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Investigating Green Cover Design Strategies for Enhancing the Environmental Performance of Biophilic Architecture with an Environmental Management Approach

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Abstract

This study aims to investigate and elucidate the role of green coverage systems in enhancing the environmental performance of biophilic architecture through an environmental management approach. The necessity of this research arises from the challenges posed by rapid urbanization, increasing energy consumption, and water scarcity across Iran's diverse climatic conditions. Accordingly, the study seeks to identify key performance indicators and propose a localized model to clarify the effective integration of natural elements, green technologies, and biophilic design principles. The research adopts a descriptive–analytical methodology, combining theoretical studies with the analysis of five domestic and international case studies. The performance indicators of green coverage systems were examined within four main dimensions: energy and thermal performance, air quality, water management, and human-centered factors, and were subsequently weighted within a conceptual model. The findings indicate that reducing energy consumption and managing rainwater have the greatest impact on improving environmental performance.

Furthermore, the combined application of green roofs and green walls significantly contributes to temperature regulation, air quality improvement, and thermal comfort enhancement. In the final model, the indicator weights were set at 35% for energy, 30% for water, 25% for air quality, and 10% for human-centered factors. This structure establishes a dynamic balance between environmental performance and user well-being, demonstrating that the success of green coverage design depends on its transformation from a decorative feature into a structural and managerial component within sustainable architecture.

Keywords: Biophilic architecture, Green coverage, Green roof, Green wall, Environmental management, Sustainable development.

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1 | Introduction

Rapid urbanization and excessive consumption of natural resources have disrupted the ecological balance of cities, leading to higher urban temperatures. This phenomenon, commonly referred to as the Urban Heat Island (UHI) effect, requires structural solutions within environmental design strategies. Under such conditions, architecture, as a key contributor to environmental quality, must move beyond its conventional functional limitations and assume a restorative role in relation to nature. This paradigm shift has directed attention toward nature-based solutions.

In recent years, the concept of biophilic architecture, emphasizing the innate human need for connection with nature, has been introduced as an effective approach to improving psychological well-being and ecological performance [1]. Biophilia, the foundational concept of this approach, holds that humans require both direct and indirect interactions with nature for health and well-being. However, biophilic design can be truly effective only when integrated with real ecological systems, such as green cover and environmental management strategies.

In this context, the application of green coverage systems in buildings not only enhances energy efficiency and reduces urban pollution but also serves as a means to restore the human-nature relationship. Green systems (including green roofs and green walls), by introducing a living layer onto building surfaces, regulate thermal exchange and improve overall building performance in line with sustainable development goals. This study is based on the assumption that integrating these three components, biophilia, green coverage, and environmental management, provides the necessary coherence for achieving sustainable architecture in challenging climatic conditions.

2 | Problem Statement

In recent years, green coverage systems have gained increasing attention as a key component of sustainable design. This trend has been further encouraged at the international level through the adoption of various standards and guidelines. However, in many implemented projects, these systems have been applied superficially and without a thorough analysis of local climatic conditions. Such mismatches have led to several issues, including the inappropriate selection of plant species (requiring excessive irrigation), high water consumption, inadequate drainage design that threatens structural stability, and insufficient maintenance. Consequently, the expected environmental benefits have not been fully realized.

Moreover, in Iran, due to severe water resource constraints and significant seasonal temperature fluctuations, green cover systems are often designed independently of comprehensive urban environmental management policies. This disconnection between the ambitious goals of green architecture and the realities of local climate has led to projects that lack long-term durability and fail to meet the objectives outlined in sustainable development frameworks.

Therefore, there is a clear need for a comprehensive study to identify and prioritize the key indicators influencing the integration of green coverage systems with biophilic design principles and environmental management frameworks within Iran's climatic context. This research aims to develop an analytical framework that leads to a localized and sustainable model, emphasizing the management of internal building resources (such as water) and compatibility with the surrounding environment.

3 | Theoretical Framework

3.1 | Biophilic Architecture

Biophilic architecture originates from Edward O. Wilson's biophilia hypothesis [2], which defines the human affinity for nature as an inherent and evolutionary need. This theory operates at two primary levels: direct experience of nature (such as light, air, and water) and indirect experience (including natural patterns, forms, and colors).

Recent studies [1], [3] have extended this approach toward the redesign of built environments based on nature-inspired patterns. A defining characteristic of biophilic architecture is the re-creation of natural processes and forms within the spatial, lighting, and functional structures of buildings.

Numerous empirical studies have demonstrated that the presence of natural elements such as daylight, visual access to greenery, and natural ventilation has positive effects on users. Specifically, research indicates that exposure to natural elements can increase cognitive performance by up to 13% and reduce employee stress levels by approximately 8%.

In this study, biophilic architecture is defined as the theoretical foundation linking humans and the environment, and its functional role in green architecture is explained through the creation of sensory-perceptual experiences. This dimension ensures that green design solutions are not merely technical interventions but also respond to occupants' biological and psychological needs.

3.2 | Green Coverage in Architecture

Green coverage represents one of the most prominent manifestations of the integration of architectural structures with natural ecological systems, occupying a significant position in sustainable and biophilic architecture. By introducing a living layer of vegetation onto horizontal and vertical building surfaces, this technology not only provides aesthetic value but also delivers extensive climatic and ecological functions.

Recent studies indicate that green roofs and green walls reduce heat exchange, mitigate air pollution, and improve relative humidity, thereby significantly enhancing thermal comfort in buildings [4], [5]. Consequently, green coverage should not be considered a decorative addition, but rather an integral component of the building's bioclimatic regulation system, actively managing heat, light, and air quality.

From a technical perspective, green roofs are generally categorized into two main types based on substrate depth and water retention capacity: extensive and intensive systems. Extensive roofs, with shallow soil layers (5–15 cm) and resilient vegetation, are suitable for buildings with structural load limitations. In contrast, intensive systems with deeper substrates (20–100 cm) support shrub growth, create social spaces, and enhance biodiversity [6].

In addition, green walls are typically classified into living walls and green façades, each differing in drainage systems and spatial integration, and thus having distinct impacts on indoor and outdoor air quality [7]. This classification highlights that each system complements specific aspects of climatic performance, and their strategic combination can produce more effective thermal and ecological outcomes.

From an environmental performance perspective, recent urban-scale studies show that green coverage can reduce roof surface temperatures by 10 to 25°C and decrease atmospheric Carbon Dioxide (CO_2) concentrations by approximately 0.3% to 0.5% [4]. This phenomenon results from the synergy between solar radiation absorption and plant evapotranspiration processes and can be approximated by the following equation:

$$\Delta T_{surface} = \alpha \times (T_{bare} - T_{green}), \tag{1}$$

where α is the thermal reduction coefficient dependent on vegetation type and moisture level, typically ranging between 0.4 and 0.6 [8].

Studies of local projects in northern Iranian cities such as Rasht and Tonekabon indicate that using native plant species, such as Tradescantia pallida and Sedum spurium, can increase system durability by up to 40% while reducing water consumption by approximately 30% compared to non-native species. These findings underscore the importance of ecological adaptation in design and suggest that the selection of green coverage systems in Iran must be based not only on aesthetics but also on environmental compatibility.

At a broader scale, green coverage systems not only reduce surface temperatures and cooling loads but also contribute to urban ecosystem health by absorbing Particulate Matter (PM2.5) and enhancing biodiversity [9]. Such systems can also be adapted to arid climates by using lightweight substrates and smart drip irrigation technologies.

Therefore, green coverage should not be viewed merely as a technical intervention but as an integral component of environmental management in practice, capable of transforming building surfaces from passive energy consumers into active regulators of energy and moisture. This perspective elevates green coverage from a formal architectural feature to a systemic element of ecological performance where biophilic architecture converges with environmental sciences and sustainable environmental management becomes embedded within the built environment.

3.3 | Green Walls and Their Performance Indicators

Green walls are among the most effective nature-based technologies in biophilic architecture. By forming a living envelope on vertical surfaces, they act as regulators of heat, pollution, and urban livability quality. This system, through the integration of vegetation, drainage layers, growing media, and automated irrigation systems, creates a dynamic interface between the building structure and the surrounding ecosystem. In doing so, it transforms the "passive envelope" into an "active and living envelope," a role that directly elevates biophilic architecture from a purely aesthetic level to an environmental performance-driven approach.

I. Studies from 2019 to 2024 generally categorize green walls into two groups: green façades, in which plants grow from the ground or adjacent planters and climb via supporting structures.

II. Living walls or modular green walls, in which planting media are integrated into modules attached to the structure.

The first group is more cost-effective and easier to maintain in traditional or humid environments, whereas the second offers greater control over humidity, temperature, and species selection. In Iran's climate, the second system performs better due to its adaptability to intense solar radiation and its use of low-water native species such as Rosmarinus officinalis and Sedum acre. Therefore, the technical choice between these two systems primarily depends on a combined energy-climate index and the structure's long-term maintenance capacity.

From a thermal perspective, the performance of green walls in reducing surface temperature and cooling energy demand is directly measurable. Findings by Ahmed et al. [9] report an average temperature difference between green and conventional façades of 5 to 9°C, expressed by the relationship:

$$\Delta Tsurface = \alpha\,(Tbare - Tgreen), \tag{2}$$

where α ranges approximately between 0.6 and 0.8 for high vegetation density, in hot and dry climates, this effect can lead to up to a 12% reduction in energy demand, while in humid northern cities its main role is to moderate envelope moisture fluctuations. These outcomes support the view of contemporary climate-responsive architecture, which defines living systems as biological energy regulators rather than decorative elements.

In terms of air quality, 2022–2023 studies show that each square meter of green wall can absorb approximately 2–3 grams of PM10 per day and remove up to 0.5 mg/m² of nitrogen oxides from the air. Species with rough leaf surfaces, such as Hedera helix and Ficus pumila, demonstrate the highest particulate capture capacity. Research conducted by the University of Tehran on projects in Enghelab Street and Niavaran indicates an average 45% reduction in airborne particles at pedestrian height, highlighting the policy relevance of green walls in high-traffic areas. Thus, the "local pollution absorption capacity" can serve as a quantitative indicator for ecological performance assessment in Iran-specific models.

From a water consumption and recycling perspective, recent technologies rely on greywater recirculation systems. Adewale et al. [10] showed that using linear pump systems and treated wastewater storage can increase water efficiency by up to 72%. This system has also been tested in Tehranpars, resulting in a direct reduction in maintenance costs. Compliance with environmental management systems (International Organization for Standardization (ISO) 14001) enables green walls to evolve from mere façade elements into resource-management modules, marking the convergence of sustainable design and environmental governance.

From an aesthetic and social perspective, green walls function not merely as decoration but as a psychological mediator between humans and space. Studies by Abdelaal [1] and Bratman et al. [11] in residential projects across Asia and Europe show that 70–80% of residents in buildings with green walls report higher perceived environmental quality and residential satisfaction. Domestic case studies in Isfahan and Shiraz also reveal a direct correlation between increased vegetation density and improved environmental satisfaction indices. These findings confirm that green walls are not limited to physical performance but form part of the biophilic relational system that restores a sense of spatial belonging.

In conclusion, the prioritization of key green wall performance indicators, based on a synthesis of global research and Iran's climatic conditions, includes four main axes:

I. Surface temperature difference (ΔT) as an energy indicator.

II. Precise measurement of particulate and gaseous pollutant absorption as an air quality indicator.

III. Water efficiency through recycling systems and reduced evaporation losses.

IV. Psychological impact on residents' aesthetic perception.

3.4 | Performance Indicators and Evaluation Criteria for Green Cover Systems

Scientific evaluation of green cover in biophilic architecture requires identifying indicators that simultaneously address environmental, energy-related, and human perceptual dimensions. These indicators emerge from the convergence of environmental sustainability principles, biophilic design theories, and environmental management frameworks, and their role is to transform design from a conceptual level into a quantitative and comparable framework. Recent studies such as Attia [12], Berto et al. [13], and Berardi and Zhang [14] indicate that four main categories of indicators form the international basis for assessment:

I. Energy and thermal indicators.

II. Air quality and microclimate indicators.

III. Water and resource management indicators.

IV. Human-centered and aesthetic indicators.

In the first category, variables such as surface temperature difference (ΔT), heat flux, and annual energy savings (kWh/m²) represent the capacity of green cover systems to regulate heat and reduce building cooling loads [9]. The second category includes PM10 absorption, reduction of CO_2 concentration, and mitigation of the UHI effect, all of which are directly linked to air pollution and urban health [15].

The third group focuses on greywater recycling ratio (RWR%), evapotranspiration efficiency, and overall water-use efficiency. Findings by Abdelaal [1] show that these indicators are among the most decisive factors in the performance of green roofs in arid climates. Finally, human-centered indicators such as environmental satisfaction, visual contact with nature, and users' psychological comfort [11] represent the subjective and social dimension of green cover benefits.

A comparative analysis of the literature shows that energy-related indicators carry the highest weight in temperate climates. However, in hot-arid regions such as Iran, water management and thermal stress reduction are more critical [1], [16]. Therefore, each indicator must be assessed in two independent dimensions: a "global standard" as a universal benchmark and a "local adaptation" based on Iran's climatic conditions. This dual framework enables green cover design to shift from a mimetic model toward an adaptive model responsive to real resource constraints. Accordingly, the differing weights assigned to energy- and water-related indicators in these two evaluation systems provide the basis for developing a climate-based decision-support model in the following chapter.

Table 1. Classification of green cover performance indicators.

Indicator Group	Sub-Indicator	Measurement Criterion (Unit)
Energy and thermal	Surface temperature difference (ΔT)	°C reduction compared to a non-vegetated surface
	Annual energy savings	kWh/m^2 or percentage of energy consumption reduction
Air quality and microclimate	PM10 and CO_2 absorption	$g/m^2 \cdot day$ or ppm reduction in concentration
	UHI reduction	Ambient temperature difference (°C)
Water and resource management	Greywater recycling (RWR%)	Percentage of water volume recycled
	Effective evapotranspiration loss reduction	Percentage reduction compared to conventional irrigation
Human-centered and aesthetic	Environmental satisfaction	Average questionnaire score (1–5 scale)
	Visual access to greenery	Percentage of spaces with natural visual connection

3.5 | Comparative Analysis of Indicators at Global and Local Scales

The dual-dimensional evaluation of green cover indicators shows that the relative importance of each metric varies across climatic and cultural contexts. Based on systematic reviews by Lotfi and Hassan [16], Ahmed et al. [9], and Abdelaal [1], in humid and semi-humid countries, energy and air quality indicators are prioritized. In contrast, in arid and semi-arid climates such as Iran, water management and passive cooling carry greater weight.

This difference arises from variations in the priority of essential environmental resources. In regions where water scarcity and high solar radiation dominate, design objectives shift from energy efficiency toward hydrological sustainability and thermal resilience. This climatic tension highlights the need to adapt imported models to Iranian ecological contexts and outlines a pathway for developing a localized framework for green cover management.

Table 2. Comparative prioritization of green cover performance indicators (global vs. Iran context).

Indicator Group	Sub-Indicator	Global Priority	Local Priority (Iran)	Key Sources (2019–2024)
Energy and thermal	Energy consumption reduction/surface ΔT	5	3	Berardi et al. [6], Lotfi and Hassan [16]
Air quality and microclimate	PM and CO_2 absorption/UHI reduction	4	3	Mohammed Al-Dulaimi and Hassan Al-Taai [15], Ahmed et al. [9]
Water and resources	Rainwater recycling/water efficiency	3	5	Abdelaal [1], Lotfi and Hassan [16]
Materials and environmental compatibility	Use of local and low-carbon materials	3	4	Attia [12], Adewale et al. [10]
Human-centered and aesthetic	User satisfaction/visual contact with nature	3	3	Bratman et al. [11], Szibbo [17]

3.6 | Interpretation of Results

The table shows that the water and resource management indicator carries the highest weight in Iran's localized models, whereas energy consumption reduction remains the top priority in global evaluation frameworks. Consequently, proposed models for Iranian conditions must shift their focus from purely energy optimization to an integrated water–energy cycle efficiency approach, as the interaction between these two components determines the true bioclimatic performance of projects. This analytical finding forms the conceptual basis for developing a climate-based decision-support model in the next chapter, where indicator weights will be quantitatively formalized within a conceptual framework.

4 | Type and Research Approach

This study is applied in nature and follows a descriptive-analytical approach, aiming to develop a localized framework to improve the environmental performance of green cover in biophilic architecture. Data were collected through a systematic review of international scientific literature and the analysis of five selected case studies. A combined inductive-deductive methodology, in line with Zhang et al. [14] and Lotfi and Hassan [16], was employed to adapt theoretical indicators to Iran's climatic conditions. This structure, while maintaining scientific rigor, enables alignment of global findings with local contextual data, thereby transforming theoretical knowledge into practical guidelines for environmentally based design.

4.1 | Research Implementation Process

The research process was organized into five sequential stages to ensure a coherent transition from theoretical data to the conceptual model. These stages were structured by integrating the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, as used in sustainable design studies [9], with a comparative analytical logic. Each stage employed a combination of qualitative methods (literature review and conceptual synthesis) and quantitative methods (indicator weighting) to ensure reproducibility and transferability of the findings to other climatic contexts. The outcome of this process is a structured model that systematically clarifies the relationship between green cover systems, biophilic architecture, and environmental management.

Table 3. Research implementation stages and content of each step.

Stage	Key Activity	Main Output
Literature review and indicator identification	Review of 52 international sources (2019–2024) and extraction of performance variables	Initial list of environmental and biophilic indicators
Development of a classification framework	Grouping indicators into four main axes	Multidimensional evaluation framework
Global–local comparative analysis	Comparison of indicator priorities in global literature and Iran's climatic data	Indicator comparative matrix
Weighting and ranking	Determination of relative importance using the pairwise comparison model (qualitative AHP)	Final indicator weighting table
Conceptual model development	Integration of results into a four-axis analytical structure	Final conceptual research model

The continuity of the five-stage process has transformed the research flow from data extraction to final modeling into a reproducible and adaptable framework. In this way, the procedure can serve as a basis for developing hybrid models in environmental design within similar climatic contexts.

4.2 | Selection and Analysis of Case Studies

In this section, to validate the performance indicators derived from the theoretical framework, a set of prominent international and domestic projects recognized for their use of green cover in biophilic architecture has been selected for comparative analysis. These case studies were chosen to represent diversity in climatic conditions, implementation technologies, and the level of integration between green cover systems and architectural structures, allowing an assessment of their compatibility with proposed Iranian contextual models.

Comparing each case's characteristics and performance indicators not only reveals the environmental and human-centered capabilities of green cover systems but also provides a theoretical and empirical foundation for developing the research conceptual model. *Table 4* presents the main specifications of the selected projects, including climate type, green system configuration, dominant performance indicator, and key biophilic feature, thereby ensuring that subsequent analysis is grounded in documented, comparable data.

Table 4. Selected case studies of biophilic green cover systems.

Row	Project Name	Location	Climate Type	Type of Green Cover	Main Performance Indicator	Key Biophilic Feature
1	Bosco verticale	Milan–Italy	Temperate mediterranean	Vertical green façade	CO_2 absorption ~30 tons/year	Over 900 trees for natural cooling
2	One Central Park	Sydney–Australia	Hot and humid	Combined green façade and green roof	25% energy savings	Yeang [3] design with sunlight-reflecting mirrors
3	Caixaforum Madrid	Madrid–Spain	Mediterranean	Dense green wall	70% runoff reduction	Patrick Blanc's design with 15,000 plants
4	ACROS Fukuoka Building	Fukuoka–Japan	Semi-humid Asian	Stepped green roof	4–6°C temperature reduction	Integration with urban topography and natural landscape
5	Parkroyal on Pickering	Singapore	Hot and humid	Green roofs and vegetated terraces	25% water consumption reduction	15,000 m^2 hanging biophilic gardens
6	Iran Mall Green Tower	Tehran – Iran	Semi-arid	Extensive green roof	18% energy consumption reduction	Use of native plants and a smart irrigation system

The review of the projects presented in *Table 4* indicates that differences in climate, construction technology, and type of green cover system directly influence environmental performance patterns. Projects implemented in hot and arid regions, such as Tehran and Dubai, place greater emphasis on irrigation efficiency, selection of native species, and evaporation control, whereas projects in humid climates, such as Singapore and Sydney, focus more on optimizing natural ventilation and humidity regulation.

Furthermore, the performance analysis shows that the level of integration between the main structure and the green system is a determining factor in thermal stability and energy efficiency. Buildings such as Bosco Verticale and ACROS Fukuoka, where vegetation was integrated into the architectural design, demonstrate superior performance in reducing energy consumption and mitigating surface temperatures.

The results indicate that integrating indigenous climatic strategies with advanced green cover technologies can provide a pathway toward achieving efficient biophilic architecture in Iran. These findings will serve as the basis for identifying key indicators and developing the research's conceptual model.

4.3 | Conceptual Model of the Research

Based on the findings and case studies, a conceptual model was developed to explain the role of green cover in enhancing the environmental performance of biophilic architecture. The model is structured around three main axes: biophilic principles, green cover technology, and environmental management. The interaction among these three axes results in reduced energy consumption, improved air quality, effective water management, and enhanced user comfort.

Using the AHP method, the relative importance of the indicators was determined as follows: energy (35%), water (30%), air quality (25%), and human-centered factors (10%). The integration of these results provides a localized, efficient model and serves as a basis for the sustainable integration of green cover into biophilic architecture.

In this model, the inputs include climatic conditions, the type of green cover system (green roof, green wall, or hybrid system), and the selection of native plant species. Through green cover, regulatory processes such as evapotranspiration, shading, pollutant absorption, and water retention transform these inputs into outputs, including reduced energy consumption, improved air quality, better water resource management, and enhanced thermal and psychological comfort for users.

A key feature of this model is the dynamic interaction among indicators, so that improvements in one component (e.g., water management) can synergistically influence others (e.g., energy performance and air quality). This structure demonstrates that the success of green cover in biophilic architecture depends on its functional integration as a system, rather than its role as an isolated decorative element.

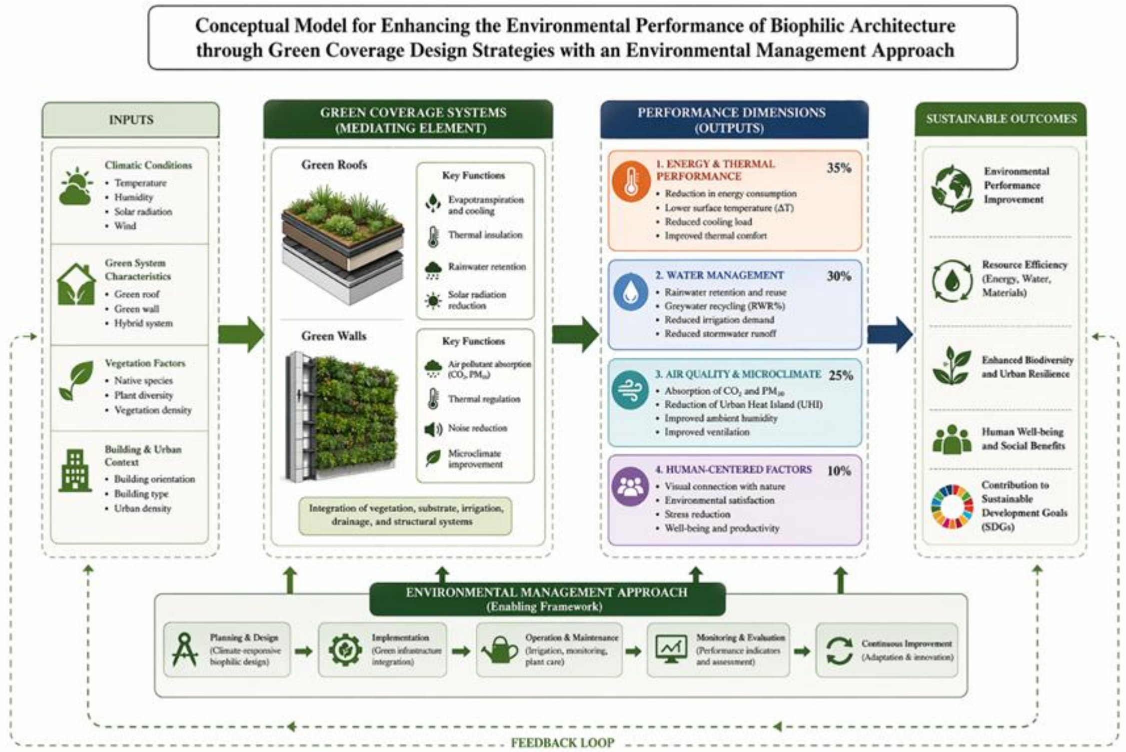

Fig. 1. Conceptual model of green coverage in biophilic architecture.

5 | Findings, Discussion, and Conclusion

The findings of this study demonstrate that green cover systems, when integrated within biophilic architectural frameworks, function as multidimensional environmental regulators rather than purely aesthetic elements. The analysis of theoretical sources, comparative indicators, and selected case studies confirms that their performance can be systematically evaluated across four core domains: energy efficiency, water management, air quality improvement, and human-centered environmental perception.

From a comparative perspective, global evidence shows a dominant emphasis on energy performance, particularly in temperate climates, where reducing heating and cooling loads is the primary objective. In contrast, the Iranian context, characterized by semi-arid and arid climatic conditions, prioritizes water efficiency and passive thermal regulation. This shift in priority underscores the need to contextualize sustainability models rather than transfer global frameworks.

The case study analysis further confirms that the degree of integration between vegetation systems and architectural form significantly influences performance outcomes. Projects with high structural–ecological integration, such as Bosco Verticale and ACROS Fukuoka, demonstrate superior efficiency in temperature regulation and energy reduction. Conversely, projects relying on less integrated systems tend to show weaker performance in long-term environmental stability, despite visual or aesthetic success.

The proposed conceptual model synthesizes these findings into a structured framework in which climatic conditions, system typology, and plant selection act as inputs, and environmental performance indicators function as outputs. The AHP-based weighting further clarifies the hierarchical importance of indicators, emphasizing energy and water as the most critical variables in the Iranian context.

Overall, the study concludes that the effectiveness of green cover in biophilic architecture depends on its systemic integration with environmental management strategies. Rather than being treated as an isolated design feature, green infrastructure should be understood as an active ecological system that simultaneously regulates energy flows, water cycles, air quality, and human well-being.

In conclusion, the research provides a climate-responsive, indicator-based framework that can support the development of adaptive biophilic design strategies in Iran and similar arid and semi-arid regions.

5.1 | Findings

The analysis of data derived from theoretical studies and case study investigations reveals several key findings:

I. Among the indicators examined, energy consumption reduction and stormwater management have the greatest impact on the environmental performance of buildings. It is particularly important in Iran's arid and semi-arid climates, where limited water resources and high solar radiation intensity drive design toward integrated and hybrid solutions.

II. The results indicate that the simultaneous combination of green roofs and green walls performs better than either system alone in terms of temperature regulation, thermal load reduction, and air quality improvement. This combination increases the biophysical exchange surface and strengthens synergistic climatic effects.

III. In terms of air quality, green cover systems demonstrate a significant capacity to absorb PM and reduce pollutants, thereby improving environmental health in dense urban areas.

IV. The findings show that using native plant species not only reduces water consumption but also enhances system durability and lowers maintenance costs. This argument confirms the importance of localization in design strategies.

V. Although human-centered indicators carry the lowest weight in the model, their role in improving user satisfaction, reducing stress, and enhancing spatial perception remains essential and complements the system's technical performance.

5.2 | Discussion

The results of this research indicate that green cover design within a biophilic architecture framework yields meaningful environmental performance enhancement only when it is considered an integrated, system-based, and management-oriented strategy. In many implemented projects, a purely decorative approach to green infrastructure has reduced its effectiveness, whereas this study's findings emphasize the need to shift toward a systemic design perspective.

From an analytical standpoint, the greater weighting of energy and water indicators suggests that environmental sustainability in the Iranian context primarily depends on the management of fundamental resources. It differs from global patterns, where energy is often the dominant priority. In Iran, however, water scarcity becomes the decisive factor. Therefore, design models must move away from imported frameworks and toward localized, climate-responsive solutions.

The case study analysis further demonstrated that successful projects are those in which green systems are integrated into the architectural structure rather than appended as secondary elements. This integration enhances thermal performance, reduces energy consumption, and improves spatial livability.

5.3 | Conclusion

Overall, this research demonstrates that the future of sustainable architecture in climates like Iran depends on transitioning from symbolic green design to performance-driven, bioclimatic architecture. In this paradigm, green cover is not a decorative element but an essential component of the building's ecological infrastructure.

The proposed conceptual model can serve as a decision-support tool for designers and urban managers in developing sustainable biophilic projects.

The results of this study indicate that green cover design within the framework of biophilic architecture yields meaningful environmental performance improvements only when it is approached as an integrated, management-oriented system. In many implemented projects, a purely decorative approach to green infrastructure has reduced its effectiveness, whereas this research's findings emphasize the need to shift toward a systemic design perspective.

From an analytical perspective, the greater weighting of energy and water indicators indicates that environmental sustainability in the Iranian context primarily depends on the management of basic resources. This result differs from global studies, where energy is often the primary priority. In Iran, however, water scarcity is a more decisive factor. Therefore, design models must move away from imported frameworks toward localized, climate-responsive strategies.

Furthermore, the case study analysis showed that successful projects are those in which green cover systems are integrated into the architectural structure rather than being added as superficial or detached elements. Such integration enhances thermal efficiency, reduces energy consumption, and improves overall environmental quality.

At the practical level, the following conclusions can be drawn:

I. The combined use of green roofs and green walls should be considered a core design strategy.

II. Plant selection must be based on local climatic conditions and regional water availability.

III. Smart irrigation systems and water recycling strategies should be integral to the design.

IV. Green infrastructure should be defined within the framework of urban environmental management policies.

In summary, this research demonstrates that the future of sustainable architecture in climates like Iran depends on a shift from symbolic design approaches to performance-driven, bioclimatic architecture. In this context, green cover is not a decorative element but a fundamental component of a building's ecological infrastructure.

The proposed conceptual model can serve as a decision-support tool for architects and urban planners in developing sustainable, biophilic projects.

5.4 | Research Limitations

Although the findings of this study were able to present a relatively comprehensive framework for designing green cover systems in biophilic architecture, several key limitations were encountered during the research process and analysis:

I. The lack of accurate and comparable statistical data from domestic projects limited the quantitative evaluation of indicators. Many existing local projects lack standardized information on energy performance, irrigation systems, and air quality monitoring, making direct comparisons with international case studies challenging.

II. The wide climatic diversity of the country, combined with the absence of a unified classification standard for thermal conditions, prevented the direct generalization of results across all regions of Iran. While the proposed model is adaptable, it requires recalibration of parameters for each specific climate zone.

III. Time and financial constraints in field data collection, as well as limited access to certain international projects, led to reliance on secondary sources in parts of the analysis. As a result, some comparisons are interpretative rather than fully empirical.

IV. Since this research primarily focused on environmental performance and design-oriented aspects within a biophilic architecture framework, economic and social dimensions were not examined in depth, these areas require further complementary studies to complete the full sustainability cycle in green architecture.

5.5 | Recommendations for Future Research

Based on the findings of this study and considering the existing limitations, several directions can be proposed for future research development and expansion:

I. There is a need for long-term field studies to monitor the actual thermal, hydrological, and ecological performance of green roofs and green walls across different climatic zones in Iran. Such studies would provide more precise quantitative data to validate and refine the proposed local model.

II. Examining the economic dimension and Life-Cycle Assessment (LCA) of green cover systems can offer a more comprehensive understanding of their financial sustainability and cost–benefit performance. This approach would support decision-making not only from an environmental perspective but also from an economic efficiency perspective.

III. Future research is recommended to focus on integrating green cover systems with emerging smart technologies, such as moisture sensors, automated irrigation systems, and bioactive materials. These technologies can optimize operational efficiency and significantly reduce maintenance requirements.

IV. From a social and cultural perspective, investigating the impact of green infrastructure on user behavior, residential patterns, and spatial perception in Iranian urban and residential contexts can provide deeper insights into the human-centered dimension of biophilic architecture.

V. It is recommended that academic institutions, in collaboration with municipalities and environmental organizations, develop localized guidelines for the design and maintenance of green cover systems and integrate them into national building regulations. Achieving this goal would represent a significant step toward a sustainable architectural future that evolves in harmony with nature rather than in opposition to it.

Authors' Contributions

The author solely conducted the research and prepared the manuscript and has approved its final version.

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Data Availability

The data are available from the corresponding author upon reasonable request.

Conflict of Interest

There are no competing interests to declare.

Consent for Publication

The author confirms consent for the publication of this work

Ethics Approval and Consent to Participate

This article does not include experiments involving humans or animals.

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