitigation to climate change, accompanied by sustainable management of environmental issues, become key challenges for all European cities (Lafortezza & Sanesi, 2018) and, to an even greater extent, for all those residing in the Mediterranean area. For this reason, this analysis suggests that it is fundamental to adopt adaptation strategies for Cultural Heritage and, more specifically, for public spaces in historic centres.

In line with the latest reports of the European Commission (European Commission, Directorate-General for Education, Youth, Sport and Culture, Strengthening Cultural Heritage resilience for climate change: Where the European Green Deal meets Cultural Heritage, Publications Office of the European Union, 2022), the role of historic centres becomes central, in relation to how

climate change is progressively undermining the tangible and intangible integrity and resilience levels of European Cultural Heritage. According to the European Union, in fact, these changes are destined to continue and intensify due to the scarcity of green commitments of member states, and this also in relation to the weakness of policies in support of heritage, the number of research programs on the subject and the failure to investigate the possible repercussions of future events.

It is important to recognise that historical centres represent an opportunity for investigation that can make cultural heritage a factor in sustainable development and economic growth for the city, and an interesting testing ground for the activation of innovative regeneration strategies. Although they are currently the victims of complex atmospheric impacts, innovative approaches to the regeneration of urban spaces affected by physical and social degradation are being implemented in the historic centres of European cities through solutions that induce new dynamics of socio-economic and environmental development (Boeri & Gaspari et al., 2016). Among the proposed intervention strategies, the fundamental one is aimed at resilient urban development, based, in addition to mitigation actions, on adaptation codes that respond quickly and flexibly to hazards arising from changing socio-economic and environmental needs. The concept of resilience, expressed previously, has now entered the field of urban planning and regeneration, and within new intervention strategies for built and not-built systems, as the connective tissue that infrastructure generates for public space (Marrone & Orsini, 2018).

Research developments focus on the positive role that cultural heritage can play in urban regeneration processes, currently examining possible impacts on historic centres and their public spaces, with particular attention to modelling and predictive simulation of future data and scenarios. The importance of the availability of such data is also highlighted in the latest Joint Programming Initiative White Paper (JPI Cultural Heritage & JPI Climate), with respect to the need for cultural heritage studies, to integrate environmental data capable of providing information on long-term processes and mitigation strategies capable of influencing decision-making (Ballard, C., & Baron, et al., 2022).

At the European level, therefore, experimentation is directed towards a multidisciplinary response to the problem, through the adoption of user-driven strategies for microclimatic adaptation of such urban spaces and the application of green and technologically advanced devices in fragile contexts and exposed to the hazards resulting from climate change.

2. Methodology

Regarding the objective of the research, which aims to identify the relationship between the hazards related to climate change and the public spaces of historic centres in the Mediterranean area to define a complete picture of user-driven, adaptive and technologically efficient solutions able to increase the urban resilience of such fragile contexts, this contribution intervenes using a rigorous and schematic methodology. Methodology is based on a transversal reading of the main lines of experimentation that European cities are practising on the themes of adaptive design and the identification of paths in which innovative and smart technologies have ensured the increase of resilience in public spaces threatened by climate hazards and extreme events. The investigation process, in fact, is fundamental to defining the characteristics that, identified through experience and case studies already consolidated, are applied in a subsequent phase of experimentation.

To define the survey framework, it was necessary to critically elaborate on some of the best practices collected and to identify, through specific criteria, the key themes, objectives, performance, strategies, and results. More specifically, this analysis will lead to the definition of the research topics necessary to construct a complete body of knowledge on these practices, which is fundamental to structuring specific objectives.

The selection of the various case studies, for which example excerpts are reported, was based on three criteria: the field of interest, the goals, and the climatic hazards addressed (Table 1). Subsequently, the critical analysis of the results provided the systematisation of these data and information concerning: the name of the case study, the field/s of interest, the goal/s, the

hazard/s considered, performance, and reference (Table 2).

Table 1. Keywords used and case study decision criteria for objectives and hazards

Priority themes	Keywords
Fields of interest	Climate change, urban regeneration, adaptive devices, co-design, cultural heritage, and historic centres
Goals	Climate adaptation, disaster risk management, urban and microclimatic resilience, sustainable urban regeneration, vulnerability reduction, monitoring, early warning systems, social cohesion, and community
Hazard	High temperatures, heat island, high rains, pluvial flooding, air pollution, multi-hazard

Table 2. Summary of case studies

n.	Name	Fields of interest	Goals	Hazard	Performance	Reference
1	CityTree, CityBreeze e WallBreez	Adaptive devices	Urban and microclimatic resilience	Atmospheric pollution	Absorption of pollutants	[1]
2	Sun&Shade	Adaptive devices	Climate adaptation, urban and microclimatic resilience	High temperatures, heat island	Urban cooling	[2]
3	Agroplaza Venecia e Agroplaza Kirikiño	Adaptive devices	Urban and microclimatic resilience, social cohesion, and community	High temperatures, atmospheric pollution	production of electricity	[3]
4	CO-MIDA	User driven strategies	Social cohesion, and community, sustainable urban regeneration	Atmospheric pollution	Atmospheric pollutant absorption, electricity production	[4]
5	Urban Program di Manifesta 14	Urban regeneration	Sustainable urban regeneration, social cohesion, and community	Other	Social inclusion, development of ICT technologies	[5]

2.1. Topics of the Research

The literature review and the recognition of the case studies have led to the identification of the research topics that can be traced back to three specific thematic areas: the first that refers to the application of adaptive and technologically efficient devices, able to respond to climate hazards in poorly resilient urban contexts, the second to the testing of user driven strategies, fundamental for the involvement of society in the processes of change, and the last to the processes of sustainable urban regeneration of contexts that are extremely exposed and threatened by the effects of climate change.

2.1.1. Application of Adaptive and Monitoring Devices in Urban Contexts

Regarding these devices, the experiments related to the CityTree panel, the CityBreeze (Figure 1) and the WallBreeze systems represent an innovative example that responds to the concept of “re-naturing cities”. These systems, in fact, through nature-inspired technologies, create a mobile plant infrastructure capable of improving air quality in surrounding contexts. The positive environmental impact of these devices, tested under the European project “CityTree Scaler” in collaboration with the German start-up Green City Solutions, is comparable to that generated by 275 trees per panel. The environmental contribution is guaranteed by a plant filter system composed of various mosses that can absorb up to 240 tons of CO2 per year. The project is in line with climate mitigation strategies aimed at increasing the resilience levels of urban areas, responding to these problems through systems capable of counteracting specific problems encountered: the presence of fine dust and the effects of heat islands. Moreover, these devices respond to these microclimatic needs also through solutions aimed at creating new sustainable

places of aggregation [1]

Figure 1. Green City Solutions, CityBreeze system, Germany (Green City Solutions, 2022)

Another reference concerns testing adaptive devices to address heat island effects. In the Sun&Shade project (Figure 2) by Carlo Ratti Associati, the processes of sustainable urban design aim to achieve active climatic well-being in extremely hot areas. The technological solution is that of a digitally controlled canopy to ensure, on the one hand, the cooling of outdoor spaces through the covering surface, and on the other hand, to meet energy supply issues through a system of reflection of the sun's rays, contributing to responding to the processes of adapting cities to climate change. The system, installed in the city of Dubai, consists of a roof formed by reflective surfaces oriented to capture the sun's rays, preventing them from reaching the ground and directing them towards a photovoltaic collector that produces and stores electricity [2].

Figure 2. Carlo Ratti Associati, Sun&Shade, Dubai (Carlo Ratti Associati, 2017)

A further experience concerns the line of investigation CiudadBótica conducted by the Spanish studio Pezestudio aimed at viewing the city as a real "living organism". This strategy is pursued through the field application of two design experiments: Agroplaza Venecia and Agroplaza Kirikiño (Figure 3), the first presented during the Venice Biennale 2020/21 and the second, in the same period, in Bilbao. Both concern self-sufficient urban furniture elements with a removable, modular wooden structure that, through a rocking system, can produce electricity. The same construction system is applied in Bilbao to create a neighbourhood outdoor space intended to promote social aggregation among the inhabitants. The materials and local vegetation used form the basis for experimentation with native techniques and technologies, within an entirely circular vision of the project. CiudadBótica is therefore a co-creation workshop aimed at building the city from the collective imagination of those who live there, in which nature regains its importance from a sustainable and inclusive perspective [3].

Figure 3. CiudadBótica, Agroplaza Kirikiño, Bilbao (Pezestudio, 2020)

2.1.2. Experimentation with user-driven strategies

The CO-MIDA project (Figure 4) establishes an innovative relationship between the project, the environment, and society. One of the seven winners of the contest "Ciutat Proactiva" held in 2020 in Barcelona, the project of the Instituto de Arquitectura Avanzada de Cataluña (IAAC), is part of the spaces of ConnectHort: a modular vertical garden prototype with elements created from 3D-printed clay for the cultivation of aromatic and edible plants in contexts with no availability of horizontal spaces. The peculiarity of the project concerns the role of bacteria and other microorganisms in the soil, which not only benefit plants but, through a Bio-Photovoltaic system, also enable the production of energy needed to power the sensors of the garden itself. The first vertical garden prototype was installed in 2021 in the Jardín de Las Mariposas in Barcelona through a vigorous co-design process and a series of workshops attended by the various stakeholders involved in the design process that led to the development of the proposal in an inclusive perspective aimed at creating a more sustainable urban ecosystem [4].

Figure 4. Bio-Photovoltaic CO-MIDA vertical garden installed in the ConnectHort space (IAAC, 2022)

2.1.3. Processes of sustainable urban regeneration

In line with experiments related to the sustainable regeneration of public spaces, the Carlo Ratti Associati studio once again intervenes through the Urban Vision and Urban Program processes of Manifesta 14 (Figure 5) for the European Nordic Biennial in Prishtina in 2022. The project proposes a new intervention methodology to reclaim the city's public spaces through temporary measures that leverage artificial intelligence for urban analysis. "Commons Sense" identifies citizens as key actors in the evolution of the urban environment by proposing a method based on a series of interventions developed through a participatory approach in places capable of becoming triggers for "urban renaissance". It is interesting to note that the sustainability of the project also depends on the use of innovative technologies developed in collaboration with the

MIT Senseable City Lab, aimed at leveraging artificial intelligence to create a path for digital fruition of the city. This methodology has been useful in the construction of a new pedestrian path: a green corridor along a former railway track with vegetation elements and ephemeral systems that are removable and reusable in other contexts [5].

Figure 5. Carlo Ratti Associati, Manifesta 14, Prishtina (Carlo Ratti Associati, 2022)

3. Conclusions and Discussions

The processes of adaptive manipulation of fragile and poorly resilient urban contexts to climate change hazards, such as historic centres, foreshadow a valid response to the trajectories and targets of green transition planned for 2030. These aspects aim to satisfy transversal needs for the reactivation of social and cultural innovation processes through user-driven strategies and sustainable urban regeneration processes linked to the adaptive reuse of public spaces in cities.

The analysis of case studies and of the experiences of interest regarding the themes of adaptive urban design has therefore offered an effective reading of the trajectories developed in recent years in Europe, allowing the formation of a complete picture of the intervention strategies to be pursued. Moreover, the critical reading of the latter proposes new modes of action for urban regeneration, sustainable, adaptive and user-driven, aimed at protecting areas exposed to changes such as the public spaces of historic centres in the Mediterranean area.

A common characteristic of all analysed case studies concerns attention to climate mitigation across various hazards through experimentation with innovative strategies that respond to the trajectories of the digital and green transition and use technological and social innovation processes as drivers of sustainable development. From this analysis, the revitalisation of historic centres inevitably arises from a bottom-up approach, driven by the definition of shared solutions that become an integral part of the regenerative process. The nature of the experiments also offers a further key to interpretation linked to the replicability of the proposed models transferred to other similar conditions regarding the cultural heritage and the material and immaterial aspects of the historic centres that are part of it. In a period of extreme transition, it is therefore desirable that these new and disruptive models of intervention, far from those of canonical regeneration of public spaces, be applied to European cultural heritage, through technological and experimental solutions through synergistic and inclusive processes capable of activating new forms of sociality, cultural and technological-environmental innovation. The themes of this ongoing PhD research are therefore under development and foresee the imminent start of the testing phase on case studies related to historical centres in the Mediterranean area and the climatic problems to which they are subject, and to which research can contribute to the identification of strategies and operational models for intervention.

Conflict of Interests

No potential conflict of interest was reported by the author.

Endnotes

This paper has been presented at the SPACE International Conference 2023 on Sustainable Architecture Planning and Urban Design.

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