DESIGNING RESILIENCE

Strategies for the sustainable development and understanding of urban complexity

a cura di
F. Mosca
G. Oneto

GENOVA UNIVERSITY PRESS

ADDDOCS

DOCUMENTS

3

Collana / Collection
ADDDOCS Documents - Quaderni di Dottorato

Dottorato in Architettura e Design
Dipartimento Architettura e Design
UniGe – Università degli Studi di Genova

Progetto grafico
Daniele Rossi

DESIGNING RESILIENCE

Strategies for the sustainable development and understanding of urban complexity

a cura di
F. Mosca
G. Oneto

GENOVA UNIVERSITY PRESS

GENOVA UNIVERSITY PRESS
è il marchio editoriale dell'Università di Genova
Università di Genova

I contributi qui pubblicati sono stati selezionati dal Comitato Scientifico del Convegno

e-ISBN (pdf) 978-88-3618-337-1

Pubblicato a ottobre 2025

Realizzazione Editoriale
GENOVA UNIVERSITY PRESS
Via Balbi 5, 16126 Genova
Tel. 010 20951558
e-mail: gup@unige.it
https://gup.unige.it

INDICE

URBAN CLIMATE SHELTERS TO ADAPT CITIES TO CLIMATE CHANGE

A Proposal for Schoolyards in Turin (Italy)

Bruna Pincegher[1], Maria Pizzorni[2], Ombretta Caldarice[3], Nicola Tollin[4]

Abstract

As the objective to limit the temperature increase to 1.5-2.0°C is still far-reaching, cities worldwide are promoting efforts to contrast the compound effects of climate change. Cities must undertake urgent actions to improve their adaptive capacities, working proactively with stakeholders and communities to cope with current and future climate change phenomena and impacts. This paper aims at understanding how cities can adapt to climate change, through a resilient transformation of urban spaces by design, and explicitly use climate shelters to respond to climate hazards, such as heat waves, flooding, and droughts. This paper

focuses on the transformative potential of climate shelters in urban design, particularly within the framework of the 'Climate Shelters (2019-2020)' project funded by the European Commission's Urban Innovation Actions (UIA) programme. The project aims at transforming schoolyards, currently based on impervious surfaces and low-albedo materials, to more sustainable, natural, and resilient ones, which contribute to adapting cities to climate change and citizens' quality of life and health.
Despite a lack of standardized terminology, the successful implementations in Madrid, Barcelona, London, Paris, Amsterdam, and The Hague prompted the introduction of the concept of Urban Climate Shelter (UCS), requesting a more comprehensive understating of this concept and its applicability to diverse urban contexts. The objective of this paper is to delve into the role of UCS within schoolyards. The focus extends beyond their function, emphasizing their potential as spaces that can strengthen the capacity of cities to adapt to climate change by engaging the local community and stakeholders and enhancing bottom-up approaches. Lastly, to illustrate this, a case study from Turin is presented, detailing the design of a proposed schoolyard and the upscaling process.

Keywords: Urban Climate Shelter, Climate Change Mitigation and Adaptation, Schoolyard Regeneration, Co-designing public spaces, Urban Resilience

1. Introduction

Currently, the world's population in urban areas has overtaken the population in rural areas, totalizing more than 55% of humanity living in urbanized areas. In Europe, precisely 73% of inhabitants live in the cities, expecting to achieve 82% in less than three decades. Considering the rapid growth of major urban centres, by the year 2050, over 65% of the global population is projected to live in urban and peri-urban areas (Chamie, 2019). Moreover, cities are responsible for more than two-thirds of CO_2 emissions, more than half of global waste, and the consumption of three-fourths of natural resources (Kamal-Chaoui & Alexis, 2009). Certainly, cities play a pivotal role in driving change and providing solutions for recurrent threats and disasters, such as social inequalities, energy safety, and climate change (IPCC, 2023).

This paper focuses on an innovative strategy for addressing the impacts of climate change: The Urban Climate Shelter (UCS). Despite being relatively new, the UCS has been adopted in several European cities over the past decade, yet there is no universally agreed-upon definition. For example, Madrid, Barcelona, London, Paris, Amsterdam, and The Hague developed this solution to use schools as cooling islands.

Initially, 'climate shelter' was defined as a natural space where animals used to hide from weather events (Florido & Florido, 2022). However, in the spatial planning context, 'climate shelter' is a new term used by Barcelona to refer to a cooling public space that provides thermal comfort for residents and tourists (Vetter, 2020). This paper adopts the term 'Urban Climate Shelter (UCS)'.

Urban Climate Shelters (UCS) are spaces to adapt cities to climate change by offering protection from extreme weather events like heat waves, floods, and droughts. They achieve this through a combination of green infrastructure (parks, trees) and blue infrastructure (water features, retention ponds), designed collaboratively with local communities, ensuring bottom-up initiatives.

First and foremost, this paper concentrates on implementing UCS in schoolyards. Transforming schoolyards into a greener environment has become a common strategy to adapt to climate change, including climate hazards such as heat, flooding, and precipitation, since schoolyards constitute a significant portion of open space within cities and serve diverse populations, including students, parents, and faculty, their enhancement holds multiple environmental and social benefits (Flax *et al.*, 2020).

Paris and Barcelona have received funding from the European Union through the Urban Innovative Action (UIA) project to transform a limited number of schools. However, both cities intend to expand the initiative to more schools. Paris aims at transforming all public schools by 2050, while Barcelona considers existing inequalities in green school infrastructure during the upscaling process. An essential requirement of the UIA project

is to enhance the utilization of schoolyards as public spaces, especially during summertime and after school hours, to provide cooling areas accessible to vulnerable populations (Antoniadis *et al.*, 2020; Baró *et al.*, 2022). Amsterdam shares a similar approach by opening schoolyards after school hours and intends to upscale to more schools (Antoniadis *et al.*, 2020).
Moreover, incorporating Nature-Based Solutions (NBSs) to transform schoolyards into UCSs presents a promising pathway to enhance multiple co-benefits, including improved health, well-being, and social justice, particularly for children and those vulnerable to extreme heat (Baró *et al.*, 2022; Flax *et al.*, 2020). Positioning schools as UCSs serves as compelling demonstration projects for climate mitigation and adaptation, benefiting cities and communities by reducing heat and restoring urban ecosystems through NBSs (Raymond, 2017).
However, understanding the implementation challenges and upscaling opportunities for UCSs in schoolyards across Europe requires further systematic research and practical case studies. Starting from this framework, the paper aims at presenting a design methodology to implement the UCS initiative for achieving a widespread impact, exemplified in the proposed case of Turin in Italy.

2. UCS proposal in Turin

Turin, located in the Piedmont region north of Italy, has many environmental peculiarities: it is surrounded by the Alps and has a complex hydrological system, crossed by three large rivers (the Po, the Dora, and the Sangone). Furthermore, Turin was considered the industrial capital that propelled Italy's post-war economic recovery among automotive and mechanical manufacturing companies in the 1990s (Department for Environmental Policies with the Coordination of the Environment Area, 2020). Given its urban development, the city is highly impervious and prone to climatic hazards such as heat waves and flooding.
Despite these challenges, Turin has committed to ambitious environmental goals outlined in its Strategic Green Infrastructure Plan and aspires to be the greenest city in Italy and the greenest large city in Europe. Additionally, 'Turin path within 100 Climate

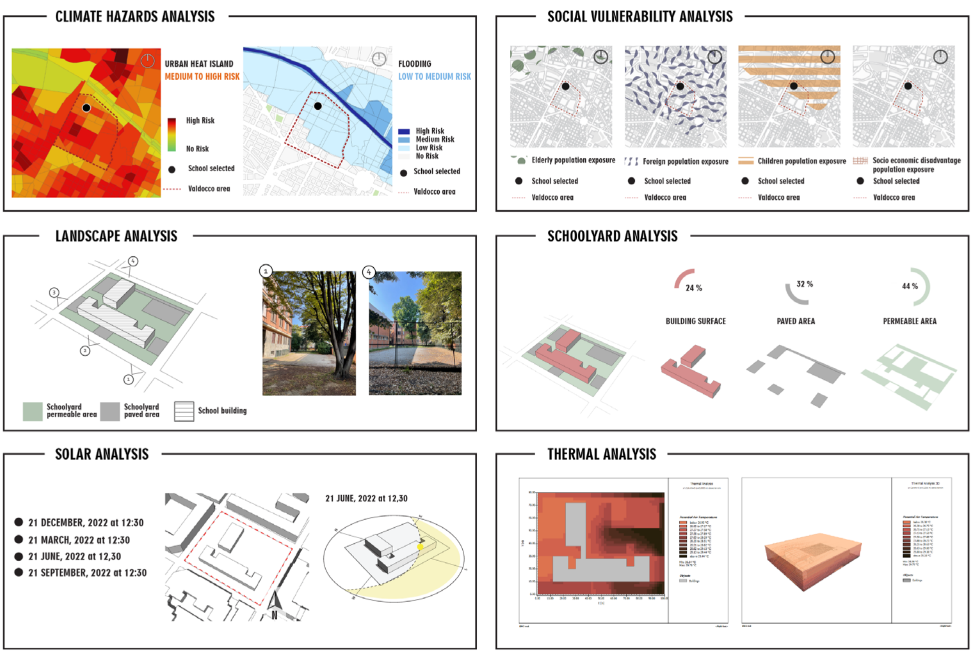
Neutrality Cities EU Mission' aims at transforming towards climate neutrality by 2030. Strategies for achieving these objectives include mitigating vulnerabilities through ecosystem services, boosting ecological health and biodiversity, increasing connectivity among green areas, utilizing green infrastructure for greater social inclusion, and promoting cultural and outdoor tourism (*Piano Strategico Infrastruttura verde – Verde pubblico,* 2020).
Turin has developed three plans and policies related to environmental sustainability and climate adaptation: Action Plan for a Sustainable and Resilient Turin 2030 (2019), Climate Resilience Plan (2020), and Green Infrastructure Plan (2020). This paper explores the interplay between these initiatives and the implementation of Urban Climate Shelters. To begin with, out of the three plans, only the Climate Resilience Plan mentions the concept of climate refuge, where it categorizes the greenery as a strategy for regulating temperature; however, the strategy only focuses on increasing the usage of the hillside area of the city.
The proposal development started by identifying two main climate hazards: Urban Heat Island (UHI) and Flooding. Referring to UHI, the analysis presents a spatial overview of the city, facilitating the understanding of the warmest spots, mainly located in the industrial areas southwest and northeast. In addition, the city centre also presents high-temperature levels due to its high densification and compact urban morphology. Associated with flooding, the analysis presents an understanding of low to high-risk areas affected by it. Furthermore, an analysis of infrastructures exposed to climate hazards reported 444 schools exposed to UHI, 53 schools exposed to flooding, and 65 schools exposed to multi-hazards, thus representing more than 90% of schools in Turin (European Green Capital Award, 2022).
The following step referred to identifying the most vulnerable groups, of which four were identified. The first two groups are the children, characterized by a population under 14 years old, and the elderly, characterized by a population over 65 years old. These first two groups were explicitly identified as representing higher vulnerability to heat events and, therefore, need special attention (Vetter, 2020). The other two groups are the foreign

Fig 1: The co-design analysis stage applied to the pilot case in Turin.

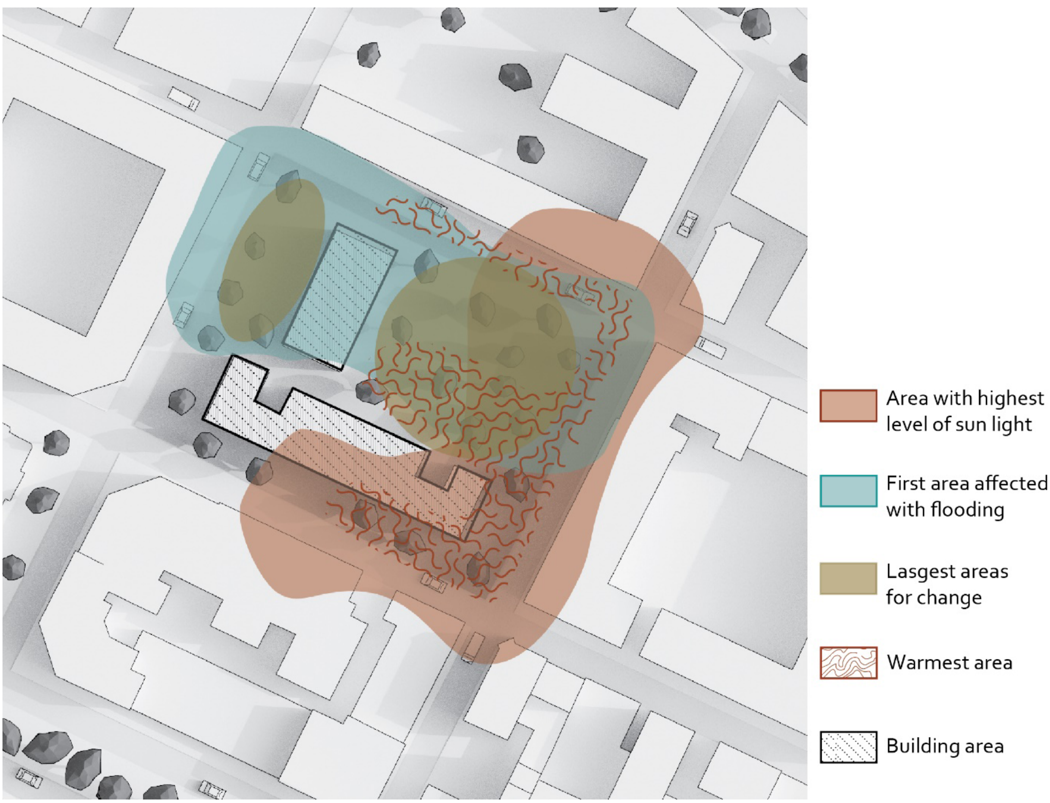
population and the population with low socioeconomic status; these groups are mainly identified as minorities with lower resources to cope with climate events.
The selected schoolyard for the proposed intervention and implementation of UCS is a medium school in the north area of the Valdocco neighbourhood. The area has developed the project 'Livable Valdoco' that aims at shifting the current neighbourhood scenario characterized by 90% of the public spaces representing roads or parking to a better one by increasing the vegetation and coping with UHI and rainwater management (*Valdocco Vivibile | Torino Vivibile*, n.d.). The project focuses on the road infrastructure and redesigning sidewalks and crosswalks, bringing more areas for pedestrians, greenery, and water management.

2.1 Single UCS implementation process

This paper primarily explores the design aspect of UCS. It initiates from a comprehensive analysis comprising climate hazard analysis, social vulnerability analysis, landscape analysis, schoolyard analysis, solar analysis, and thermal analysis (Figure 1).



An approach was employed to analyse previous steps and highlight key findings thoroughly. The first one related to the thermal analysis, which provided the warmest area in the school perimeter. The second finding was from the solar analysis to understand where the sun irradiates more. The following finding was related to the area of flooding. For this step, two observations were necessary: firstly, to understand the location of the school and the location of the river and, therefore, the direction of the water; subsequently, the other observation was done from the flooding map. The building mass and schoolyard analysis provided insight into the most significant area for change. As a result, five main categories were identified: Area with the highest level of sunlight, primarily area affected by flooding, largest area for change, warmest area, and building area.



The strategy proposed focused on incorporating the key findings from the analysis into the design strategy, comprehending the school's surroundings, particularly emphasizing flooding and the Urban Heat Island (UHI) effect, both significant climate risks in Turin and present in the selected schoolyard (Figure 3). Additionally, while the existing greenery in the schoolyard is valuable, there is potential for enhancing vegetation, which offers numerous benefits. Moreover, the proposal included utilising natural materials and expanding permeable paving to improve environmental sustainability. Lastly, water management features, such as rain gardens and bioswales, were integrated to collect and manage water effectively, thereby mitigating the demands on water resources.

Finally, the proposed design incorporates a set of six strategies/elements to be implemented in the schoolyards: water management, garden, permeable path, shading elements, water fountain, and increase of greenery (Figure 4). This includes, for example, within water management, bioswale that can serve as a feature for collecting and slowing down the water, especially since this strategy can have greater results when implemented in larger areas such as highly impervious urban areas (Jusić *et al.*, 2019). Gardens enhance both the permeability and vegetation of the schoolyard while using natural materials in the permeable paths promote sustainability and reusability. Shading elements not only expand shaded areas but also offer diverse experiences for users, particularly children. Water fountains are intended to be used for drinking and as a playful feature for cooling down. Lastly, the plantation of trees, especially in the areas with a higher level of sunlight and the warmest spots.

2.2 Upscaling UCS proposal in Turin

In order to provide sheltered cities, one essential step is the upscaling. Moreover, it facilitates the transition from implementing a single UCS to establishing a network of UCS, thereby fostering adaptation to climate change. The strategy for the city of Turin is first to prioritize the transformation in the most vulnerable

Fig 2: Key findings from the analysis of the schoolyard.

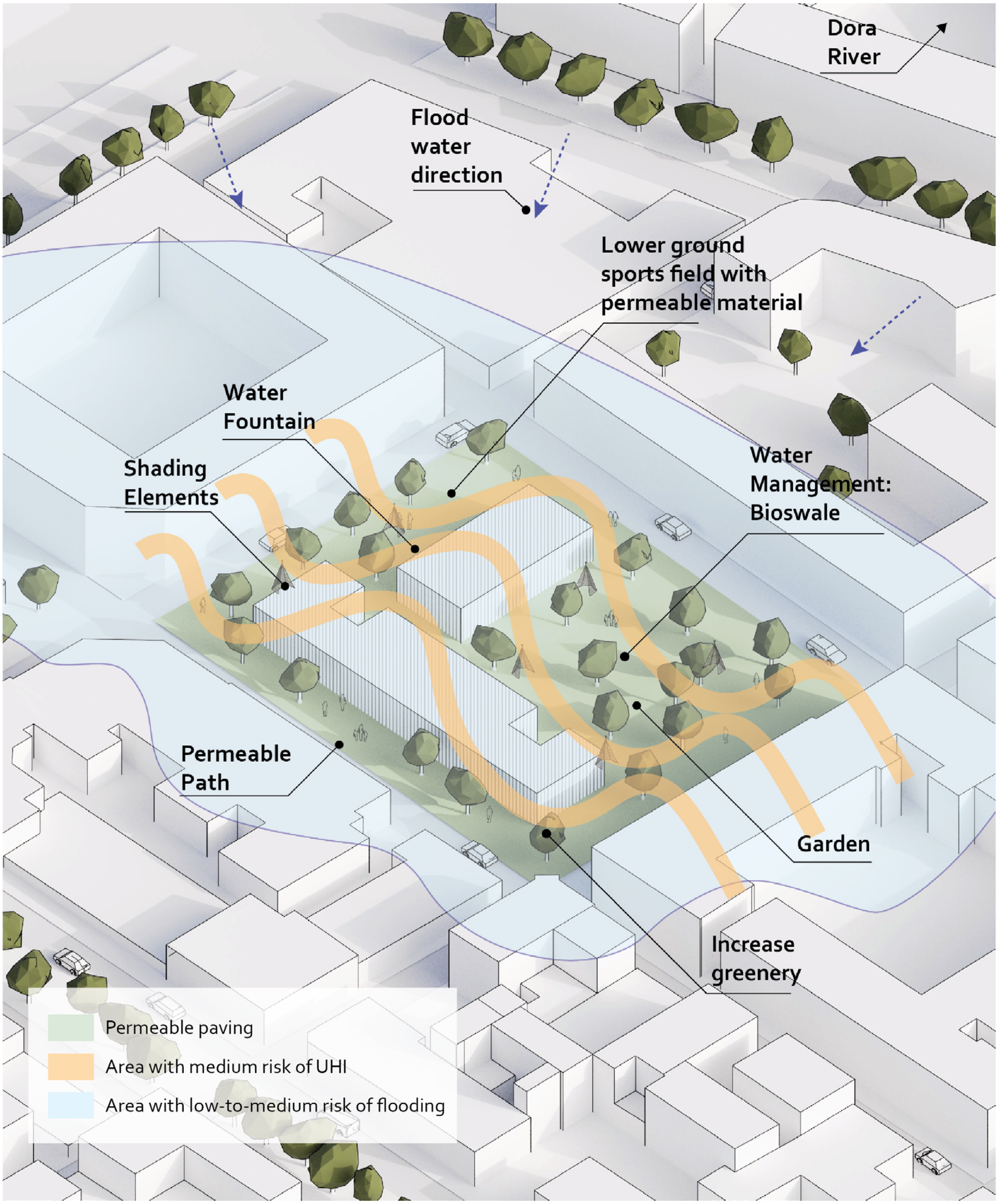
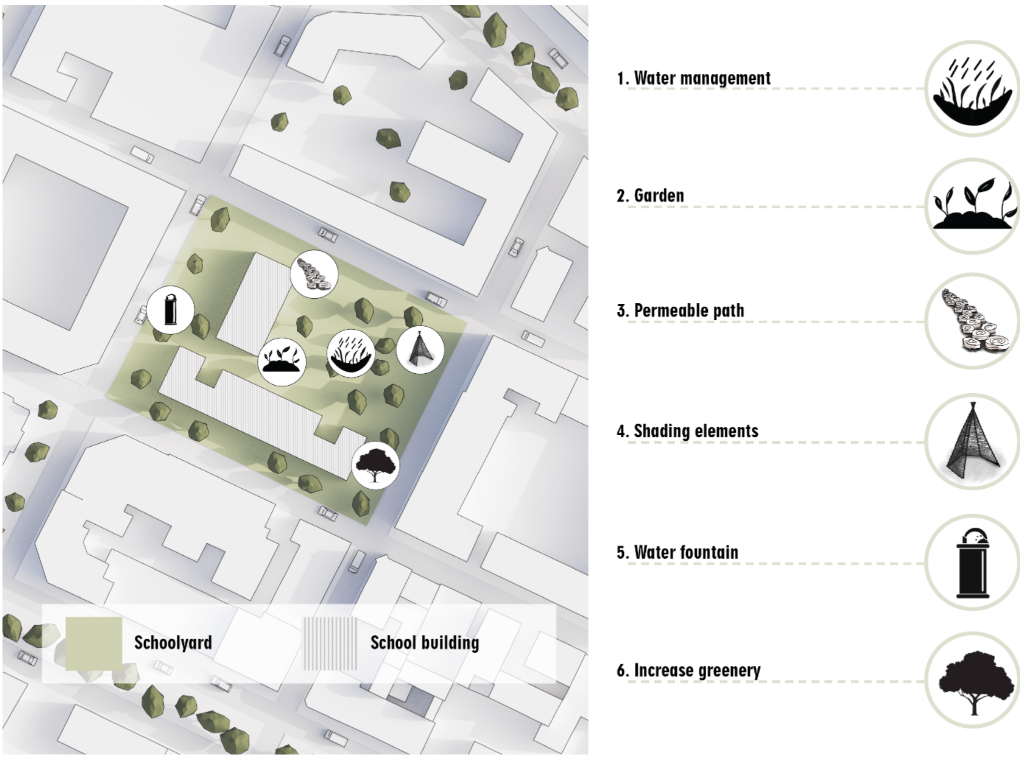


Fig 3: Design strategies.

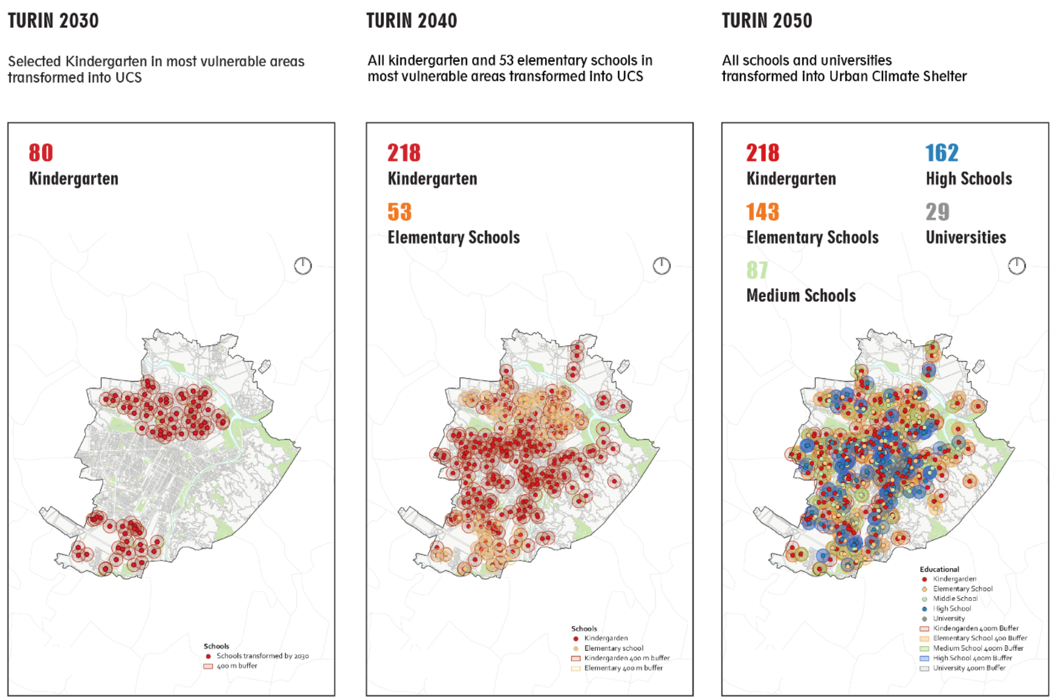
Fig 4: The schoolyard design proposal.

areas (presented with areas with high concentrations of vulnerable groups and climate hazards). The strategy entails a phased plan (Figure 5): By 2030, transform 80 selected kindergartens in the most vulnerable areas into Urban Climate Shelters. By 2040: transform 218 kindergartens in Turin and 53 elementary schools in the most vulnerable areas. By 2050: Upgrade to all schools and universities in Turin (218 kindergartens; 143 elementary schools, 87 medium schools, 162 high schools, and 29 Universities.



It is crucial to realize that the potential areas for upscaling were addressed in this research as a starting point without determining whether the area is appropriate for the project. For instance, a detailed analysis is required, including climate hazard analysis, social vulnerability analysis, landscape analysis, schoolyard analysis, solar analysis, and thermal analysis for each school in the city. In the same way, it is essential to align with existing projects, plans and policies in the given area/city. Finally, the

UCS initiative encourages the transformation beyond schoolyards involving other sectors and facilities, subsequently fostering resilient and shelter cities.



3. Conclusion

Transforming schoolyards into UCS can enhance the interaction area that is so important for the school community, improve the quality of life for everyday school usage, and provide additional public space for citizens, increasing greenery and adapting to climate change. The UCS concept encourages a gradual start by installing a single UCS as a reachable goal. Nevertheless, the objective is to upscale and implement in most spaces, fostering a sheltering and resilient city. Additionally, it enhances the idea that every space has a potential for change, whether by implementing one or all the design features.

While this paper primarily focuses on schoolyards, it acknowledges the broader applicability of the Urban Climate Shelter concept to other public spaces such as parking lots, squares, li-

Fig 5: Strategy for upscaling in Turin.

braries, and hospital yards. Consequently, schoolyards might be just the starting point of community awareness of climate change and co-production initiatives transformations at the city scale.
Furthermore, UCS provides a valuable addition to the city of Turin, fostering awareness and community engagement and tangible transformations that benefit both the population and the environment. Moreover, it coordinates with the city's goals and missions to become the greenest city in Italy and the greenest large city in Europe and to move towards climate neutrality by 2030. Finally, the process of scaling up UCS in Turin extends beyond the scope outlined in the Climate Resilience Plan, not only focusing on the hilly area of the city but especially addressing the most vulnerable areas to climate hazards, including ex-industrial areas and the city centre.

Biographies

Bruna Pincegher, Research Assistant in Urban and Regional Planning, Politecnico di Torino, Interuniversity Department of Regional and Urban Studies and Planning (DIST), Responsible Risk Resilience Centre (R3C).

Maria Pizzorni, PhD Candidate on 'Multi-risk assessment of urban flood and drought' at the UNESCO Chair on Urban Resilience, Section of Civil and Architectural Engineering, Department of Technology and Innovation (ITI), Faculty of Engineering (TEK), University of Southern Denmark.

Ombretta Caldarice, Assistant Professor in Urban and Regional Planning, Politecnico di Torino, Interuniversity Department of Regional and Urban Studies and Planning (DIST), Responsible Risk Resilience Centre (R3C).

Nicola Tollin, Professor with special responsibilities in Urban Resilience at the UNESCO Chair on Urban Resilience, Section of Civil and Architectural Engineering, Department of Technology and Innovation (ITI), Faculty of Engineering (TEK), University of Southern Denmark.

references

+ Antoniadis, D., Katsoulas, N., & Papanastasiou, D. (2020). Thermal Environment of Urban Schoolyards: Current and Future Design with Respect to Children's Thermal Comfort. *Atmosphere*, 11(11), 1144. https://doi.org/10.3390/atmos11111144.

+ Baró, F., Camacho, D.A., Perez del Pulgar, C., Ruiz-Mallén, I., & García-Serrano, P. (2022). Nature-Based Climate Solutions in European Schools: A Pioneering Co-designed Strategy Towards Urban Resilience. In *Urban Book Series* (pp. 125-146). Springer Science and Business Media Deutschland GmbH. https://doi.org/10.1007/978-3-031-07301-4_6.

+ Caldarice, O., Tollin, N., & Pizzorni, M. (2021). The relevance of science-policy-practice dialogue. Exploring the urban climate resilience governance in Italy. *City, Territory and Architecture*, 8(1). https://doi.org/10.1186/s40410-021-00137-y.

+ Department for Environmental Policies with the coordination of the Environment Area. (2020). *Climate Resilience Plan*. Comune Torino. Retrieved August 7, 2023, from http://www.comune.torino.it/ambiente/bm~doc/resilienza-climatica_en.pdf.

+ *Developing cooler, greener schoolyards across the city | Resilient City Den Haag*. (n.d.). Retrieved July 19, 2023, from https://resilientthehague.nl/en/projects/koelere-en-groenere-schoolpleinen-in-de-stad/.

+ Flax, L., Korthals Altes, R., Kupers, R., & Mons, B. (2020). Greening schoolyards – An urban resilience perspective. *Cities*, 106. https://doi.org/10.1016/j.cities.2020.102890.

+ Florido, F., & Florido, F. (2022, October 21). What are climate shelters? – Blog CREAF. Blog CREAF – EL BLOG DEL CREAF. *Novetats sobre recerca en ecologia terrestre del CREAF*. https://blog.creaf.cat/en/knowledge/what-are-climate-shelters/.

+ Giezen, M., & Pellerey, V. (2021). Renaturing the city: Factors contributing to upscaling green schoolyards in Amsterdam and The Hague. *Urban Forestry and Urban Greening*, 63, 127190. https://doi.org/10.1016/j.ufug.2021.127190.

+ IPCC, 2023: Summary for Policymakers. In: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)].

+ IPCC, Geneva, Switzerland, pp. 1-34, doi: 10.59327/IPCC/AR6-9789291691647.001

+ Jusić, S., Hadžić, E., & Milišić, H. (2019). Urban Stormwater Management – new technologies. In *Lecture notes in networks and systems,* pp. 790-797. https://doi.org/10.1007/978-3-030-18072-0_90.

+ Kamal-Chaoui, Lamia and Alexis Robert (eds.) (2009), 'Competitive Cities and Climate Change', *OECD Regional Development Working Papers N° 2*, 2009, OECD publishing, © OECD.
+ Meerow, S., & Newell, J.P. (2019). Urban resilience for whom, what, when, where, and why? *Urban Geography*, 40(3), pp. 309–329. https://doi.org/10.1080/02723638.2016.1206395.
+ *OASIS – Schoolyards: Openness, Adaptation, Sensitisation, Innovation and Social ties: Design and transformation of local urban areas adapted to climate change, working jointly with users | UIA – Urban Innovative Actions*. (n.d.). Retrieved July 19, 2023, from https://uia-initiative.eu/en/uia-cities/paris-call3.
+ Orsetti, E., Tollin, N., Lehmann, M., Valderrama, V.A., & Morató, J. (2022). Building Resilient Cities: Climate Change and Health Interlinkages in the Planning of Public Spaces. *International Journal of Environmental Research and Public Health*, 19(3). https://doi.org/10.3390/ijerph19031355.
+ *Piano Strategico Infrastruttura verde – Verde pubblico.* (2020). http://www.comune.torino.it/verdepubblico/il-verde-a-torino/piano-infrastruttura-verde/.
+ Raymond, C.M., Frantzeskaki, N., Kabisch, N., Berry, P., Breil, M., Nita, M.R., Geneletti, D., & Calfapietra, C. (2017). A framework for assessing and implementing the co-benefits of nature-based solutions in urban areas. *Environmental Science and Policy*, 77, pp. 15–24. https://doi.org/10.1016/j.envsci.2017.07.008.
+ Chamie, J. (2019). *World Urbanization Prospects: The 2018 Revision*. https://doi.org/10.18356/b9e995fe-en.
+ *Valdocco vivibile | Torino vivibile.* (n.d.). https://www.torinovivibile.it/aree-tematiche/valdocco-vivibile/.
+ Vetter, R. (2020). *Cooling Schools Experiences from C40'S Cool Cities Network, C40 Knowledge*. urly.it/31chh9.

note

[1] Bruna Pincegher – ORCID ID: 0009-0002-9663-5950, bruna.pincegher@polito.it, Dipartimento Interateneo di Scienze, Progetto e Politiche del Territorio –Politecnico di Torino
[2] Maria Pizzorni – ORCID ID: 0000-0002-0355-5904, mpiz@iti.sdu.dk – Department of Technology and Innovation – University of Southern Denmark
[3] Ombretta Caldarice – ORCID ID: 0000-0001-6172-908X, ombretta.caldarice@polito.it, Dipartimento Interateneo di Scienze, Progetto e Politiche del Territorio – Politecnico di Torino
[4] Nicola Tollin, 0000-0002-6028-4733, nto@iti.sdu.dk, UNESCO Chair on Urban Resilience – University of Southern Denmark

Francesca Mosca, architect and Post-Doc at the Department of Architecture and Design of UNIGE. Obtained the EU PhD label in Architecture cum Laude. She was visiting researcher at the Technical University of Munich, and she contributed to National and International research projects. Her research focuses on nature-based solutions for climate change adaptation to improve urban environmental conditions.

Gabriele Oneto, PhD student at the Department of Architecture and Design of UNIGE, holding a PNRR PhD research grant. He visited the Technical University of Munich (Germany) and at CIMA Foundation (Italy), contributing to International and National research projects. His research interests range from urban form and spatial analysis, landscape and urban ecology, and applied machine learning.

The European Union defines resilience as the ability to withstand and undergo transitions in a sustainable, fair and democratic way. For an urban system, resilience represents the ability to adapt and transform in response to stress while maintaining its essential functions and identities. The designer is therefore called to guide this movement, conducting innovative analyses and validating and experimenting with new ways of designing cities. Designing resilience involves adopting a holistic and systemic approach that considers the interdependencies and interactions between different urban components. Only by addressing urban habitats in their entirety can designers truly understand the changing kinetics of cities and their populations.

e-ISBN: 978-88-3618-337-1

Università di Genova

RICERCA