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Living Wall Systems As Educational, Cultural and Climate-Adaptation Devices: A Case Study

Carlotta Fasano(✉)

Department of Architecture and Design, Politecnico di Torino, Turin, Italy
carlotta.fasano@polito.it

Abstract. Climate change increasingly affects liveability and thermal comfort in dense urban areas, requiring cities to adopt adaptive and user-centered strategies. In this context, Nature-Based Solutions (NBS) represent efficient tools in urban regeneration and social cohesion. Turin is advancing this approach through its Climate Resilience Plan and Green Infrastructure Strategic Plan, promoting initiatives such as rooftop gardens on the Lidl supermarket in Via Bologna and the NBS Living Labs implemented within the EU project ProGIreg.

This contribution examines the Living Wall System (LWS) installed in 2025 in the courtyard of the Pertini School in Turin. Initially designed as a temporary installation for the ATP Finals, the system was repurposed as a permanent green infrastructure. The study investigates how the LWS evolved from a simple regeneration measure into an educational and cultural device that makes climate adaptation principles tangible, fostering environmental awareness and inclusive participation.

The methodology combines a qualitative assessment of spatial, cultural and pedagogical dimensions with a quantitative framework based on consolidated scientific data on LWS performance. Literature-based indicators provide a benchmark for understanding the system's potential for urban heat-island mitigation and air-quality improvement, while field-based qualitative analysis highlights the architectural and pedagogical value of the installation, which enables students to directly observe system functioning and translate environmental benefits into accessible learning experiences.

Results confirm the capacity of LWS to integrate environmental, social and educational benefits within school contexts. However, high installation and maintenance costs remain a barrier, underscoring the need for more scalable, affordable and circular solutions.

Keywords: Nature-Based Solutions (NBS) · Living Wall Systems (LWS) · Climate Adaptation · Environmental Education · Urban Regeneration

1 Introduction

Climate change is increasingly affecting urban liveability, thermal comfort and public health, particularly in densely populated areas where built surfaces intensify heat accumulation and limit ecological regulation processes. According to the Intergovernmental

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Panel on Climate Change (IPCC), cities are both major contributors to climate change and highly vulnerable systems exposed to rising temperatures, extreme weather events and deteriorating air quality [1]. Consequently, climate adaptation has become a central objective of urban policy and design, requiring strategies that integrate environmental, social and infrastructural dimensions.

Within this framework, Nature-Based Solutions (NBS) are increasingly recognized as effective and multifunctional instruments to enhance climate resilience while producing co-benefits for biodiversity, health and social cohesion [2]. However, recent studies highlight that many NBS initiatives remain confined to pilot interventions, often lacking scalability, long-term monitoring or integration within circular economy models [3].

Among NBS, Living Wall Systems (LWS) represent a promising vertical greening strategy able to face multiple urban challenges simultaneously. Several studies demonstrate their contribution to surface temperature reduction, mitigation of the urban heath island effect, particulate matter retention and carbon sequestration [4–7]. In addition to environmental benefits, vertical greenery systems are associated with psychological well-being, improved spatial perception and enhanced learning conditions in educational environments [8, 9]. Nevertheless, large-scale implementation remains limited due to installation and governance costs [10]. Furthermore, the socio-pedagogical function of such systems as so far been marginally investigated.

This contribution therefore aims to explore the potential of LWS not only as environmental solutions but also as cultural and educational devices. In this context, the paper analyses the LWS installed in 2025 in the courtyard of the Pertini Comprehensive Institute in Turin as an example of circular recontextualization, where an event-based green installation is transformed into long-term public intervention.

2 NBS in Turin: From Strategy to Practice

The transition toward climate-resilient and circular urban systems requires policies capable of integrating environmental, social and infrastructural dimensions across scales [11]. In this regard, the City of Turin represents a relevant case of institutional alignment between climate adaptation strategies and green infrastructure planning.

Turin's current adaptation trajectory is shaped by two complementary instruments. The Climate Resilience Plan of the City of Turin [12] identifies urban heat island mitigation, soil de-paving and green infrastructure expansion as priority actions to address rising temperatures and climate-related risks. Complementarily, the Green Infrastructure Strategic Plan [13] frames urban greenery as a multifunctional system providing ecosystem services across environmental, social and economic spheres. It explicitly connects green infrastructure to climate mitigation, stormwater management, biodiversity enhancement and public well-being, and recognises the role of public–private partnerships and community engagement as enabling factors for scaling NBS.

Together, these instruments mark shift from fragmented greening interventions toward an integrated urban agenda that includes NBS within planning tools, regulatory processes and long-term development visions.

In addition to policy framing, local experimentation demonstrates progressive NBS implementation. Rooftop gardens realized on a commercial building in Via Bologna

demonstrate how private actors can contribute to ecosystem service provision into dense urban contexts. Similarly, the ProGIreg living lab in Turin [14], developed within the EU Horizon 2020 framework, has provided a structured environment for testing and co-designing NBS in post-industrial neighbourhoods, fostering collaboration among academia, public authorities, private stakeholders and citizens. Within this project an indoor green wall was implemented in schools to improve environmental quality and activate environmental educational pathways [15, 16].

Despite this supportive governance framework, challenges remain in translating strategic objectives into adaptable and resource-efficient interventions able to ensure long-term usability and effective integration into everyday urban spaces. The Pertini case study can therefore be interpreted as a bridging action, connecting policy objectives, circular reuse practices and pedagogical innovation within a single infrastructural intervention, where recontextualization extends the system's life and expand its function within an educational setting.

3 The Pertini Living Wall System

Installed in June 2025 in the courtyard of the Sandro Pertini Comprehensive Institute in Turin, the LWS was originally conceived as a temporary installation for the ATP Tennis Finals and later donated by the Japanese company Nitto to the City of Turin as a permanent green legacy of the event. The municipal administration accepted the donation within the framework of its climate-adaptation strategy and identified the Pertini school courtyard as a suitable site for relocation. The school lies near the Inalpi Arena, the venue of the tournament, and it is characterised by extensive asphalt paving and a blind façade. The relocation was also facilitated by the city's previous experience with the green wall implemented in schools during the ProGIreg project [15, 16].

The system is a 15 × 8m substrate-based modular LWS (VP Modulo®, Verde Profilo [17]) composed of independent expanded polypropylene tray containing growing medium and integrated irrigation components. Approximately 300 modular trays were installed, hosting about 950 plants including Fatsia japonica, Lonicera nitida, Hedera helix and Liriope muscari. The modules are installed on a lightweight aluminium supporting frame anchored to the existing façade, minimising structural load while ensuring durability and adaptability. The irrigation system is automated and designed to optimise water consumption (see Fig. 1).

A key technical feature of the system is its design for disassembly, allowing modules to be independently removed and replaced. This modularity enabled the dismantling of the installation from the event site and its reassembly in the school courtyard without structural reconfiguration, according to circular construction principles [18].

In line with established evidence on substrate-based LWS, this system can be framed within consolidated environmental performances ranges. Tabatabaei & Fayaz' (2023) studies report air temperature reductions of up to 3 °C in proximity to vegetated façades under specific climatic conditions, contributing to urban heat island mitigation [5]. CO_2 sequestration values between 0.44 and 3.18 kg CO_2eq/m^2/year have been documented depending on plant species and system configuration [7], while airborne particulate matter retention has been observed in comparable living wall typologies, contributing to improved urban air quality [6].



Fig. 1. Living Wall System installed in the Pertini School courtyard.

Although no direct environmental measurements were conducted in this study, the technical configuration of the Pertini installation aligns with those analyzed in the literature, suggesting that the LWS may contribute to local micro-climatic mitigation and environmental regulation in its immediate urban context. This assumption provides the basis for identifying a limited set of indicators that could be monitored in future phases, including surface-temperature variations between different surfaces, seasonal plant survival rate, irrigation demand, maintenance frequency and visible particulate deposition on leaf surfaces.

4 A Multilevel Approach

This research adopts a multilevel approach integrating quantitative aspects based on literature benchmarks with qualitative cultural and pedagogical analysis in order to provide a multidimensional interpretation of the Pertini LWS, in line with integrated NBS evaluation models [19].

The quantitative component relies on literature-reported performance indicators related to substrate-based LWS relevant to climate adaptation, including surface and air temperature mitigation, air quality improvement and carbon sequestration. These parameters serve as comparative references rather than site-specific measurements, positioning the Pertini installation within established environmental performance ranges and defining a scientifically grounded reference framework to be integrated into the educational design of the project.

A participatory educational programme was incorporated as both a dissemination tool and a qualitative research instrument. The activities, developed in collaboration with teachers, involved second-year middle school students and classroom-based sessions with courtyard hands-on activities in order to connect theoretical knowledge with direct observation.

Classroom-based discussions introduced climate change impacts, urban heat islands effect, evapotranspiration processes and air-quality dynamics. Literature-derived quantitative benchmarks were simplified and presented as scientific support to explain what LWS are, how different typologies operate and what environmental contribution they may provide.

Subsequently, courtyard hands-on exercises allowed students to test and critically reflect on the theoretical principles previously discussed. These activities were conceived as guided experiential sessions supporting the qualitative evaluation of the LWS as a cultural and pedagogical device.

In parallel the research also included an assessment of circular and spatial valorisation dimensions considering the system's design for disassembly, relocation and reuse, as well as its architectural impact on a previously neutral courtyard façade. This reflection contributes to understanding how material reuse and spatial enhancement reinforce the cultural potential of the system.

5 Pedagogical and Socio-Cultural Outcomes of the Pertini LWS

While temporary event-based installations are typically conceived for short life cycles and frequently dismantled after the event, the relocation of Pertini LWS extended its life beyond the sporting event and ensured functional continuity within a public educational setting. In this sense, circularity operates simultaneously at material, functional and spatial levels: the components were reused and their purpose evolved from temporary representational installation to long-term climate-adaptive educational device. Along with the material reuse, the intervention introduced a green landmark in the school courtyard strengthening the place identity. According to studies enhancing the positive effects of vertical greenery systems on perceived environmental quality and people well-being in built contexts [8], the Pertini LWS operates as a regenerative architectural tool, reconfiguring the school courtyard perception and increasing its attractiveness. This spatial requalification reinforces the socio-cultural dimension of the intervention, extending its impact not limited to environmental regulation alone.

Moreover, the developed educational programme allowed the enhancement of the LWS as a pedagogical device. Introductory classroom-based sessions functioned as interactive and participatory learning environments (see Fig. 2a). Simplified scientific data were shown through images, videos and guided questions, actively engaging students in the discussion. Examples of similar NBS implemented within the local urban context were presented to emphasise the tangible nature of these solutions. Students frequently recognised such installations, demonstrating the activation of curiosity and contextual awareness.

Field-based activities in the courtyard further consolidated this learning process. The opportunity to physically observe and analyze the wall's structure and components enabled true understanding of LWS's technological functioning. Subsequently, students measured surface temperatures of asphalt, the bare façade and the vegetated wall using a thermal camera, allowing discussion on solar radiation absorption, material albedo and cooling mechanisms. Air-quality awareness was supported through leaf-surface cleaning tests providing visible evidence of particulate deposition (see Fig. 2b). Finally,

plant inventory documentation allowed students to estimate potential CO_2 sequestration using online available carbon calculation tools [20], linking biomass presence to climate mitigation processes.

These activities enabled students to translate theoretical data into observable phenomena, experiencing the LWS as an interface through which climate-adaptation principles become tangible. Technical learning emerged from students' ability to relate the system's material and technological components to its environmental functions. In addition, a post-activity questionnaire was administered by the teacher to assess students' perceived learning, interest and awareness of NBS and urban sustainability, representing a first step toward a more structured evaluation of the initiative's educational and social impact.



Fig. 2. **a.** Classroom-based concept introduction. **b.** Hands-on "leaf-cleaning" test

Overall, the contribution recognizes the Pertini LWS qualitative potential that extends beyond the energy and environmental performance commonly addressed in literature. By integrating circular reuse, spatial requalification and structured educational engagement, the system operates as an environmental, pedagogical and socio-cultural device, reinforcing its relevance within contemporary climate-adaptation strategies.

6 Conclusions

The Pertini case study contributes to current debates on the sustainable and circular transformation of the built environment by demonstrating how LWS can operate simultaneously as climate-adaptation strategy, circular reuse intervention and educational device. While environmental performance of LWS has been extensively analysed in literature, this example highlights their potential as cultural and pedagogical tools.

The relocation of a temporary installation into a permanent school setting exemplifies a form of circular recontextualization, where material reuse, functional transformation and spatial regeneration converge, extending material lifespan and generating social value. Moreover, through structured pedagogical integration, the LWS becomes a tangible interface through which students engage with climate-adaptation principles, reinforcing environmental literacy and collective awareness.

However, installation costs, technical complexity and maintenance requirements remain critical constraints for wider diffusion, particularly in resource-limited contexts. The present study is also limited by the absence of long-term site-specific environmental monitoring, while the post-activity questionnaire already administered provides a basis for further assessing the educational and social impact of the initiative. Future research should therefore focus on scalable and economically sustainable models, supported by simple monitoring protocols that combine environmental indicators, maintenance data and educational and social-awareness assessment. This would allow future developments to integrate environmental performance, circular principles and pedagogical value within a more evidence-based framework.

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