THE INNER LIFE OF NATURE-ADAPTED BUILDINGS: INTEGRATING FORM AND FUNCTION THROUGH STRATEGIC DESIGN/

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Abstract. Living organisms have evolved complex strategies to adapt and thrive in their environments, constantly balancing form and function to ensure survival, resilience, and efficiency. This evolutionary model offers a profound lesson for architecture, highlighting the potential of strategic design to create buildings and spaces that are not only functional but also regenerative, responsive, and comfortable for their inhabitants. This paper explores how architecture can draw inspiration from the adaptability and functionality of living organisms to integrate nature's principles into the built environment, with a particular focus on the processes of regenerative, bioclimatic, and biophilic design.

Strategic design in architecture is the deliberate synthesis of form, function, and context, guided by a comprehensive understanding of natural systems and processes. By studying how organisms seamlessly integrate energy flows, resource management, and environmental responsiveness into their structures, architects can adopt a holistic approach that prioritizes human health, comfort, and well-being.

The integration of these principles - regenerative, bioclimatic, and biophilic - into a coherent strategic design framework offers architects and planners a powerful toolkit for shaping the future of the built environment. Nature-adapted buildings, conceived through this lens, not only respond to environmental challenges but also cultivate spaces where people can thrive. The synthesis of form and function through strategic design thus emerges as a pathway to healthier, more comfortable, and more meaningful buildings and urban areas.

This paper argues that architecture must embrace a dynamic, nature-based design philosophy to respond effectively to the challenges of contemporary living, from climate change to urban densification. By learning from nature's adaptability and resilience, strategic design can transform buildings into living systems that interact symbiotically with their surroundings, contributing positively to both the human experience and the broader ecological context. In this way, architecture becomes a medium for reimagining our relationship with the natural world, fostering a built environment that supports life in all its complexity.

Introduction. Architectural spatial organisms are fundamental components of everyday life, shaping the behaviours, habits, and sensorial impressions of those who inhabit and experience them. The adage "form follows function", famously articulated by Louis Sullivan, has laid a foundational understanding in modern design philosophy, emphasizing the necessity for architectural forms to reflect their intended functions. Pais advocates for a modern reassessment of this maxim, emphasizing that emerging architectural movements contest and broaden this principle by incorporating ecological and social factors into design methodologies (Pais, 2024). However, contemporary architectural paradigms have considerably evolved, revealing a more dynamic interplay among form, function, and the contexts of use. Over time, contemporary conceptions of architectural space have acquired new meanings, diversifying both the ways of thinking about design and the modes of intervention available to architects. The structural rigidity traditionally associated with buildings has become more fluid, the organization of functions has grown more dynamic, and construction methods and building product technologies have diversified. Collectively, these transformations have unveiled new opportunities for architectural practice, more congruent with contemporary developmental conditions and the developing paradigms through which space is conceptualised and created.

The necessity to reconfigure architectural methods in response to urgent climatic issues demands a synthesis of ecological awareness, human welfare, and regenerative principles. Placing the paper at this juncture creates a framework in which a nature-based perspective functions not just as a metaphor but also as a practical basis for building practice. This methodology is essential for transcending conventional sustainability towards authentically regenerative architecture solutions that promote resilient habitats and improve human quality of life.

The "inner life of buildings", based on natural solutions, as a key theme of this research, must be seen as a passage from metaphorical interpretations to tangible architectural principles, fostering practices that exemplify resilience and inclusivity. The systematic review made by Houlden et al. (2018) illustrates the advantageous effects of urban greenspace on mental health, highlighting the importance of incorporating natural aspects into urban environments. This research feeds design frameworks that prioritise the psychological well-being of occupants and underscores the importance for architects to address human emotional responses in conjunction with utilitarian considerations. Therefore, such themes as bioclimatic and biophilic design are intended to strategically support the decisions made throughout the design process. The "inner life" can therefore be understood as the set of flows, feedback loops, and adaptive responses that link climate, envelope, occupants, and ecology.

Languages of form and function within nature-adapted buildings. In contemporary architectural discourse, the integration of form and function in nature-adapted buildings is increasingly recognised as essential for attaining sustainability and resilience. This integration is based on an expanding corpus of research about biomimicry, biophilic design, climatic adaptability, and regenerative architectural approach, which jointly reconceptualises the building as a dynamic, learning entity situated inside its ecological environment.

Nature-Inspired Design Approaches. Biomimicry has become a significant method for harmonising architectural design and functionality with ecological principles. It entails the methodical examination and interpretation of natural processes, structures, and systems into design principles for the constructed environment. Elsamadisy et al.

define biomimicry as an increasingly prevalent approach in architectural engineering that allows designers to create more sustainable and regenerative settings by emulating the principles of natural systems in human constructs (Elsamadisy et al., 2019). This viewpoint indicates a transition from a solely technocentric framework to a design philosophy that prioritises ecological integrity, environmental performance, and human comfort as interdependent goals.

Within this comprehensive framework, research on building envelopes demonstrates the practical application of biomimetic techniques. Sommese and Ausiello illustrate that passive and low-tech solutions derived from plant morphology and behaviour can markedly enhance the efficacy of building skins (Sommese & Ausiello, 2023). Their research demonstrates that enclosures inspired by botanical analogies can decrease energy use while also improving indoor microclimates. Aesthetic expression is inherently linked to environmental function in such designs. The envelope serves as a mediating interface where visual aesthetics, material composition, and climate control are intricately linked, thus reflecting a profound synergy between form and function.

Climate Responsiveness and Adaptability. Adaptability to fluctuating climatic circumstances is a distinguishing characteristic of nature-adapted structures.

The significance of climate responsiveness is also apparent in historical and vernacular examples. Holstov et al. juxtapose historic constructions, which were fundamentally influenced by local climatic and material limitations, with numerous modern structures that predominantly depend on mechanical systems for comfort (Holstov et al., 2017). Their research advocates for the reimplementation of design principles that explicitly integrate natural ventilation, solar gain, and passive cooling into the spatial and formal arrangement of the structure. By reintegrating these concepts, architects can create designs that are visually harmonious and energetically efficient. The building's internal dynamics, perceived as its continuous environmental engagement, influence its external structure.

Structural Innovations Inspired by Nature. Nature offers a collection of structural and organizational principles that can guide the development of novel building envelopes and structural systems. Zhdanova and Dorokhina advocate for the integration of architectural design and functional zoning using adaptive smart facades that concurrently facilitate renewable energy technologies (Zhdanova & Dorokhina, 2024). These facades are designed not merely as protective barriers but also as dynamic systems for energy generation, light regulation, and environmental management. The architectural expression renders the underlying functional processes comprehensible, allowing the facade to convey the building's operational plan. Cenk et al. investigate biomimetic approaches to improve building envelopes for water management and energy efficiency (Cenk et al., 2024). By examining the mechanisms by which organisms acquire, retain, and allocate resources, they extract design analogies applicable to architectural systems for rainwater harvesting, moisture management, and heat regulation. The integration of these biomimetic systems into the building envelope enhances resource efficiency while strengthening a cohesive architectural narrative. Each component of the envelope is seen as both a technological apparatus and a formal element, thus merging functionality with expressive form.

Contemporary studies on nature-adapted architecture indicate a converging path where biomimicry, climate responsiveness, AI-driven adaptability, and nature-inspired structural principles are progressively integrated. Research by Elsamadisy et al. (2019), Sommese and Ausiello (2023), Holstov et al. (2017), Zhdanova and Dorokhina (2024), and Cenk et al. (2024) collectively indicates that the future of architecture involves conceptualising buildings as dynamic, environmentally integrated systems. In these systems, form and function are collaboratively built through strategic interaction with natural models and processes. The internal dynamics of nature-adapted structures are defined by ongoing engagement with their ecological surroundings, allowing them to fulfil human requirements while promoting overall environmental sustainability.

Strategic design in architecture. Regenerative design, in contemporary architectural discourse, represents a decisive shift in the ambition of built practice: it asks not only that buildings do less harm but that they actively participate in the renewal of their places, weaving climate, culture, and community into a unified architectural proposition where form embodies regenerative function (Naboni et al., 2019). Naboni, Natanian, and Brizzi (2019) operationalise this shift through a digital workflow that quantifies regenerative performance across multiple environmental parameters — climate, energy, biodiversity, resource consumption, and human well-being — demonstrating that regenerative outcomes are not incidental but the result of deliberate, integrated design decisions. This framework is directly relevant to strategic design thinking: it requires that architectural form be conceived as a generative instrument capable of producing net-positive environmental and social effects, rather than merely minimising deficits. In this sense, regenerative design constitutes the most demanding expression of the form-function synthesis examined throughout this paper, since it obliges the designer to hold in tension the material specificity of a place, the biological cycles that sustain it, and the experiential and cultural expectations of its community. Form, under this paradigm, is no longer a resolution of competing functional demands but a spatial commitment to the ongoing regeneration of the living systems that the building inhabits.

The synthesis of form and function is a core principle in architectural design, especially when envisioning nature-adapted structures. This integration is facilitated by several strategic design techniques that prioritise aesthetics while enhancing functional efficiency and environmental flexibility.

Among the foundational theoretical contributions to strategic design in architecture, Christopher Alexander's work occupies a singular position. His "A Pattern Language" (Alexander et al., 1977) articulates a hierarchical system of 253 spatial patterns, spanning scales from regional planning to constructional detail, each encoding recurring configurations that sustain human well-being, social cohesion, and environmental responsiveness. Samalavičius (2023) characterises Alexander as an architectural thinker

whose legacy transcends conventional disciplinary categories, emphasising his commitment to an empirical and collaborative design process that privileges the vitality of living spatial structures over abstract formal invention. His concept of "wholeness"—the quality of coherence and aliveness that distinguishes both natural organisms and well-made buildings—directly anticipates the ecological sensibility informing contemporary nature-adapted architecture. By treating the building not as an object imposed upon its context but as a living configuration arising from the patterns of its inhabitants and surrounding environment, Alexander established a theoretical basis for strategic design that remains deeply relevant to regenerative and biophilic approaches (Dawes & Ostwald, 2024).

A complementary and historically decisive contribution was made by Reyner Banham in "The Architecture of the Well-Tempered Environment" (Banham, 1969), a work that fundamentally reframed the relationship between environmental systems and architectural form. Banham argued that heating, ventilation, lighting, and acoustic control are not secondary additions to architecture but constitutive elements of its spatial and formal logic. Shing (2021) documents how Banham criticised the modernist tendency towards univocal environmental standardisation and proposed instead a "campfire model" in which spatial arrangement and environmental gradient mutually define one another, generating differentiated zones of activity and comfort rather than homogeneous conditioned interiors. This analytical reframing of the building as an integrated environmental system establishes a direct theoretical precedent for the bioclimatic principles examined in this paper, demonstrating that the synthesis of form and function through climate-responsive design has deep roots in twentieth-century architectural theory.

A third conceptual resource is provided by the metadesign framework developed by Giaccardi and Fischer (2008), which reconfigures the design process as the creation of environments and systems capable of evolving in response to emerging user needs and changing contextual conditions. Rather than conceiving the building as a closed and fully determined artefact, metadesign proposes that designers construct open frameworks, analogous to ecological niches, within which occupants and communities can continue to act as co-designers throughout the life of the building. As synthesised by Fernandes et al. (2018), metadesign systems must be flexible, open to user collaboration, and designed from the outset to evolve. This orientation resonates profoundly with the regenerative and biophilic paradigms examined in this paper, extending the logic of nature-adaptation from climatic performance to organisational and social responsiveness, and proposing that truly nature-adapted buildings must be designed not only to respond to their physical environment but also to accommodate the ongoing agency of their inhabitants.

Modular design offers a further avenue for harmonising form and function at the scale of individual components and spatial configurations. From the perspective of product and organisational theory, Sanchez and Mahoney (1996) demonstrate that modular structures enhance coordination, incremental modification, and adaptability in complex systems. When applied to architecture, modular principles enable buildings to be reconfigured, expanded, or repurposed while maintaining overall spatial coherence, and they support long-term sustainability by reducing waste and accommodating evolving user needs (Sanchez & Mahoney, 1996). Applied research on modular furniture and interior systems similarly illustrates how spatial elements can be designed for both aesthetic appeal and functional reconfiguration in response to changing user requirements (Pambudi et al., 2024).

The integration of form and function in architecture is greatly enhanced by deliberate design strategies. By employing systems analysis, scenario planning, and user-centred methodologies, architects are becoming capable of designing places that are both aesthetically pleasing and functionally effective. This comprehensive approach is particularly essential in situations requiring adaptation, such as climate-responsive architecture and healthcare institutions. As the discipline progresses, these techniques will remain pivotal in reconciling the dual aims of aesthetics and utility in architectural designs, ultimately promoting a constructed environment that accommodates both human need and ecological sustainability.

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Linking the Integration of Form and Function within Strategic Design Methods in Architectural Conceptualization. The harmonization of form and function is fundamental to architectural conceptualization, directing choices from the initial ideas to the intricate design phase. Strategic design methodologies that facilitate this integration are crucial for generating architectural solutions that are formally cohesive, functionally resilient, and contextually adapted. Recent research on bioclimatic and biophilic methodologies, knowledge-based collaboration, and computational tools, alongside historical and theoretical perspectives on Disegno and Strategic Design Architecture, establishes a systematic framework for comprehending the alignment of form and function in contemporary practice (Akinyemi et al., 2024; Ip, 2024; Sanchez & Mahoney, 1996; Pourzolfaghar et al., 2013; Jabi & Chatzivasileiadi, 2021; Wang et al., 2022; Faroughi & Faroughi, 2012).

Conceptual Frameworks for Integration of Biophilic Design and Human-Centred Approaches. Biophilic design is based on the premise of an inherent human connection to nature and contends that constructed settings should deliberately incorporate natural features to improve user well-being. This framework articulates the integration of form and function through spatial and formal choices that include vegetation, natural illumination, water features, organic materials, and organic geometry into quotidian architectural environments. Empirical research suggests that such spaces might enhance comfort, psychological well-being, and perceived spatial quality, illustrating that aesthetically pleasing, nature-oriented designs can fulfil specific functional and health-related objectives (Akinyemi et al., 2024; Ip, 2024).

From a strategic perspective, biophilic principles guarantee that the aesthetic arrangement of buildings is not merely ornamental but is intrinsically linked to functionality. The placement of openings for natural light

and vistas, the arrangement of landscaped areas, and the configuration of interior transitions are intended to enhance environmental comfort, alleviate stress, and influence behavioural patterns. In biophilic design, shape serves as a conduit for the simultaneous pursuit of functional, ecological, and experiential objectives (Akinyemi et al., 2024; Ip, 2024).

This methodology characterizes conceptual design as a collaborative, iterative process of problem identification and resolution, rather than a sequential transfer. The objective is to achieve design decisions where formal and functional considerations are collaboratively addressed, allowing spatial concepts, material strategies, and performance aims to mutually influence one another instead of being regarded as isolated decision processes (Pourzolfaghar et al., 2013).

Conceptual Frameworks for Integration of Bioclimatic Design. Bioclimatic design relies on the intentional application of local climate data and natural resources to improve occupant comfort and minimise environmental impact. El Sayed (2023) characterises bioclimatic design as a methodology that enhances building quality via passive strategies that utilise environmental resources for heating, cooling, and illumination. Bioclimatic design prioritises thermal comfort, energy efficiency, and environmental performance, ensuring that architectural form is directly influenced by functional requirements and climatic conditions, rather than being created in isolation (El Sayed, 2023). In this context, form serves as a tangible manifestation of climate-responsive functionality.

Recent theoretical research has contextualised bioclimatic design within broader sustainability frameworks. Almirón Cuentas and Bernedo Moreira (2024) emphasise the dynamic nature of bioclimatic architecture and its contribution to sustainable development goals, demonstrating how climate-responsive techniques simultaneously affect the morphological structure of buildings and their operational efficacy. Within this framework, design decisions are directly informed by environmental and site-specific data: shading devices, building orientation, and envelope articulation serve both as aesthetic choices and as strategic responses to solar exposure, prevailing winds, and temperature patterns, so ensuring that visual expression and climatic functionality are inseparable (Almirón Cuentas & Bernedo Moreira, 2024).

Bioclimatic design is methodologically organised through a series of climate-responsive strategies. Hildayanti and Wasilah (2022) delineate strategic methodologies that direct the architectural process from an initial comprehension of climatic impacts to the optimisation of natural ventilation, daylighting, and passive cooling. Their research delineates the phases of bioclimatic architecture development, encompassing climate analysis, zoning based on environmental requirements, and the incorporation of passive systems, collectively illustrating how spatial arrangement and formal expression emerge from environmental considerations (Hildayanti & Wasilah, 2022).

In addition to these stage-based methodologies, Krivenko and Changpu (2024) present a systematic approach to bioclimatic modelling that underscores the incorporation of several parameters into unified design solutions. Their model integrates environmental, technological, and aesthetic factors to produce building designs that comprehensively address climate conditions (Krivenko & Changpu, 2024). From this systemic viewpoint, the envelope, structure, and spatial arrangement are regarded as interrelated elements of an environmental system, with the synthesis of form and function arising from the interplay of these factors rather than from independent choices.

Historical approach and Strategic Design Perspectives. The traditional approach of the design process, Faroughi and Faroughi re-examine the Renaissance notion of Disegno to elucidate the historical foundations of integrated design thinking (Faroughi & Faroughi, 2012). Utilizing the works of Vitruvius, Alberti, Filarete, Vasari, and others, they formulate a system termed “Ordine Disegno”, organized around three processes and other essential components. Conceptually, “idea” refers to the intrinsic essence or intelligible form of an entity, akin to a vision of the ideal in Platonic philosophy. Disegno is defined as a creative process that synthesizes concept and form, translating an abstract idea into a tangible, material structure. Execution actualizes the results of Disegno, necessitating elevated degrees of technical proficiency.

In this historical context, architecture transcends mere building construction and is perceived as the creation of intricate artefacts that must fulfil the criteria of stability, utility, and aesthetics, reflecting the Vitruvian triad of firmitas, utilitas, and venustas as interpreted in Renaissance theory (Faroughi & Faroughi, 2012).

Knowledge and identity are fundamental elements. The architect is anticipated to have extensive, interdisciplinary knowledge and to define the project’s identity as something “unprecedented,” while remaining focused on human needs and aspirations. The Renaissance notion of Disegno presages a robust integration of form and function, since form serves as the apparent expression of a more profound intellectual and functional order.

Vernacular architecture provides a significant empirical basis for biophilic and bioclimatic design. Nugroho et al. (2023) analyse traditional Madurese buildings as exemplars of intrinsically energy-efficient architecture, demonstrating the alignment of historical construction techniques with local climatic and cultural trends. Their analysis demonstrates how features like raised floors, roof configurations, and material selections facilitate natural ventilation, shield against solar radiation, and enable heat regulation (Nugroho et al., 2023). Through the examination of these vernacular predecessors, contemporary architects can discern climate-responsive concepts that may be recast using modern materials and technologies. The incorporation of traditional knowledge into contemporary practice demonstrates the historical interconnection of design and function in culturally particular manners, highlighting how these insights can guide new, contextually relevant bioclimatic solutions (Nugroho et al., 2023).

Strategic Design Architecture as a Contemporary Framework. Based on this historical reconstruction, Faroughi and Faroughi present a modern design system model structured around external environments, human and organisational design perspectives, and a triad of visionary,

strategic, and operative design within the design organisation (refer to the model on page 6 of their article). Strategic design occupies a central position, linking visionary design, which formulates optimal identities and long-term aspirations, with operative design, which converts those aspirations into tangible products and services (Faroughi & Faroughi, 2012). They subsequently delineate a Strategic Design Architecture (SDA) with three primary components, each encompassing formative and informative processes. Design Knowledge oversees the generation, integration, transformation, and dissemination of knowledge, encompassing integration, transformation, problem identification and resolution, as well as environmental learning. Design Identity governs and distinguishes identities while fostering creativity through the introduction of novel interpretations. Design Strategy oversees the formulation of strategies, creates scenarios, and converts strategies into product specifications (refer to the illustrations on pages 7–8). These components establish a systematic connection between the abstract realm of ideas and identities and the tangible realm of concrete solutions, so enhancing the integration of form, function, and context in strategic terms (Faroughi & Faroughi, 2012).

In this context, the SDA is delineated into seven iterative design activities: comprehending the human and organisational context, establishing design identities, delineating the problem space, generating ideas that integrate perspectives, formulating design strategies, converting these into requirements, and deriving insights from the social, cultural, economic, and technological milieu. Every action is designed to harmonise formal expression with practical objectives and contextual circumstances, reflecting both the Renaissance Disegno and the intricacies of modern design practice (Faroughi & Faroughi, 2012).

Design Tools and Technologies. Computational technologies enhance strategic and historical insights by offering operational methods to integrate form and function in the design process. Jabi and Chatzivasileiadi delineate computational techniques that amalgamate geometry and topology, augmenting spatial cognition and facilitating the parametric evaluation and manipulation of complex forms (Jabi & Chatzivasileiadi, 2021). Parametric and algorithmic processes enable the direct encoding of performance-related criteria, such as structural efficiency and environmental behaviour, into the development and change of shapes. Thus, computational design aligns with the concept of Disegno as a process connecting idea and form, now enhanced by precise digital tools that provide systematic exploration of design spaces within defined limits and objectives (Jabi & Chatzivasileiadi, 2021).

Graphic statics offers a supplementary, visually focused approach for incorporating structural behaviour into conceptual design. Wang et al. demonstrate how visual statics converts intricate structural computations into geometric diagrams that designers can edit during the initial phases (Wang et al., 2022). These diagrams elucidate the flow of forces, so prompting architects to design forms that both articulate and enhance structural performance. By utilising visual statics in the conceptual phase, designers regard structure as a generative component rather than a subsequent limitation. This methodology enhances the synthesis of form and function, harmonising the project's aesthetic attributes with its mechanical and material principles (Wang et al., 2022).

The amalgamation of form and function in strategic design methodologies is fundamental to modern architectural conceptualisation, enhanced by both historical and contemporary viewpoints. Biophilic and human-centered methodologies demonstrate how nature-oriented formal solutions can concurrently enhance well-being and environmental efficacy (Akinyemi et al., 2024; Ip, 2024). Modularity conveys lessons from organisational theory into adaptive spatial systems that are structurally cohesive and functionally versatile over time (Sanchez & Mahoney, 1996). Knowledge-based frameworks underscore the significance of organised collaboration in harmonising aesthetic objectives with technical specifications (Pourzolfaghar et al., 2013).

Faroughi and Faroughi's reconstruction of Ordine Disegno and their Strategic Design Architecture introduces a theoretical and systemic dimension, connecting Renaissance concepts of idea, form, and execution with modern requirements for managing complexity, identity, and strategy within design organisations (Faroughi & Faroughi, 2012). Simultaneously, computational design tools and graphic statics offer definitive techniques for integrating performance metrics and structural comprehension into form development (Jabi & Chatzivasileiadi, 2021; Wang et al., 2022).

Collectively, these frameworks and tools delineate a paradigm wherein strategic design serves as a conduit between visionary concepts and practical implementation, and where form and function are concurrently developed across various scales, from conceptual identity and strategy to material specifics and environmental efficacy.

Conclusion. This paper has argued that the inner life of nature-adapted buildings is constituted by the dynamic interplay of three interdependent design logics: regenerative, bioclimatic, and biophilic. Far from being independent or additive, these logics converge in a strategic design framework where form and function are inseparable, each shaping the other through continuous engagement with environmental conditions, human experience, and ecological systems. The theoretical genealogy traced here—from Alexander's pattern-based wholeness through Banham's environmental systems thinking to the metadesign principle of open, co-evolving systems—demonstrates that this convergence has a long intellectual history, and that contemporary computational tools, biomimetic strategies, and bioclimatic modelling represent its current instrumentation rather than its origin.

The body of evidence reviewed across the sections of this paper confirms that nature-adapted buildings are not a stylistic tendency but a coherent architectural paradigm. Biomimetic building envelopes, climate-responsive spatial organisation, passive environmental strategies drawn from vernacular traditions, and computational simulation tools all converge on the same fundamental principle: that architectural form should arise from, and remain accountable to, the functional, ecological, and experiential conditions it inhabits. The research of Elsamadisy et al. (2019), Sommese and Ausiello (2023), El Sayed (2023), Holstov et al. (2017), and Akinyemi et al. (2024) collectively demonstrates that this principle

is not merely normative but technically and practically achievable across diverse building typologies and climatic contexts.

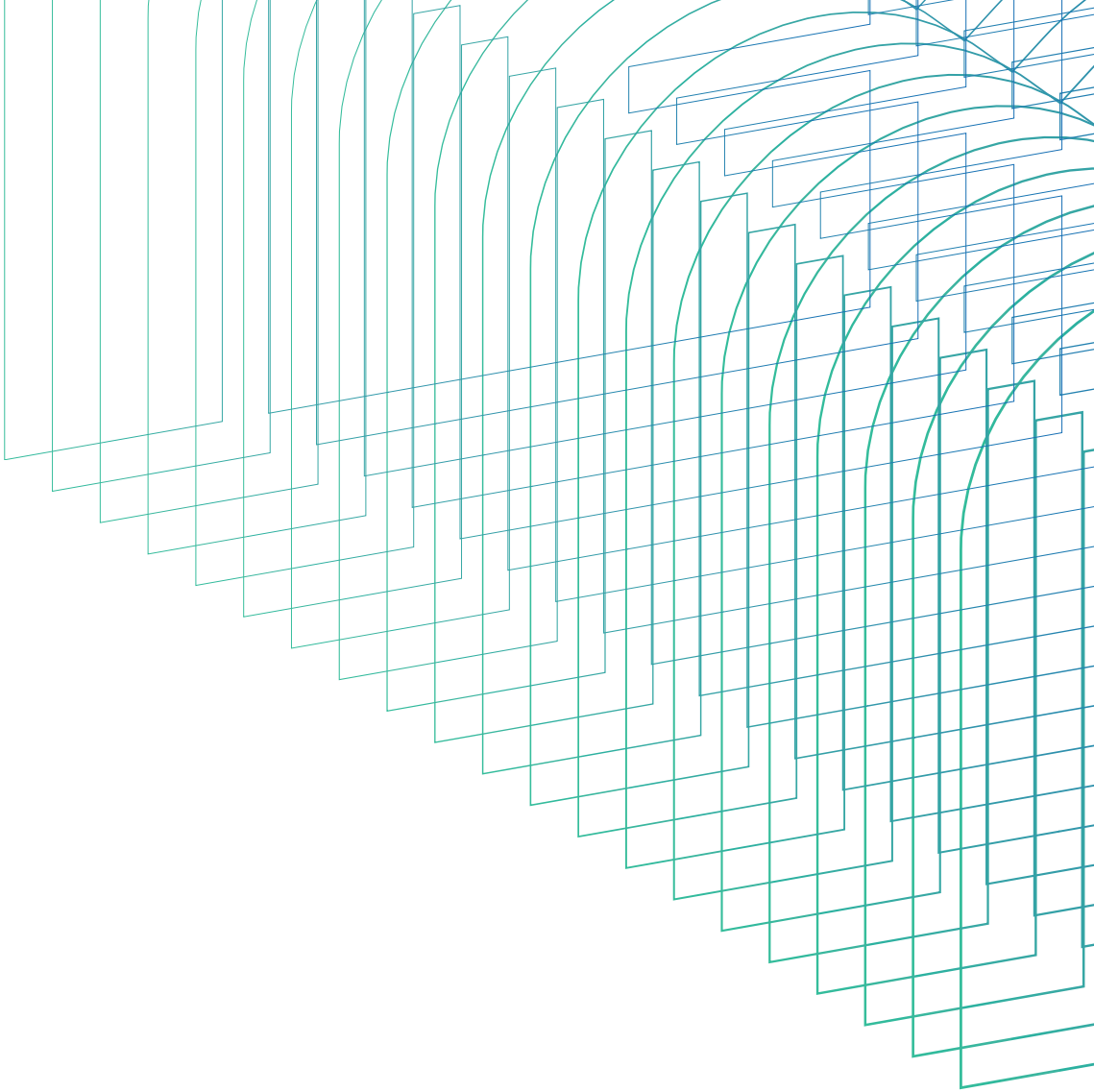
The theoretical and practical implications of this framework are significant. For architectural practice, it suggests the need to reintegrate environmental performance, structural expression, and spatial experience as co-generative design forces rather than sequentially resolved problems. For design education, it calls for a closer engagement with natural systems as models of adaptive organisation. For research, the most productive directions ahead lie in the empirical evaluation of lived performance in nature-adapted buildings, the development of integrated assessment tools capable of capturing regenerative outcomes across environmental, social, and psychological dimensions, and the further exploration of metadesign principles as a basis for buildings that evolve with their communities over time. Architecture that learns from nature's inner life has the potential not only to reduce its ecological footprint but to actively contribute to the regeneration of the environments it inhabits.

A final consideration concerns the cultural and pedagogical transformation that this paradigm demands. The integration of regenerative, bioclimatic, and biophilic principles into professional practice requires not only new technical competences but a fundamental reconceptualisation of the architect's role: from designer of fixed objects to orchestrator of adaptive systems. This shift calls for architectural education to engage more deeply with ecological literacy, systems thinking, and the interdisciplinary knowledge that connects building science, cognitive psychology, and environmental ethics. As Jang (2024) demonstrates in the context of regenerative architecture teaching, integrative design processes that combine environmental analysis, systems thinking, and place-specific research groups to move beyond conventional sustainability towards genuinely restorative practice. The buildings that best embody the principles examined in this paper are those designed not merely to perform well on delivery but to deepen their relationship with nature, place, and community across time.

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URBAN TRANSFORMATIONS AND HERITAGE FORMATION. THE CASE OF THE TRAIN STATIONS IN VALLE DEL CAUCA, COLOMBIA/

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Abstract. The construction of the railroad system in Colombia and its subsequent consolidation throughout the 20th century is one of the symbols of the transformations the country experienced during the last century. This was characterized by the generation of new building typologies adapted to the physical and spatial needs of Colombian society. In the region of Valle del Cauca, in the southwest of the country, one of these new typologies was the train stations, which were distributed throughout the territory, reaching 47 stations, forming a system that functioned as an integrating element of an area historically and geographically isolated by the geological characteristics of the territory. In this way, the stations can be categorized into three groups according to the degree of contextual modification they represent; the first group as town originators, since some show the emergence of populations as a process of consolidation of the buildings used for the railway function and later urban growth given the commercial and industrial activity that arose in their contexts. A second group can be called town transforming stations, where existing settlements benefited from the need to implement a station for passengers and cargo nearby, which promoted the modification of urban layouts, affecting land use and subsequently leading to significant geometric changes. Finally, there is a third group, which includes large and medium-sized cities which allowed the arrival of the train with specific modifications, but which were not as significant as the previous ones. Likewise, in this group there is evidence of the appearance of some minor stations that did not generate urban modifications in their surroundings. These modifications can be studied on the basis of geometric changes in the urban layouts made after the station appeared, or even based on commercial activities, the hierarchy of the station in the towns and the emergence of new squares or parks within historical or consolidated urban realities. Despite the enormous relevance of the railway system, it has been progressively dismantled since the second half of the 20th century, closing passenger transportation since 1980 and being currently relegated to an intermittent cargo system. From this moment on, the evident obsolescence of the system has meant a clear deterioration of the stations, which present phenomena of abandonment, unproper occupation and destruction, thus generating poles of insecurity and deterioration. For this reason, the following research seeks to understand the phenomenon of train stations in Valle del Cauca as an integrated system that is implanted in strategic places of the territory connecting important historical, social and environmental values. Thus, being an integral part of a landscape that can be understood under the parameters of the concept of cultural landscape, and for that reason be the object of future conservation and restoration projects that face the social and environmental challenges that currently threaten these buildings and the existing social and environmental structures, to generate strategies that ensure the valorization of this system, turning the stations into poles of social and cultural development as well as opportunities for environmental restoration and conservation.

Introduction: Historic and Economic Context. The construction and consolidation of the railroad system in Colombia during the 20th century stands as a key symbol of the country's profound transformations. This process marked the shift from an agricultural-based economy toward the first steps of industrialization. Beyond its economic significance, the railroad system generated new building typologies that reflected and adapted to the evolving physical and spatial needs of Colombian society, through the transformation of traditional landscapes by the addition of new layers and elements that would come to configure the contemporary composition of the territory. In Valle del Cauca region, located in the southwest of the country, one of the most notable typologies was the train station. At their peak, 47 stations were distributed throughout the territory, in an interconnected network, that helped to integrate an area historically isolated by complex geological and geographic conditions (Figure 1). These stations, more than functional nodes of transportation, became architectural and social landmarks (Mejía Pavony, 1999), that brought together a geographically separate region (La Rosa and Mejía, 2017).

In this sense, the development of Colombia's railroad system must be understood within the broader historical and economic transitions of the late 19th and early 20th centuries. Especially because until the beginning of the 20th century, the Colombian economy was predominantly agrarian, centered on subsistence farming and regional exchange. The lack of efficient transportation infrastructure reinforced the isolation of many areas, where rivers and mule tracks were the only viable means of communication (González, 2006). A turning point came with the coffee boom, which emerged as the main driver of Colombia's export economy at the beginning of the 20th Century. Coffee cultivation, particularly in regions of Cundinamarca, Antioquia, and the western slopes of the *Andes Mountain Range,* required improved transportation to connect rural producers with export ports on both the Caribbean and Pacific coasts (Valencia Llano, 2018). As Posada Carbó notes, this demand coincided with a broader process of modernization promoted by both national governments and foreign investors, who saw railroads as essential tools to facilitate commerce, attract capital, and expand state presence into remote territories (Posada Carbó, 1998). During the early 20th century, the Colombian state, with limited financial resources, often relied on foreign concessions and capital to construct and operate railroad lines. British and later American companies played a central role in financing, equipping, and managing many of the first systems (Safford, 1989). Despite difficulties, such as political instability, technical challenges in mountainous terrains, and recurring financial crises, the railroad gradually extended across several key regions. In Valle del Cauca, the construction of railways was particularly transformative. This region, long isolated by the Andes Mountain chains, began