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Article

Sustainable Architecture in Office Spaces: Principles, Impacts, Regulations and Challenges

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Abstract

The office building sector concentrates a significant proportion of urban energy consumption and carbon emissions, while simultaneously facing the organizational reconfiguration driven by the COVID-19 pandemic and the growing demand for occupant well-being. The objective of this study was to comprehensively analyze design principles, environmental, economic and social impacts, certification frameworks and barriers to implementing sustainable architecture in office spaces. A qualitative approach of documentary review was adopted, inspired by the PRISMA-ScR protocol, through categorical thematic analysis of 63 sources indexed in Scopus and ScienceDirect, selected from an initial corpus of 152 records after the application of inclusion and exclusion criteria. The findings show that the integration of passive strategies, indoor vegetation and smart technologies (BIM, IoT, artificial intelligence) reduces operational energy consumption between 15% and 70%, while the life cycle assessment allows for a reduction of up to 50% in environmental impacts through recycled materials and envelope insulation. Certified buildings report productivity increases of between 2.5% and 26%, cognitive performance improvements of up to 61% and rent and market value premiums of between 10% and 12% in Europe and the United States, although in emerging economies adoption faces cost overruns of between 5% and 21% with payback periods of less than four years. Relevant gaps persist in the integration of social criteria within certification systems (DGNB, LEED, BREEAM) and financial, organizational and technical training barriers that limit the adoption of BIM and sustainable materials, particularly in Latin American contexts. It is concluded that the sustainability of contemporary offices requires a holistic framework that articulates technology, public policy and organizational culture, with direct implications for curricular updating in architecture and construction management programs.

Keywords: sustainable architecture; office spaces; environmental certification; energy efficiency; occupant well-being; BIM; green buildings

1. Introduction

Corporate real estate is facing an unprecedented convergence of environmental, economic, and social pressures that has transformed sustainable office architecture from an optional practice to a strategic imperative. Office buildings account for a substantial fraction of urban energy consumption and carbon emissions associated with the built environment, in a context where the 2030 Agenda and national climate commitments require increasingly demanding decarbonization trajectories for the commercial real estate stock (Maltseva et al., 2022). Added to this environmental pressure is the organizational disruption caused by the COVID-19 pandemic, which durably reconfigured occupants' expectations regarding indoor environmental quality, spatial flexibility, and well-being in the workplace (Araya & Abella, 2022).

The contemporary approach to sustainable architecture in offices has gone beyond the reductionist conception focused exclusively on energy efficiency, to incorporate climate resilience, functional flexibility and occupant well-being as equivalent pillars of design in an integrated way (Valencia & Husen, 2024). This conceptual evolution is reflected in the proliferation of advanced

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digital technologies (Building Information Modeling (BIM), Internet of Things (IoT), and artificial intelligence) that allow energy performance, thermal comfort, and operational management of buildings to be optimized simultaneously (El-Ashmawy et al., 2024). In parallel, environmental certification systems (DGNB, LEED, BREEAM, HQE, and their regional adaptations such as SBToolCZ and GreenShip) have evolved as standardization and market signaling mechanisms, although their coverage of social and resilience criteria remains uneven (Polli et al., 2022; Zimmermann et al., 2019).

Table 1 summarizes the methodological scope and characteristics of the documentary corpus that underpins this analysis, delimiting the period, disciplines, and databases consulted.

Table 1. Scope and characteristics of the analyzed documentary corpus on sustainable architecture in office spaces.

Dimension	Description
Publication period	2006–2026, with concentration in the five-year period 2021–2026 (79% of sources included)
Databases consulted	Scopus y ScienceDirect
Integrated disciplines	Architecture, civil engineering, real estate management, environmental psychology, management sciences and public policy
Types of studies identified	Systematic and bibliometric reviews, case studies, life cycle analysis (LCA), occupational surveys, energy simulations and econometric models
Initial corpus identified	152 records
Sources included in the final analysis	63 sources
Predominant geographical scope	Europe, North America, the Middle East and Asia-Pacific; limited representation from Africa and Latin America

Note. Own elaboration based on the systematization of the documentary corpus analyzed in this study.

Despite the breadth of the available literature, a relevant analytical gap persists: existing studies tend to address the technological, economic, regulatory, and social dimensions of sustainability in offices in isolation, without articulating an integrated framework that allows understanding the interactions between these dimensions and their differentiated relevance for emerging economies versus developed economies. Likewise, the representation of Latin American contexts in the indexed literature is marginal, which limits the direct transferability of the findings to the region.

The objective of this study is to comprehensively analyze the design principles, environmental, economic and social impacts, regulatory and certification frameworks, and the barriers to the implementation of sustainable architecture in office spaces, in order to build an updated synthesis that guides both professional practice and the formulation of public policy and academic training in architecture and construction management.

2. Methodology

2.1. Study Design

The study adopted a qualitative analytical-documentary approach, structured as a *scoping review* inspired by the guidelines of the PRISMA-ScR (*Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews*) protocol. This design is appropriate for the stated objective, insofar as it allows mapping the extent, diversity and nature of the available evidence on a multidimensional phenomenon—the sustainability of office spaces—without restricting itself to the evaluation of a single causal effect, which would be typical of a conventional systematic review.

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2.2. Sources of Information and Selection Criteria

The Scopus and ScienceDirect databases were consulted, preferably limiting the search to the period 2021–2026, including seminal studies from previous periods when their conceptual relevance justified it (e.g., reference life cycle assessments published between 2006 and 2019). The keywords used, in Boolean combination, included: *sustainable office building*; *green certification LEED BREEAM DGNB*; *post-pandemic workplace design*; *Life Cycle Assessment Office*; *smart energy management building*; *sustainable construction barriers*. Searches were conducted in English and Spanish.

The inclusion criteria were: (a) articles in journals indexed in Scopus or published on ScienceDirect platforms with peer review; (b) studies specifically focused on office buildings or the corporate work environment; (c) documents with complete and verifiable bibliographic metadata (authorship, year, journal and access link). The exclusion criteria applied were: (a) gray literature without peer review; (b) records with incomplete or unverifiable metadata; (c) studies focused on non-corporate building typologies (housing, heavy industry) unless they provide transferable methodological evidence. From an initial corpus of 152 identified records, and after the application of these criteria prioritizing the completeness of metadata and the validity of the evidence, 63 sources were integrated into the final analysis.

2.3. Analytical Procedure

The analysis was structured in three sequential stages. Stage 1 consisted of a thematic analysis with categorical coding of the revised documents, identifying eight emerging thematic axes: (i) design principles and sustainable technologies, (ii) post-pandemic adaptation and passive comfort strategies, (iii) life cycle assessment and renewable energies, (iv) comparative environmental, economic and social impacts, (v) productivity and value for stakeholders, (vi) smart energy management and organizational culture, (vii) regulatory frameworks and certification systems, and (viii) implementation barriers and gaps. Stage 2 involved the comparative systematization of the quantitative findings reported in the literature (magnitudes of energy reduction, market premiums, productivity increases), constructing comparative matrices by thematic axis. Stage 3 consisted of the integration of the identified patterns into a single analytical framework, submitted to triangulation with independent literature to verify their internal consistency.

2.4. Reliability and Validity

The reliability of the analysis was based on the triangulation of academic sources indexed in two independent databases (Scopus and ScienceDirect) and on the cross-verification of convergent findings between studies from different geographical contexts. Constructive validity was guaranteed by explicitly anchoring each analytical category in documented empirical evidence, prioritizing studies published in the last five years to reflect the current state of the discipline. The inherent limitations of desk analysis—focused on indexed scholarly production rather than primary field data—are explicitly acknowledged in the Discussion section.

3. Results

3.1. Design Principles and Integrated Sustainable Technologies

The documentary analysis shows a consolidated consensus around the guiding principles of sustainable office design: the balance between energy efficiency, use of ecological materials and human well-being; the integration of interior vegetation, natural lighting and cross ventilation; and the incorporation of modelling tools (EDGE, SketchUp) to optimise orientation and water and energy efficiency from the early stages of design (Valencia & Husen, 2024; El-Ashmawy et al., 2024). Life cycle assessment (LCA) is consolidated as a criterion for selecting materials and construction systems with the lowest aggregate environmental impact, while the incorporation of smart technologies—

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BIM, IoT and artificial intelligence—allows for more precise and adaptive energy and comfort management (Maltseva et al., 2022).

In terms of materials and systems, the literature documents a sustained trend towards the use of recycled and locally sourced materials, advanced insulation systems and smart windows, complemented by renewable energy sources—photovoltaic panels, heat pumps and hybrid storage systems (hydrogen/batteries)—that optimise energy performance throughout the building's life cycle (Le et al., 2024). Contemporary sustainable design is therefore based on the simultaneous integration of passive and active solutions, digital technologies and low-impact materials, aimed at maximising occupant comfort and minimising the environmental footprint throughout the building's life cycle.

3.2. Post-Pandemic Adaptation and Passive Strategies for Environmental Comfort

The COVID-19 pandemic decisively accelerated the transformation of office spaces, prioritizing health, flexibility, and spatial resilience over occupational density (Hou & Sing, 2025). Documented organizational changes include the reduction of the physical footprint occupied in favor of higher indoor environmental quality, the adoption of advanced ventilation strategies (displacement, natural, and hybrid) to improve air quality and thermal comfort, and the integration of sustainable practices into facility management (*facility management*)) oriented to hybrid work (Oladiran et al., 2025). Evidence-based design, which combines objective environmental parameters with subjective perceptions of occupant well-being, has become the emerging standard for evaluating the performance of post-pandemic workspaces (Araya & Abella, 2022).

At the same time, passive strategies for environmental comfort have experienced a remarkable technical sophistication. Passive cooling through night ventilation, *skycourts* and thermally activated systems (TABS), together with shading strategies and green facades, makes it possible to significantly reduce cooling loads without resorting to energy-intensive mechanical systems (Sadevi & Agrawal, 2025). The optimization of the window-to-floor ratio and the incorporation of smart materials in facades—capable of dynamically regulating thermal and visual properties—complement these strategies, while hybrid ventilation systems, which combine natural and mechanical flow with phase-change materials (PCM), make it possible to balance indoor air quality with energy consumption through real-time monitoring (Fathi & Fakhraeimanesh, 2025; Cao et al., 2025).

The incorporation of indoor vegetation is a complementary strategy with documented benefits both in air quality—increased relative humidity and reduction in volatile organic compounds (VOCs)—and in the health and psychological well-being of the occupants, including the reduction of symptoms associated with sick building syndrome and the improvement of concentration and perceived productivity (de Vries et al., 2023; Li et al., 2025). However, its effect on the direct reduction of carbon dioxide is limited in environments that already have adequate mechanical ventilation, which repositions indoor vegetation as a strategy for psychological well-being and environmental perception rather than as a primary air purification mechanism (Poncelet et al., 2025).

3.3. Life Cycle Assessment and Renewable Energy

Since the seminal studies that established the predominance of the operational phase over the total environmental impact of the building life cycle (Junnila et al., 2006), the life cycle assessment (LCA) confirms that this phase continues to dominate the aggregate environmental impact of office buildings, and that the incorporation of recycled materials and envelope insulation systems can reduce this impact by up to 50% (Dakhia & Zemmouri, 2021). Smart window and hybrid energy storage systems further optimize performance and reduce emissions associated with building operation (Le et al., 2024). The comparison between construction systems indicates that precast concrete buildings generally have a lower aggregate environmental impact than equivalent steel structures, although this relationship is sensitive to the regional energy mix and local climatic conditions (Pushkar & Yezioro, 2022; Mensinger et al., 2011). The most recent reviews of the LCA literature applied to green building confirm the methodological heterogeneity between studies and

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the need to standardize the limits of the analyzed system to allow valid comparisons between cases (Assadiki et al., 2024).

Table 2 systematizes the impact magnitudes documented in the reviewed literature for the main dimensions of sustainability in offices, allowing a comparative reading of the available evidence.

Table 2. Documented impact magnitudes of sustainable architecture in office spaces, by dimension.

Dimension	Indicator	Magnitude reported	Sources
Environmental	Reduced impact from recycled materials and envelope insulation (LCA)	Up to 50%	Dakhia y Zemmouri (2021); Le et al. (2024)
Energy	Reducing energy consumption through intelligent management (IoT, AI)	Between 15% and 70%	Ikbal (2025); Alotaibi (2025); Song et al. (2025)
Productivity	Increased work productivity in certified offices	Between 2.5% and 26%	Licina and Yildirim (2021)
Cognitive performance	Improved cognitive performance in green environments with improved ventilation	Up to 61%	Irfan et al. (2025)
Market (developed economies)	Rent premium and transaction value of certified buildings	Between 10% and 12%	Barthauer (2025); Ghosh y Petrova (2024)
Costs (emerging economies)	Initial cost overrun of sustainable construction, with return on investment	Between 5% and 21%, *payback* less than 4 years	Ekung et al. (2022); Ahram y Syed Zakaria (2023)

Note. Prepared by the author based on the systematization of the quantitative findings reported in the sources cited. The magnitudes correspond to ranges documented in case studies and specific reviews; Their transferability depends on the climate, regulatory, and market context of each original study.

3.4. Environmental, Economic and Social Impacts Compared to Conventional Offices

The systematic comparison between sustainable and conventional offices confirms a consistent superiority of the former in environmental performance—significant reduction in energy consumption and carbon emissions—and in indoor thermal, visual and acoustic environmental quality (El-Ashmawy et al., 2024). From an economic perspective, while the initial costs of sustainable construction tend to be higher, the literature documents consistent long-term economic benefits derived from energy savings and reduced maintenance costs, as well as increased rent and market value premiums in certified buildings (Barthauer, 2025). In the social dimension, the findings converge in a sustained improvement in health, productivity, and occupant satisfaction, which acts as a mediating mechanism between the environmental and economic benefits of building sustainability (Elnaklah, 2025).

These results must be interpreted considering that the full integration of the three dimensions—environmental, economic and social—continues to face implementation challenges, particularly with regard to the standardized quantification of social well-being, whose measurement is methodologically more complex than that of environmental and economic indicators.

3.5. Productivity, Cognitive Performance, and Stakeholder Value

The evidence on work productivity in sustainable offices is particularly robust: the studies reviewed document productivity increases of between 2.5% and 26%, along with significant reductions in absenteeism rates (Licina & Yildirim, 2021). Green environments with improved ventilation and the presence of natural elements are associated with increases in cognitive performance of up to 61% compared to conventional conditions (Irfan et al., 2025), while the aggregate economic benefits derived from these productivity gains are estimated to be orders of magnitude considerable at the real estate portfolio scale. However, the magnitude of these benefits is

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mediated by organizational factors: environmental design alone does not guarantee the expected results if it is not articulated with an organizational culture and management practices consistent with sustainability objectives (Azizan et al., 2025).

From the perspective of stakeholders, companies and investors that occupy or develop sustainable buildings report lower operating costs, higher occupancy rates, and a strengthened corporate image (Riratanaphong & Pewklieng, 2025). Tenants with demanding environmental, social, and governance (ESG) standards show a growing willingness to pay rent premiums for certified spaces, reinforcing the adoption of *Corporate Real Estate Sustainable Management* (CRESM) practices and the use of sustainable performance indices as a decision-making tool (Liu, N., et al., 2025; Fauzi et al., 2024).

3.6. Smart Energy Management and Organizational Culture

The digitalisation and automation of energy management emerge as determining factors to maximise the operational efficiency of sustainable offices. Systems based on IoT, artificial intelligence, and reinforcement learning enable energy consumption reductions of between 15% and 70%, through the dynamic optimization of HVAC systems, lighting, and equipment, with the consequent reduction of emissions and operating costs (Alotaibi, 2025; Song et al., 2025). These intelligent control systems not only optimize technical variables, but also generate data that allows real estate managers to identify usage patterns and adjust operational strategies in real time (Ikbal, 2025).

However, the success of these technologies depends critically on non-technical factors. Organizational culture and green management practices enhance occupant motivation, commitment, and productivity, functioning as a mediation mechanism between sustainable physical infrastructure and its expected outcomes (Ali et al., 2024). The early integration of sustainable design with organizational change management strategies maximizes comfort and occupying performance, while its absence systematically limits the effectiveness of the technological investments made (Krishnan et al., 2024).

3.7. Regulatory Frameworks and Sustainability Certification Schemes

Environmental certification schemes—DGNB, LEED, BREEAM and HQE on a global scale, together with regional adaptations such as SBToolCZ (Czech Republic) and GreenShip (Indonesia)—constitute the predominant standardisation and market signalling mechanism for building sustainability (Polli et al., 2022). The DGNB system stands out for more comprehensively addressing the criteria defined in the ISO 21929-1 standard, explicitly balancing environmental, social and economic dimensions, while LEED and BREEAM maintain a comparatively greater emphasis on indoor environmental quality and thermal, visual and acoustic comfort (Trebilcock-Kelly & Chávez-Finol, 2022).

Table 3 presents a comparative matrix of the main certification systems identified in the reviewed literature.

Table 3. Comparative matrix of sustainability certification schemes applicable to office buildings.

System	Geographical scope	Main Emphasis	Integration of social criteria	Reference Tool/Standard
DGNB	Germany and international adoption	Environmental-social-economic balance according to ISO 21929-1	High, comparatively	ISO 21929-1; Certification for Comprehensive Performance
LEED	United States and Global Adoption	Indoor environmental quality and energy efficiency	Limited	Points system by categories (USGBC)

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BREEAM	United Kingdom and European adoption	Comprehensive environmental lifecycle management	Media	Weighted Category Assessment (BRE)
SBToolCZ	Czech Republic (regional adaptation)	Adjustment of criteria and weights to materials and local climate	Media	Local adaptation of the international SBTool
GreenShip	Indonesia (regional adaptation)	Adaptation to tropical climatic conditions	Limited	Indonesian Green Building Council (GBCI)

Note. Authors' elaboration based on Polli et al. (2022), Trebilcock-Kelly and Chávez-Finol (2022) and Zimmermann et al. (2019).

Green certifications have a measurable influence on market value: the literature documents income and transaction value premiums of between 10% and 12% in European and US markets (Barthauer, 2025; van Overbeek et al., 2024), a pattern that is also observed in the resale phase of certified assets, where the initial price premium tends to be offset by higher transaction speed and value in the secondary market (Jiang et al., 2021). However, in markets such as Spain, certification tends to operate more as a discount mitigation mechanism against non-certified assets than as a direct premium (Espinoza-Zambrano et al., 2024). Recent regulatory updates—including the incorporation of emerging technologies such as BIM and 3D printing into certification processes—reflect the continued evolution of these systems towards more multidisciplinary, simulation-based approaches (Al Jabri et al., 2025; Ly & Kiroff, 2023).

Despite these advances, a structural limitation remains: the integration of social and resilience criteria in certifications remains uneven across systems, and their environmental dominance limits the holistic assessment of occupant well-being and social equity in the built environment (Payne & Layton, 2025). This gap is confirmed in studies focused specifically on the spatial dimension of social sustainability perceived by interior designers themselves (Altamimi et al., 2023) and in comparisons of occupant satisfaction between sustainable and conventional buildings, which show significant differences not always captured by technical certification criteria (Szery & Sunindijo, 2021). The experience of certified urban regeneration projects in emerging contexts reinforces this conclusion, showing that technical-environmental performance alone does not guarantee the social appropriation of the regenerated space (Korkmaz & Balaban, 2020). Additionally, certification systems face criticism for prioritizing the accumulation of points per category over the systemic sustainability of the building, which can lead to incentives misaligned with actual performance in use (Ly & Kiroff, 2023).

3.8. Barriers, Capacity Gaps and Implementation Challenges

The implementation of sustainable architecture in offices faces multifactorial barriers that operate simultaneously at the financial, organizational, technical, and regulatory levels. Table 4 systematizes these barriers by category, incorporating the mitigation strategies documented in the literature.

Table 4. Barriers to the implementation of sustainable architecture in offices and documented mitigation strategies.

Barrier category	Main manifestations	Documented mitigation strategies	Sources
Financial	High upfront costs, limited access to financing, variability of market incentives	Combined tax and financial incentives, green financing programs	Kineber et al. (2023); Alwafi (2026)
Organizational	Resistance to change, lack of managerial commitment,	Change management, committed leadership,	Benham and Pullot (2025)

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	absence of a culture of sustainability	sustained internal communication	
Technical and Contracting	Poor BIM interoperability, multidisciplinary coordination difficulties, scarcity of certified sustainable materials	BIM implementation frameworks, process standardization, sectoral collaboration	Silva et al. (2025); Waheed et al. (2025); Finished (2025)
Educational and training	Insufficient integration of sustainability and BIM in vocational training	Experiential pedagogical models, use of VR and generative AI in teaching	Xia et al. (2025); Wu et al. (2025); Liu, Y., et al. (2025)

Note. Prepared by the author based on the systematization of the barriers and mitigation strategies reported in the sources cited.

In terms of human capital formation, the effective adoption of BIM and digital technologies continues to face a lack of standardization, insufficient training, and cultural resistance in the construction sector, barriers that can only be overcome through structured implementation frameworks and sustained training programs (Hammes et al., 2026; Nguyen & Adhikari, 2025). In education, the integration of emerging technologies—virtual reality, generative artificial intelligence, and creative pedagogical methodologies such as CPS+SCAMPER—is emerging as an effective way to bridge the gap between traditional academic training and the technological demands of the professional sector (Nguyen & Adhikari, 2024). Finally, the effectiveness of combined government incentives—financial, fiscal, and educational—is consistently higher than that of isolated measures to accelerate the adoption of sustainable practices, particularly in emerging economies where dynamic supervision and regulatory transparency enhance the motivation of market players (Ai et al., 2024).

4. Discussion

4.1. Theoretical Implications for Sustainable Architecture and the Management of the Built Environment

The findings of this study provide evidence that allows us to overcome the fragmented conceptualization of building sustainability, usually approached as the sum of independent technical measures, to postulate a model of systemic interdependence between the technological, environmental, economic and organizational dimensions. The documented convergence between the environmental performance of sustainable offices and their results in productivity and occupant well-being (Licina & Yildirim, 2021; Irfan et al., 2025) theoretically supports the shift of the building assessment paradigm from an approach focused exclusively on resource consumption to an approach focused on human performance within the built environment, consistent with the conceptual frameworks that articulate indoor environmental quality with organizational human capital theory.

Likewise, evidence that organizational culture systematically mediates the relationship between sustainable infrastructure and productivity outcomes (Azizan et al., 2025; Ali et al., 2024) reinforces the theoretical relevance of sociotechnical models that recognize the building not as an autonomous technical artifact, but as a component of a broader organizational system, whose effectiveness depends on the coherence between physical design, change management, and corporate culture.

4.2. Practical Implications for Public Policy, Professional Practice and Academic Training

The results generate direct implications on three levels. First, for public policy formulation, evidence on the greater effectiveness of combined incentives compared to isolated measures (Ai et al., 2024; Guo et al., 2025) suggests that government programs aimed at accelerating the adoption of sustainable office architecture—particularly in emerging economies such as Peru—should simultaneously articulate financial instruments, clear regulatory frameworks, and technical training components, rather than relying on isolated fiscal incentives.

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Secondly, for professional practice, the persistence of technical barriers to interoperability and coordination in the adoption of BIM (Silva et al., 2025; Hammes et al., 2026) indicates that architectural offices and construction companies require structured implementation frameworks and not just software procurement, to translate the technical potential of BIM into effective sustainability. Third, for academic training—an area of particular relevance for undergraduate and graduate programs in architecture and construction management—evidence on the effectiveness of experiential methodologies and immersive technologies in sustainability teaching (Wu et al., 2025; Xia et al., 2025) supports curricular updating towards pedagogical models that integrate virtual reality, generative artificial intelligence, and applied projects, replacing exclusively theoretical approaches.

4.3. Comparison with Existing Literature

The results of this study are consistent with the international literature in several central axes. The magnitude of energy consumption reductions through smart management documented in this analysis (15%–70%) converges with the findings of previous studies on HVAC system digitalization (Song et al., 2025), reinforcing the robustness of this evidence across different geographic and climatic contexts. Similarly, the evidence on market premiums for certified buildings (10%–12%) is consistent with previous studies on green real estate valuation in developed markets (Ghosh & Petrova, 2024).

A relevant point of tension with part of the literature is identified in the interpretation of the role of indoor vegetation: while some studies emphasize its benefits on indoor air quality, the most recent findings qualify this interpretation, documenting that its effect on CO2 reduction is limited in environments that are already mechanically well ventilated (Poncelet et al., 2025), suggesting that its primary value lies in perceived psychological well-being rather than direct environmental purification. Likewise, in terms of the regulatory dimension, the results coincide with the critical literature on certification systems (Zimmermann et al., 2019; Payne & Layton, 2025) in pointing out that these instruments, although effective as market standardization mechanisms, have not yet achieved full integration of social and climate resilience criteria.

4.4. Limitations of the Study

The present study has limitations that need to be explicitly acknowledged. First, the document review design does not allow establishing causal relationships between sustainable design strategies and the reported productivity or well-being results; Most of the primary studies reviewed are observational or correlational in nature. Second, the empirical evidence reviewed comes predominantly from European, North American, Middle Eastern, and Asia-Pacific contexts, with a marginal representation of Africa and Latin America, limiting the direct extrapolability of the findings to emerging economies in the region. Third, the analysis focuses on indexed academic output and does not incorporate actual implementation primary data or post-occupational field assessments, restricting the ability to verify whether the benefits documented in controlled studies are consistently replicated under ordinary operating conditions.

5. Conclusions

This study has systematized the available evidence on the principles, impacts, regulatory frameworks and barriers of sustainable architecture in office spaces, demonstrating that it is a phenomenon of a multidimensional nature whose effectiveness depends on the simultaneous articulation of technology, organizational culture and public policy.

The first conclusion is that the integration of passive strategies, indoor vegetation and smart energy management technologies constitutes the most consistent mechanism to reduce the operational environmental impact of offices, with documented energy consumption reductions of between 15% and 70% and aggregate environmental impact reductions of up to 50% through life cycle assessment.

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The second conclusion is that the economic and productivity benefits of sustainable office architecture are substantial and measurable (productivity increases of between 2.5% and 26%, cognitive performance improvements of up to 61% and market premiums of between 10% and 12% in developed economies), but their effective realization is mediated by organizational culture and change management practices. and it does not depend exclusively on the physical design of the building.

The third conclusion is that environmental certification systems (DGNB, LEED, BREEAM and their regional adaptations) have played a central role in standardization and market signaling, but they maintain an uneven integration of social and resilience criteria, which constitutes a structural gap that these systems must solve in order to evolve towards a truly holistic assessment of sustainability.

The fourth conclusion is that the implementation of sustainable architecture in offices faces multifactorial barriers—financial, organizational, technical and regulatory—whose overcoming requires combined public policies and not isolated measures, this gap being particularly critical in emerging economies with less institutional development and limited access to green financing.

5.1. Recommendations

For architects and designers:

- Integrate life cycle assessment (LCA) from the early stages of design, prioritizing recycled materials and high-performance envelope insulation systems.
- Adopt BIM tools with an interoperable approach from the preliminary design phase, avoiding their late incorporation as an exclusively certification mechanism.

For property managers and developers:

- Articulate investment in smart energy management technologies with parallel programs of organizational change management and sustainable culture development among occupiers.
- Evaluate environmental certification not as an end in itself, but as a component of a comprehensive strategy for the valuation and risk management of real estate assets.

For policymakers:

- Design combined incentive packages (financial, fiscal and technical training) instead of isolated measures, particularly aimed at facilitating the adoption of BIM and sustainable materials in the segment of small and medium-sized construction companies.
- Develop specific regulatory frameworks for office sustainability in emerging Latin American economies, adapting lessons from documented success stories in Asia-Pacific and the Middle East to local institutional conditions.

For educational institutions:

- Update architecture and construction management curricula by incorporating experiential methodologies, virtual reality, and generative artificial intelligence for the teaching of sustainability principles, following the evidence of pedagogical effectiveness documented in recent literature.

5.2. Future Lines of Research

Longitudinal Post-Occupational Assessment: Develop field studies that verify whether the productivity and welfare benefits documented in controlled studies are sustained under actual operating conditions over multiple seasonal cycles.

Standardised occupancy well-being metrics: propose and validate comparable quantitative indicators of social and psychological well-being that can be systematically integrated into existing environmental certification systems.

Adaptation of the analytical framework to Latin American contexts: to replicate this analysis with emphasis on the regulatory, climatic and market specificities of economies such as Peru, Chile,

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Colombia and Mexico, given the marginal representation of the region in the current indexed literature.

Comparative Effectiveness Analysis of Government Incentives: Develop quasi-experimental studies comparing the effectiveness of different combinations of fiscal, financial, and educational incentives in accelerating the adoption of sustainable architecture in different institutional contexts.

Integrating generative artificial intelligence into the design process: deepening research on the impact of generative AI tools on the conceptual phase of sustainable design, beyond their documented application in educational contexts.

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