RESIDUAL INFRASTRUCTURES AS REGENERATIVE TERRAINS: CLIMATE-ADAPTIVE AND CULTURALLY SITUATED DESIGN IN POST-COLONIAL TANZANIA

Mariachiara BONETTI - *Università degli Studi di Brescia*

mariachiara.bonetti@unibs.it

Abstract. Begin Across sub-Saharan Africa, the transformation of colonial infrastructures presents a distinct set of challenges and opportunities that diverge from Eurocentric narratives of post-industrial redevelopment. Cities such as Iringa are shaped not by decommissioned factories, but by residual socio-productive architectures whose material logics, climatic intelligence, and symbolic weight continue to structure everyday life. These spaces are neither abandoned nor fully assimilated into the contemporary urban metabolism; rather, they occupy an intermediate condition where memory, identity, and environmental adaptation intersect in complex ways.

This contribution emerges from a fifteen-year trajectory of field-based research conducted between universities, local institutions and rural communities in southern Tanzania, integrating architectural analysis, historical mapping, ethnographic observation, and environmental interpretation. Due to the limited availability of original architectural documentation—often inaccessible or never formally archived in the Tanzanian context—the analysis does not rely on conventional planimetric reconstruction. Instead, it is grounded in long-term fieldwork, direct observation, and the interpretation of material conditions and contemporary patterns of use. Within this framework, the study examines two colonial-era infrastructures—the Iringa Boma and the Iringa Central Market—to explore how regenerative design can operate as a culturally anchored and climate-adaptive methodology in post-colonial urban contexts.

The Iringa Boma, originally conceived as a German administrative complex, has undergone a notable transformation into a museum and cultural centre. Its layered architecture—thick walls, deep verandas, and a courtyard that mediates air and light—illustrates a form of climatic responsiveness that resonates with contemporary ecological concerns. Its current role, shaped through anthropological engagement and community-driven cultural programmes, provides a compelling example of heritage as an active urban catalyst. Conversely, the Iringa Central Market remains a vibrant yet increasingly pressured infrastructural organism: dense, porous, thermally stressed, and central to the city's socio-economic life. Its morphology offers significant potential for regenerative strategies that enhance ventilation, shading, circulation, and resilience for informal economies in a warming climate. Rather than applying external templates, the paper argues for a regenerative approach grounded in ecological intelligence and local agency. The two case studies demonstrate how residual colonial infrastructures—neither obsolete nor fully requalified—can become metabolic catalysts for low-carbon, culturally meaningful urban futures.

Keywords: Iringa Boma; Regenerative Design; Post-Colonial Urbanism; Climate-Adaptive Architecture; Cultural Heritage; Field-based research

Introduction

Urban transformation in sub-Saharan Africa unfolds along trajectories that differ profoundly from the European or North American narratives most commonly associated with the regeneration of industrial ruins. In many African cities, the spaces that shape contemporary debates on reuse are not former factories or post-Fordist warehouses, but colonial infrastructures—architectures conceived for administrative control, military governance, or regulated exchange, whose material logics and spatial configurations continue to influence daily life long after the political systems that generated them have receded. These infrastructures are not neutral residues of history; they are stratified palimpsests where environmental intelligence, extractive ideologies, cultural assimilation, and community practices have interacted for decades.

Iringa, a medium-sized city perched on the edge of the Southern Highlands of Tanzania, offers a fertile terrain in which to investigate the regenerative potential of such colonial spatial devices. Its urban fabric retains the imprint of German and later British occupation: fortified compounds, wide avenues engineered for surveillance and sanitary control, market structures built to regulate flows of goods and labour, and administrative buildings that mediated between colonial power and local society. Yet these same structures—thick-walled, climatically responsive, materially robust—are also the place where contemporary forms of cultural expression, community gathering, and socio-economic life unfold. In this perspective, climate-adaptive design is not interpreted as a new layer imposed onto existing structures, but as the continued and evolving performance of architectures originally conceived with passive environmental strategies. These colonial infrastructures—through elements such as thermal mass, shaded thresholds, and natural ventilation—already embody forms of climatic intelligence that can be reactivated through contemporary uses.

This paper examines two of these infrastructures—the Iringa Boma and the Iringa Central Market—to explore how regenerative design can emerge from a deeper reading of post-colonial spatial conditions. The Boma, originally the German administrative and military headquarters, has been transformed into a cultural and educational centre, becoming a reference point for participatory heritage practices, anthropological research, and climatic reinterpretation. The Central Market, by contrast, remains a pulsating organism of urban life—dense, porous, and dynamic, but increasingly vulnerable to heat, congestion, and unregulated extensions. Its spatial potential is evident, yet its climatic and infrastructural challenges demand new approaches.

The discussion develops within a research trajectory extending over fifteen years of fieldwork, conducted between institutional collaborations, architectural surveys, community-based projects, and long-term engagements with the Catholic University of Ruaha (RUCU) and with

numerous villages in the Iringa Region. The methodology is rooted in architectural analysis, historical and cartographic reconstruction, ethnographic participation, and environmental observation—a combination that allows for a nuanced understanding of how colonial structures can become catalysts for climate-adaptive and culturally meaningful regeneration.

The objective is not to reproduce Eurocentric frameworks of urban redevelopment, but to articulate a regenerative paradigm in which environmental performance, socio-cultural continuity, and spatial justice become coexistent and indivisible. Through the dual lens of the Boma and the Central Market, Iringa becomes a case study of broader processes shaping the future of African urbanism: a future in which colonial infrastructures, neither obsolete nor fully assimilated, may operate as metabolic nodes in evolving ecological and cultural systems.

Theoretical Framework

The concept of regenerative design, though increasingly present in global architectural discourse, requires careful contextualisation when applied to African cities. The term itself suggests a movement beyond sustainability: not simply reducing environmental impact but actively renewing ecological, cultural, and social systems. In the African context, its relevance is amplified by the coexistence of rapid urbanisation, climatic instability, deep cultural pluralism, and the layered presence of colonial infrastructures whose material intelligence and symbolic power remain unresolved. These overlapping pressures are widely recognised in contemporary research on African urbanisation, which emphasises how risk, vulnerability, and infrastructural fragmentation accumulate in rapidly expanding cities (Dodman et al. 2017). As Mang and Haggard suggest, regenerative development requires a systemic shift from linear sustainability to living-process frameworks capable of restoring ecological and cultural systems (Mang & Haggard, 2016)

Colonial infrastructures as climatic mediators

Colonial architecture in East Africa frequently incorporated climatic adaptations, not out of ecological consciousness but as a pragmatic response to tropical and semi-arid conditions. German and British colonial engineers experimented with thick masonry walls, verandas, porticoes, cross-ventilation, and orientation strategies to mitigate heat and enhance comfort. As scholars such as Gutschow and Neumann (2019) suggest, these buildings often achieved effective thermal performance despite their ideological foundations in control and domination. Their spatial porosity, deep eaves, and intermediary thresholds constitute an archive of environmental intelligence that contemporary regenerative design can reinterpret.

Urban voids and residual infrastructures

Urban voids in African cities do not align neatly with the "post-industrial ruins" of Western imaginaries. As Myers (2011) observes, African urbanism is characterised by ambivalent spaces—neither fully formalised nor entirely informal, neither obsolete nor newly produced, often functioning as sites of negotiation between the state, communities, and economic actors. This aligns with contemporary urban climate research showing how sub-Saharan African cities must integrate adaptive strategies within existing infrastructural fabrics. In Iringa, colonial infrastructures are residual not because they are abandoned, but because they occupy a liminal position within the city's contemporary metabolism: used, adapted, appropriated, and sometimes contested. Recent scholarship highlights how African post-colonial infrastructures operate as hybrid systems where memory, governance, and adaptation intersect (Mavhunga, 2023).

The Boma is the clearest example: historically a symbol of power, later adapted as administrative offices, and today a cultural centre that mediates between memory and innovation. Conversely, the Central Market operates as a residual infrastructure not in the sense of decay but in its inability to fully accommodate the environmental and socio-economic pressures placed upon it. Its porosity and micro-architectural fabric, originally conceived to regulate airflow and movement, now struggle to cope with heat, density, and infrastructural fragmentation.

Heritage as an active spatial process

Unlike European heritage discourses that often emphasise monumentality and conservation, heritage in African contexts frequently emerges as a dynamic process of negotiation and reinterpretation. The work of anthropologist Jan Küver in Iringa exemplifies this shift: by involving communities, students, and local institutions, the Boma has been reframed not as a relic but as a living cultural interface. This aligns with Fathy's understanding of architecture as a socially embedded act and with Folkers' and Newman's emphasis on the ecological and anthropological roots of design in African rural and urban contexts. Such an understanding is consistent with broader debates on heritage as a political, community-driven process in African contexts (Silverman & Ruggles, 2007).

In this perspective, regenerative design becomes inseparable from heritage, not because it preserves the past but because it activates latent cultural and environmental capacities.

Spatial justice and regenerative ethics

Regenerative design in African cities must also contend with questions of equity, access, and participation. Markets, streets, and reappropriated colonial spaces operate as platforms of community agency and socio-economic resilience. As Goodfellow (2022) argues, participatory dynamics in East African cities are not optional but structurally embedded, while top-down interventions often reproduce inequalities and overlook the spatial knowledge of informal systems.

In Iringa, the Central Market is a clear embodiment of spatial justice in action: an infrastructure that hosts hundreds of livelihoods and whose future cannot be determined without engaging the people who inhabit and shape it daily. Regeneration here requires a sensitivity to the cultural, climatic, and economic dimensions that converge in this space—dimensions too often excluded from formal planning frameworks

Methodology

The methodological framework underpinning this research emerges from a long-term engagement with the architectural, cultural, and environmental dynamics of the Iringa Region. Over fifteen years of fieldwork—conducted

between the Catholic University of Ruaha (RUCU), local institutions, and numerous village communities—have shaped an approach that weaves together architectural analysis, historical interpretation, ethnographic immersion, and environmental observation. This multi-scalar perspective allows the study to inhabit the intersection between material form, climatic behaviour, and social practice. The research adopts a qualitative and interpretative methodology rooted in long-term field engagement (since 2008), privileging direct observation, lived experience, and spatial practices over purely formal or typological analysis. In this sense, the study does not aim to reconstruct buildings through metric precision alone, but to understand how they operate as socio-climatic devices within everyday life.

Architectural analysis forms the first layer of inquiry. Through extensive on-site surveys, direct measurement, and spatial reading, the study reconstructs the morphologies of the Boma and the Central Market—their alignments, thresholds, construction logics, ventilation paths, and thermal behaviours. These observations are complemented by historical and cartographic research, drawing from colonial-era plans, missionary records, administrative archives, and early aerial imagery where available. Such materials reveal not only the ideological foundations of these structures, but also the environmental strategies embedded within their materiality. In many cases, original architectural drawings were either unavailable, incomplete, or inaccessible due to administrative constraints. This condition reinforces the methodological choice to prioritise in-situ observation, material reading, and use-based analysis as primary sources of knowledge.

A further methodological dimension arises from ethnographic and participatory engagement. Years spent working alongside local communities—in university programs, rural development projects, and cultural initiatives—have made it possible to understand how these infrastructures are perceived, inhabited, and transformed from within. This includes informal conversations with market vendors, cultural practitioners, youth groups, and administrators; participation in community-driven events hosted at the Boma; and direct observation of the seasonal, climatic, and economic rhythms that shape the market's life. As anthropology and architecture increasingly converge in the study of African urbanism, such forms of presence and reciprocity become essential tools rather than external supplements.

Environmental performance interpretation constitutes the final layer. The climatic behaviour of both infrastructures is examined through shadow patterns, temperature fluctuations across walls and floors, air movement in corridors and courtyards, and the tactile experience of materials under different times of day. These readings resonate with the environmental sensibility present in the work of Fathy (1969) and in contemporary African architectural researchers—an approach that sees climate not as a constraint, but as an active protagonist shaping space, use, and meaning.

Together, these methodological components—architectural, historical, ethnographic, environmental—form a regenerative interpretative framework capable of addressing the layered realities of Iringa's colonial infrastructures. They allow the study to position the Boma and the Central Market not as static objects, but as living spatial organisms embedded within dynamic ecological, cultural, and socio-economic processes.

Case Study 1 — Iringa Boma: A Regenerative Cultural Landscape

The Iringa Boma occupies a singular position within the city's urban and cultural geography. Built during the early phase of German colonial rule, it stood as the symbolic and administrative heart of the town, commanding the plateau and overseeing the valleys below. Its spatial configuration—an enclosed courtyard framed by thick walls, porticoes, and defensive corners—reflected both the ideological apparatus of colonial authority and a pragmatic response to climatic conditions. The materials, construction techniques, and spatial sequencing reveal a sensitivity to the highland climate: diurnal temperature swings, strong valley winds, intense sunlight, and seasonal rains. Thick masonry walls slow thermal transmission; deep verandas provide shade; the central courtyard acts as a thermal mediator and social condenser (Figure 1).

This architectural intelligence, however, did not remain bound to its colonial origins. Over the decades, the Boma underwent multiple transformations, serving as administrative offices, storerooms, and institutional premises. Yet it was only in the early twenty-first century—through the Fahari Yetu Project and the coordinated effort of the Iringa Regional Administration, local researchers, and the anthropological team led by Jan Küver—that the Boma was reimagined as a cultural and educational centre. This reinterpretation marked a decisive shift in meaning: from a building once associated with domination to a space of dialogue, learning, and identity. Within this transformation, the Boma can be interpreted as a cultural landscape rather than a single architectural object. Its significance extends beyond the built form to encompass the network of relationships it generates—between communities, institutions, cultural practices, and territorial dynamics—thus positioning it as an active node within a broader socio-cultural system.

Inside its walls, the museum articulates a curatorial stance rooted in participation and co-production. Exhibitions are shaped not as static ethnographic displays, but as dynamic narratives emerging from collaboration with communities, students, and artisans. Themes such as intangible heritage, local histories, and contemporary artistic expressions are presented with sensitivity to cultural agency. The building's spatial qualities—its verandas, rooms, and courtyard—serve as frameworks for debates, performances, workshops, and educational programmes. In this sense, the Boma embodies the notion of heritage as process, aligning with Küver's view of cultural heritage as a "situated practice rather than an objectified memory."

What makes the Boma particularly relevant for regenerative design is its capacity to translate climatic intelligence into contemporary relevance. Temperature measurements across the building reveal that its thick walls continue to regulate heat effectively during the warm season, while the verandas and open thresholds facilitate air movement even under high solar exposure (Figure 2).

The central courtyard, once a locus of colonial authority, now accommodates workshops, gatherings, and shaded rest areas—its microclimate distinctly cooler than the adjacent streets at midday. These

environmental performances demonstrate how historical architectures can offer more than symbolic value; they can provide operational strategies for climate adaptation.

Moreover, the Boma serves as an anchor for urban identity. Positioned between the commercial heart of Iringa and the historical neighbourhoods, it acts as a hinge between different social groups—students, elders, vendors, tourists, administrators. Its events bring together diverse publics; its physical presence offers a spatial continuity that resists the fragmentation of contemporary urban development. The reinterpretation of the Boma as an inclusive cultural hub provides a model for how colonial infrastructures can transcend their origins and become catalysts in regenerative urban processes.

In the context of Iringa, the Boma stands as an example rather than an exception. It demonstrates that heritage in African cities need not be preserved as inert monuments, nor erased as remnants of oppression, but can be transformed into active cultural landscapes where climatic intelligence, historical depth, and community agency converge. In this sense, the Boma operates not only as architecture, but as a relational landscape of cultural production.

Case Study 2 — Iringa Central Market: A Residual Socio-Climatic Organism

If the Boma represents the contemplative side of Iringa—the place where history, culture, and climatic intelligence are distilled into a public institution—then the Iringa Central Market embodies its kinetic heart. Situated within the dense commercial grid of the contemporary city, the market is not a monument but a living organism: noisy, porous, irregular, and full of movement. The definition of "organism" is used here to describe a system in continuous transformation, where spatial configurations, environmental conditions, and social practices are interdependent and constantly renegotiated over time. Its colonial origins reveal a structure conceived to regulate flows of exchange. Verandas, lightweight roofs, narrow passages, intermittent openings, and a patchwork of shaded stalls were arranged to facilitate cross-ventilation and incremental expansion. Even today, these elements persist, though layered with decades of informal adaptation.

Walking through the market at mid-morning, one encounters dramatic variations in temperature, sound, and light. Certain corridors remain surprisingly cool, protected by overlapping roofs and aligned with the prevailing winds, while others accumulate heat due to new metal additions or congested alcoves that block airflow. These environmental conditions are not accidental; they reveal a dialogue between the original climatic logic of the structure and the improvisations of everyday life. The market, as observed in multiple field visits, demonstrates how architecture in East African cities is often co-produced by the interaction between built form and social use (Figure 3). The market functions today as a crucial socio-spatial node where rural communities, traders, and visitors converge, not only for economic exchange but also for social interaction. Its large covered spaces provide protection across seasons—mitigating both intense solar exposure and heavy rains—demonstrating an implicit climatic adaptability embedded in its spatial configuration. The relationship between the existing architectural structure and its contemporary uses is therefore not fixed, but emerges through continuous processes of occupation, adaptation, and informal modification.

Yet the Central Market is also under strain. Urban expansion has intensified the pressure on its spatial fabric; informal structures proliferate at its edges; circulation patterns become constricted at peak hours; and the increase in hot days due to shifting climatic baselines has made some areas uncomfortably warm. As UN-Habitat has noted for many African cities, markets are among the infrastructures most exposed to climate stress because their lightweight materials and high densities amplify thermal vulnerability. In Iringa, these pressures coexist with social and economic dependence: for hundreds of vendors and farmers from surrounding villages, the market is a vital platform for livelihood and connection (UN-Habitat, 2014). As Goodfellow (2022) notes, informal economies in East African cities are not peripheral phenomena but crucial political and spatial forces shaping urban transformation (Figure 4).

The environmental behaviour of the market shows both fragility and promise. Measurements taken during different times of the day highlight significant cooling effects in zones where air movement is unobstructed, where shading is continuous, or where the ground remains unpaved and therefore more permeable

Comparable observations have been highlighted in studies examining how marketplaces across the Global South function as micro-arenas of climatic adaptation (Smith, 2020). Conversely, overheating tends to occur where newer, ad hoc structures obstruct breezes, where metal roofs lack insulation, or where circulation has narrowed. These findings reveal a spatial metabolism in need of recalibration rather than replacement.

What distinguishes the Central Market as a site of regenerative potential is its combination of climatic porosity and socio-economic vitality. Its architectural DNA—lightweight, modular, open to adaptation—aligns naturally with regenerative principles that privilege reversible construction, passive cooling, circular material cycles, and incremental improvement. But perhaps more importantly, the market's cultural density—its rhythms, negotiations, colours, and interdependencies—provides a social foundation for inclusive regeneration, echoing the role of markets in East African cities as spaces where spatial justice is continuously negotiated through everyday practices, as widely observed in studies on informal urban systems.

If the Boma demonstrates how colonial heritage can be reinterpreted as a cultural catalyst, the Central Market illustrates how residual infrastructures can absorb climatic and urban pressures while still offering a framework for future transformation. Rather than viewing the market as an infrastructural problem, regenerative design allows us to see it as an ecological and cultural opportunity: a place where passive ventilation can be restored, shading enhanced, materials improved, and community agency positioned at the centre of spatial evolution.

Regenerative Strategies: Climate, Culture, and the Urban Metabolism of Iringa

The regenerative strategies outlined in this section are derived from observed patterns of spatial use, environmental behaviour, and socio-cultural practices, and are subsequently interpreted and systematised as a framework for understanding adaptive processes in similar contexts.

The juxtaposition of the Boma and the Central Market enables a deeper reflection on regenerative design as it applies to African urban contexts. In Iringa, regeneration is not a matter of erasing colonial residues nor of imposing external models, but of recognising the latent climatic intelligence and cultural agency embedded within existing infrastructures. Regenerative strategies must therefore emerge from the dynamics already at play, amplifying what works and recalibrating what does not.

A first strategy concerns climatic re-attunement. Both case studies reveal the value of passive environmental performance: thermal mass, shaded thresholds, open courtyards, transitional spaces, and oriented ventilation corridors. By reinforcing these elements—through selective opening of blocked passages, planting of shade trees, introduction of lightweight canopies, or reconfiguration of roof geometries—the market can regain equilibrium with the local climate, much as the Boma has retained its comfort through the decades.

A second strategy addresses heritage as a regenerative resource. At the Boma, heritage is not conserved as a static object but activated as a living cultural process, sustained by participatory programming and anthropological sensitivity. Such an approach can inform interventions in the market, where intangible heritage—crafts, food knowledge, agricultural exchanges—already shapes the daily atmosphere. Rather than formalise or suppress these practices, regeneration should create spatial conditions that allow them to flourish with dignity, safety, and climatic comfort.

A third strategy concerns spatial justice and community agency. Regeneration cannot be imagined as a top-down redesign; it must incorporate the voices of those who use and maintain the market daily. Their spatial knowledge—where airflow is strongest, where shade is insufficient, where circulation constricts—is essential. This aligns with Newman's view that African architectural innovation emerges from the dialogue between designers and communities, and with Folkers' insistence that climate and culture co-author the built environment.

Finally, regeneration in Iringa calls for an understanding of urban metabolism. The Boma and the market operate as complementary organisms within a broader ecological and economic system: one stabilises cultural memory, the other sustains economic exchange. Regenerative design seeks to reinforce the connections between these nodes and to imagine how future infrastructures can draw from their climatic intelligence, material logic, and communal vitality. This systemic approach resonates with the foundational principles of regenerative development, which frame built environments as living systems capable of evolving through ecological feedback (Mang & Haggard, 2016). Such approaches reflect the broader shift from sustainability toward regeneration, grounded in systems thinking and interdependent ecological processes (Reed, 2021).

Conclusion

The analysis of the Iringa Boma and the Iringa Central Market demonstrates how colonial infrastructures in sub-Saharan Africa can serve as pivotal references for rethinking regenerative design at the intersection of climate, culture, and community. The Boma exemplifies a successful transformation: a space of historical tension reinterpreted as an inclusive cultural and educational centre, where climatic intelligence and participatory heritage converge. The Central Market, though more vulnerable to environmental and spatial pressures, reveals a resilient social and architectural fabric capable of supporting regenerative strategies that enhance comfort, equity, and ecological responsiveness.

Together, these two case studies challenge the assumption that regenerative design must originate from new constructions or imported paradigms. Instead, they show that the most promising pathways for African cities may lie within existing infrastructures—those that, though residual or strained, still carry the memory of environmental wisdom, collective identity, and socio-economic interdependence. By embracing this perspective, regeneration becomes not an act of replacement but a process of re-alignment: restoring climatic balance, strengthening community agency, and transforming inherited spaces into catalysts for sustainable and culturally meaningful urban futures.

Iringa, in this sense, stands not only as a local example but as a lens through which broader patterns of African urbanism can be interpreted. Its Boma and its market embody the coexistence of memory and transformation, vulnerability and opportunity, constraint and ingenuity. Through them, regenerative design finds a grounded, situated, and hopeful expression—one capable of informing the future of cities across the continent and beyond.

It is important to note that this contribution represents a synthesis of a broader research trajectory developed through doctoral work and subsequent publications. Given the constraints of the paper format, the aim is not to provide an exhaustive analysis, but to open a line of inquiry into the regenerative potential of post-colonial infrastructures in African contexts.

References

1. Dodman, D., Leck, H., Colenbrander, S., & Rusca, M. (2017). African rbanisation and urbanism: Implications for risk accumulation and reduction. International Journal of Disaster Risk Reduction, 26, 7–15. https://doi.org/10.1016/j.ijdrr.2017.06.029

2. Fathy, H. (1969). Architecture for the poor: An experiment in rural Egypt. University of Chicago Press.

3. Goodfellow, T. (2022). Politics and the urban frontier: Transformation and divergence in late urbanizing East Africa. Oxford University Press.

4. Gutschow, N., & Neumann, K. (2019). Colonial architecture in Africa: Form, climate, and control. Routledge.

5. Küver, J. (2016). Community heritage practices in Iringa: Anthropological perspectives. Iringa Regional Museum Press.

6. Mang, P., & Haggard, B. (2016). Regenerative development and design: A framework for evolving sustainability. Wiley. https://doi.org/10.1002/9781119149699

7. Myers, G. (2011). African cities: Alternative visions of urban theory and practice. Zed Books.

8. Silverman, H., & Ruggles, D. F. (Eds.). (2007). Cultural heritage and human rights. Springer. https://doi.org/10.1007/978-0-387-71313-7

9. Smith, D. (2020). Towards marketplace resilience: Learning from trader, customer and household studies in African, Asian and Latin American cities. International Journal of Urban Sustainable Development, 12(2), 1–20. https://doi.org/10.1080/19463138.2019.1666851

10. UN-Habitat. (2014). Promising practices on climate change in urban Sub-Saharan Africa. UN-Habitat.

Figures

Figure 1 - Boma la kijeshi la Mjerumani (Iringa German Military Station). Historical image of the Iringa Boma showing its courtyard-centered configuration and defensive geometry. Image: Boma's archival sources.

Figure 2 - Shaded verandas and high thermal-mass walls of the Iringa Boma, illustrating passive cooling performance. Image: Author's field survey (2022).

Figure 3 - Soko la mjerumani (German Market), 1908. Circulation corridors and porous stall arrangements in the Iringa Central Market during morning activity. Image: Image: Boma's archival sources.

Figure 4 - Circulation corridors and porous stall arrangements in the Iringa Central Market during morning activity. Image: Author's field survey (2022).


1.
Militärstation "Boma" Iringa -Ostseite-


2.

3.



4.





SHAPING A RESILIENT FUTURE: SCHOOLS AS EXPERIMENTAL HUBS FOR CLIMATE CHANGE ADAPTATION

Carlotta FASANO - *Politecnico di Torino*

carlotta.fasano@polito.it

Abstract. In line with European policies for ecological transition, this paper reflects on regenerative architecture as a technical and pedagogical tool to address climate change challenges. The contribution investigates the potential of nature-based solutions as devices for both adaptation and learning, capable of combining environmental sustainability, participation and educational innovation.

The work presents a participatory, replicable and scalable methodology based on the learning-by-doing approach and articulated in four phases: (1) interactive lesson; (2) experiments and field data collection; (3) co-participatory implementation of full-scale interventions; (4) maintenance guidelines. This approach was tested through two case studies: in Cavallerleone (CN), the depaving of urban areas and the development of an infiltration basin regenerated underutilized urban spaces and promoted circular economy practices; in Turin, a Living Wall System installed in the courtyard of the "Pertini" Institute was enhanced as a demonstration device, allowing students to directly measure the microclimatic and air quality benefits.

The results show how collaboration between universities, local administrations and schools generates measurable impacts on the environmental (soil permeability, water management, microclimatic comfort), social (participation and shared stewardship) and pedagogical (development of technical-scientific and soft skills) levels.

The proposed methodology, replicable and adaptable across contexts and age groups, identifies schools as strategic nodes of the ecological transition, capable of combining innovative teaching and urban regeneration, transforming educational spaces into hubs for climate adaptation.

Keywords: Nature-based solutions; Experiential learning; Urban resilience; Climate Adaptation

Introduction

Climate change is no longer a future prospect but a concrete and measurable condition. Recent international reports confirm an average global temperature increase of approximately 1,5°C compared to pre-industrial levels, with the real possibility of reaching +2,8°C by the end of the century in the absence of effective mitigation and adaptation measures (UNEP, 2025). This phenomenon has a significant impact on the urban environment, where building density and soil impermeabilization amplify the effects of heatwaves, extreme rainfall and air pollution. At the same time, the construction sector continues to contribute substantially to global greenhouse gas emissions, accounting for more than 37% CO_2 emissions per year (UNEP, 2022).

Within this context, the concept of urban resilience assumes a strategic importance in the framework of European policies for ecological transition. The European Green Deal (2019) and the EU Climate Adaptation Strategy (2021) outline the need for cities able to adapt to climate change through sustainable and integrated solutions, promoting the active involvement of local communities and citizens in the co-design of resilient spaces. The recent Nature Restoration Law (2024) further reinforces this vision, introducing binding targets for the restoration of urban and peri-urban ecosystems.

In line with these objectives, this paper reflects on regenerative architecture as a technical, pedagogical and social tool capable of fostering co-design practices and experiential learning. Through the direct engagement of schools, considered as true laboratories for resilience, the contribution investigates the educational and transformative potential of nature-based solutions, laying the foundations for a multidimensional approach to urban sustainability.

Nature-based solutions as climate change adaptation strategies

Nature-based solutions, defined by the European Commission (2021) as "actions inspired and supported by nature", represent a promising approach to addressing urban environmental challenges through strategies that enhance ecosystem processes. More than simple "greenspace", these solutions are the result of deliberate planning, design and management, capable of addressing environmental and social challenges simultaneously, including climate change adaptation, protection of biodiversity and improvement of human well-being.

Among the different types of nature-based solutions, living wall systems are among the most promising technologies for reducing urban heat islands and improving air quality, offering measurable benefits. Recent studies show that such systems can reduce the external walls surface temperature by up to 9°C during the summer months (Vox et al., 2018) and contribute to lowering the surrounding air temperature by 1,8-3,3°C (Tabatabaei & Fayaz, 2023), significantly mitigating the urban heat island effect. Moreover, these solutions have proven effective in reducing air pollutants, with the capacity to sequester between 1,5 and 2,3 kg of CO_2 per square meter per year (Bernardo et al., 2025). Beyond measurable outcomes, vertical greenery systems have been shown to improve psychological and physical well-being and the urban spaces perception, reducing stress and promoting a sense of community belonging (Pérez-Urrestarazu et al., 2017; Sadick & Kamardeen, 2020).

Another type of nature-based solution widely recognized for its effectiveness in urban climate adaptation is the rain garden and related infiltration basins. Integrated into the urban structure or open spaces of public buildings, these systems play a key role in sustainable stormwater