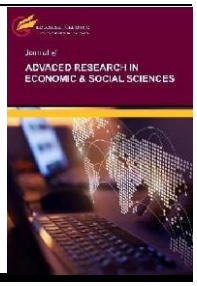
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Journal of Advanced Research in Economic & Social Sciences (JARESS)
Journal Homepage:www.eduglobepublishing.com



Sustainable Building Strategies for Green Buildings in Urban Environments: A Narrative Review of Design, Technology, and Governance Pathways

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Abstract

Cities concentrate population, economic activity, and environmental pressure. The building sector alone is responsible for close to 40% of global energy use and more than 30% of carbon dioxide emissions, and the share attributable to urban buildings continues to rise with rapid urbanisation. Against this background, green and sustainable buildings have become central instruments for lowering the environmental burden of the urban built environment while protecting occupant health and comfort. This narrative review synthesises recent international literature to map the principal strategies through which green buildings are designed, delivered, and governed in urban settings. The evidence is organised into six interrelated domains: passive and bioclimatic design of the envelope and façade; operational energy efficiency and building performance; materials, embodied carbon, and the circular economy; urban form, microclimate, and climate resilience; digital and intelligent technologies; and assessment systems, governance, and policy. The review also examines the social dimension of sustainable building, including affordable housing, stakeholder behaviour, construction skills, and architectural education, and it gives particular attention to evidence from developing and rapidly urbanising economies. Across the corpus, three findings recur. First, well-chosen passive measures, such as optimised window-to-wall ratios, shading devices, and high-performance envelopes, deliver substantial energy savings at modest cost and should precede mechanical and renewable solutions. Second, building-scale gains are amplified or eroded by decisions at the urban scale, so building and city strategies must be planned together. Third, technology and rating systems are necessary but not sufficient; governance, finance, awareness, and skills determine whether strategies are actually implemented. The review proposes an integrative framework that links the building, the precinct, and the city, and it sets out priorities for future research, including life-cycle thinking, context-specific evidence, and the equitable diffusion of green building practice.

Keywords: green building; sustainable construction; urban environment; passive design; energy efficiency; embodied carbon; circular economy; climate resilience; building assessment; sustainable cities

1. Introduction

The world is becoming increasingly urban. More than half of the global population now lives in cities, and projections indicate that the urban share could reach roughly 68% by 2050, with most of the growth concentrated in Asia and Africa (Surya et al., 2024; Pawłowska et al., 2025). Cities generate the bulk of economic output, but they also absorb a large share of resources and emissions. Urban areas consume around two-thirds of global energy and produce about 70% of greenhouse gas emissions (Giai, 2023). Within this picture, buildings are a decisive component. The built environment accounts for nearly 40% of global energy use and over 30% of carbon dioxide emissions, and the building sector alone represents close to a third of urban energy demand (Bera & Nag, 2025; Carvalho et al., 2025).

These figures explain why sustainable and green buildings have moved from the margins of practice to the centre of urban policy. A green building, also known as a sustainable building, is one that is designed, built, operated, and eventually decommissioned in an environmentally responsible and resource-efficient manner throughout its entire life cycle (Hasan & AL-Salam, 2025). The core objectives are familiar: efficient use of energy, water, and materials; reduced emissions and pollution; and the protection of occupant health, comfort, and well-being (Bankar & Jogdand, 2020). What has changed is the urgency and the scale of ambition. Sustainable Development Goal 11, which calls for inclusive, safe, resilient, and sustainable cities, has given the agenda a shared global reference point, while national commitments such as China's dual-carbon targets have translated it into binding objectives for the construction sector (Zhou, 2024; Shao et al., 2025).

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Yet sustainable building in cities is not simply a matter of better individual buildings. The performance of any single structure is shaped by its climate, its orientation, the density and form of its neighbourhood, the materials available in its region, and the policies and incentives that govern its delivery. A building that performs well in isolation may still contribute to an urban heat island, depend on carbon-intensive materials, or remain unaffordable to the households that need it most. Sustainable building strategies in urban environments, therefore, span several scales at once, from the detail of a window reveal to the morphology of a city block, and several domains at once, from physics and materials science to finance, governance, and education.

This review brings together the wide literature. Its aim is to provide a structured, up-to-date synthesis of the strategies for pursuing green buildings in urban settings, to show how those strategies connect, and to identify where the evidence is strong, where it is thin, and where it is contested. The review is deliberately broad in scope because the value of a synthesis lies in revealing relationships that narrow studies cannot. At the same time, it keeps a consistent organising question in view: which strategies most effectively reduce the environmental burden of urban buildings while safeguarding comfort, health, affordability, and resilience, and what conditions enable their implementation?

The terms green building and sustainable building are often used interchangeably, and both describe an approach in which environmental responsibility and resource efficiency are pursued throughout the building life cycle, from planning and design through construction, operation, refurbishment, and demolition (Hasan & AL-Salam, 2025). The underlying objectives are usually grouped into a small number of recurring themes: energy efficiency, water efficiency, material efficiency, and indoor environmental quality, all pursued without compromising durability, comfort, and occupant well-being (Bankar & Jogdand, 2020). In the urban context, two further considerations come to the fore. The first is the relationship between the building and the surrounding microclimate, because dense urban fabrics modify temperature, wind, and daylight. The second is the relationship between the building and the city's wider systems, including energy, water, waste, mobility, and governance.

Sustainability in buildings is therefore best understood as multidimensional. Assessment frameworks increasingly recognise environmental, economic, social, infrastructural, and institutional dimensions, rather than environmental performance alone. A study of vertical housing in Indonesia's new capital, for example, used a multidimensional scaling approach across exactly these five dimensions to classify developments as highly sustainable only when they performed well on all of them (Suprijanto et al., 2025). Comparative work on green cities in the Gulf reaches a similar conclusion from a different angle, showing that environmental standards, technological innovation, and cultural identity each shape what a sustainable building looks like in practice (Hasan & AL-Salam, 2025).

Two ideas recur throughout the literature and are worth stating at the outset because they structure the sections that follow. The first is the life-cycle perspective: the environmental burden of a building is distributed across its embodied stage, its long operational life, and its end of life, and a strategy that reduces one may increase another. The second is the principle of the design hierarchy, sometimes expressed as a loose order of priority in which the demand for energy and resources is first reduced through passive and bioclimatic design, then met efficiently through good systems, and only then supplied through renewable and low-carbon sources (Bera & Nag, 2025; Poma García et al., 2025). These two ideas, life-cycle thinking and the design hierarchy, provide a coherent lens through which the diverse strategies reviewed below can be read.

The remainder of the paper is organised as follows. Section 2 sets out the methodology, describing the review approach and scope. Section 3 presents the results, organised into three thematic domains: building-scale strategies, urban-scale and digital strategies, and governance, social, and regional dimensions. Section 4 discusses the findings, synthesising them into an integrative framework and setting out barriers, gaps, and future directions. Section 5 concludes.

2. Methodology

This article is a narrative review rather than a systematic review. The purpose of a narrative review is to interpret and integrate a body of literature, drawing out themes, tensions, and gaps, rather than to answer a single, tightly bounded question through an exhaustive, fully replicable search. This approach suits the present topic, which is broad, multidisciplinary, and fast-moving, and where the value lies in connecting findings across design, engineering, materials, planning, and policy.

The literature considered here was assembled from peer-reviewed journal articles and conference papers published predominantly between 2020 and 2026, retrieved from major indexing databases using combinations of the terms green building, sustainable building, sustainable construction, urban environment, energy efficiency, and related concepts. Studies were selected to provide broad coverage of strategy types, building uses, and geographical contexts, with particular effort to include evidence from rapidly urbanising regions that are sometimes under-represented in the literature. The corpus includes empirical case studies, simulation-based investigations, surveys of practitioners and the public, and earlier review papers, which together allow both depth on specific measures and breadth across the field.

Two boundaries should be stated clearly. First, because the review is narrative, it does not claim to capture every relevant study, and the absence of a formal protocol means that selection inevitably reflects judgment about relevance and representativeness. Second, the studies drawn together here use a wide range of methods, climates, and metrics, so

quantitative results are not strictly comparable across contexts. Figures such as percentage energy savings are reported to illustrate the magnitude and direction of effects, not to support direct numerical comparison between unrelated cases. With those caveats in mind, the synthesis aims to be faithful to what the underlying studies actually demonstrate.

3. Results

3.1 Building-scale strategies: passive design, energy performance, and materials

The largest and most consistent body of evidence in the corpus concerns passive and bioclimatic design. These strategies work with the local climate rather than against it, using a building's form, orientation, envelope, and openings to reduce the need for mechanical heating, cooling, and lighting. Their appeal is practical. Passive measures are typically low-cost, low-maintenance, and effective over the long operational life of a building, reducing demand before any system or renewable source is considered (Bera & Nag, 2025). A comprehensive review of energy in the built environment grouped efficiency strategies into architectural, technological, and renewable categories, and concluded that passive and bioclimatic design, which exploits local climatic conditions, lowers reliance on mechanical systems while improving occupant comfort (Bera & Nag, 2025).

The envelope is the primary filter between indoor and outdoor environments, and the fenestration, meaning the size, proportion, and properties of windows, is one of its most influential elements. Several studies converge on the finding that the window-to-wall ratio (WWR) is a powerful and easily adjusted design variable. In the hyper-arid coastal climate of Kuwait, a simulation study found that combining a double-glazed clear unit, a one-metre projecting overhang, and a 20% WWR reduced annual energy consumption by about 16.55% while maintaining adequate daylight, with the orientation of the façade strongly influencing the result (Edbais & Hossain, 2025). In the humid temperate climate of Rasht, in Iran, a parametric study of low-rise housing varied window proportions from 10% to 100% on each façade and identified proportions that minimise the combined heating and cooling load, again confirming that there is an optimum rather than a maximum (Bagheri et al., 2024).

Insulation and thermal mass complement fenestration. A design study of an ecological pavilion complex in Meizhou, China, evaluated several passive strategies using building simulation and reported that added insulation could reduce the internal cooling load by roughly 52%, while thermal mass walls and external green space reduced cooling energy demand by up to about 25% (Chiu et al., 2025). Work on Egyptian residential buildings, framed around the EDGE standard, similarly identified an optimal thickness of envelope insulation and showed that building orientation and insulation together govern both energy use and operational carbon emissions (Arandah et al., 2025). The consistent message is that envelope decisions are not independent; WWR, glazing, shading, insulation, mass, and orientation interact, and the best results come from optimising them together for the specific climate.

Where solar gain dominates cooling demand, shading and façade design become decisive. A recurring theme is the reinterpretation of traditional passive devices for contemporary buildings. A study in the hot, dry climate of Diyarbakır, Turkey, adapted the mashrabiya, a traditional perforated screen, for a modern façade and tested 148 configurations of perforation size, depth, and component. The best configurations reduced the cooling load by approximately 21% on the south façade, 17% on the west façade, and 13% on the east façade, demonstrating that heritage strategies can be quantified and tuned for modern use (Ergün, 2025). This reinterpretation of vernacular wisdom recurs elsewhere in the corpus and is one of the more promising bridges between cultural identity and measurable performance.

Secondary skins and double façades extend the same logic. An educational building in Semarang, Indonesia, was studied to compare façade options for their effect on energy use intensity and daylight. A horizontal louvre system offered the best balance, lowering energy use intensity while preserving daylight quality, and the authors emphasised the role of façade strategies in cutting operational energy and supporting national energy-transition goals (Bramiana et al., 2025). For the large stock of existing buildings, retrofitting the façade is often more important than designing new ones. A framework for textile façade retrofit strategies classified interventions into three families, described as replace, add, and wrap, encompassing nine specific strategies suited to different scenarios, and argued that lightweight textile systems can improve both thermal performance and appearance while extending the life of ageing façades (Procaccini & Monticelli, 2024).

Passive design ultimately serves human comfort, and comfort is shaped as much by behaviour as by physics. A study of office workers in Bireuen, in tropical Indonesia, found that most occupants actively modified their environment and that a large majority relied on air conditioning when overheated, yet many were unaware of the energy consequences of their preferences and all expressed willingness to adopt energy-conserving behaviour (Zuraihan et al., 2025). This points to a substantial behavioural opportunity that sits alongside physical design. Comfort modelling is also becoming more refined. A study supporting building and urban design developed a method to predict local clothing insulation across body segments rather than assuming a single uniform value, and showed that this markedly improved the accuracy of skin-temperature predictions and, by extension, comfort assessment (Lin et al., 2025).

Climate-specific design data underpin all of this. For Nigeria's air-conditioning industry, researchers used twenty-three years of hourly climate data to establish location-specific outdoor cooling and heating design values for Lagos and Abuja, providing the percentile-based conditions that energy-efficient systems require (Ishola et al., 2025). Together these studies make clear that comfort, behaviour, and design data are not peripheral to sustainable building; they are the basis on which passive strategies either succeed or fail in practice.

Beyond passive design, the operational performance of buildings depends on systems, controls, and the way performance is measured and managed over time. The built environment's share of global energy, near 40%, and the building sector's roughly 32% of urban energy demand, make operational efficiency a first-order concern (Bera & Nag, 2025). The same comprehensive review noted that global energy use rose by about 2.2% in 2023, driven largely by emerging economies, even as several developed nations reduced consumption through sustainability initiatives, underlining that the trajectory of urban energy demand is still upward where growth is fastest (Bera & Nag, 2025).

Measurement is the foundation of management. A case study of an educational building in Victoria, Australia, combined high-frequency monitoring, regression modelling, and psychrometric analysis to show that the building's annual energy intensity of 211 kWh per square metre outperformed national and state averages but fell well short of the City of Melbourne's future target of 60 kWh per square metre, with space heating in winter the dominant driver (Li et al., 2026). The gap between current performance and forward targets, even for a relatively efficient building, illustrates how demanding decarbonisation goals are and how essential granular, temporally resolved data are to meeting them.

Energy performance is also shaped by factors beyond the individual building. A study of 183 older residential communities in Wuhan, China, used geographic information systems and simulation to relate twelve morphological indicators, including floor area ratio, building density, and average height, to heating, cooling, and total energy consumption, and derived optimisation strategies for the layout of existing communities (Jiang & Zou, 2026). This work bridges the building and urban scales and previews the argument, developed further below, that operational efficiency cannot be fully optimised at the level of the single building alone.

As operational energy falls, the relative importance of embodied carbon, meaning the emissions associated with materials and construction, rises. Several studies in the corpus quantify this stage and propose strategies to reduce it. A rapid accounting method for the embodied stage of city buildings in China found an average carbon intensity of around 400 kg per square metre, with civil engineering works accounting for more than 75% of embodied emissions and steel and concrete together representing 80% to 90% of the total, leading the authors to highlight green material selection and higher assembly rates as the most effective levers (Li et al., 2026). Parametric design offers a complementary route. A study of a Bajau maritime house used parametric tools to calculate and then minimise carbon emissions through optimisation of the building form, presenting form optimisation as a low-carbon design strategy aligned with Sustainable Development Goal 11 (Zhou, 2024).

The circular economy provides an organising philosophy for material strategy. The construction sector consumes around 40% of global raw materials and generates roughly a third of waste in some regions, so principles such as material reuse, design for adaptability, waste minimisation, and recovery are central to lowering its footprint (Carvalho et al., 2025). Bio-based materials are an important expression of this thinking. A survey across four Portuguese cities examined public awareness of cork as a sustainable construction material and found that, despite cork's strong environmental credentials, public understanding of its potential in building remains limited, indicating that material substitution depends on awareness as well as availability (Sequeira et al., 2026). Timber follows a similar pattern. A study of wooden retrofits in Finland described an emerging business ecosystem in which city-owned housing companies were the most active in seizing the climate and renewal benefits of wood, while noting that such projects remain rare and depend heavily on individual champions (Viljanen et al., 2024).

Closing material loops also requires managing construction and demolition waste and reusing earth and aggregate. A SWOT analysis of construction-waste policy in Xi'an, China, found that fiscal support and standards were offset by weak enforcement and low market trust, and proposed a phased shift from policy-driven pilots to market-driven normalisation (Liu et al., 2025). At the site-preparation stage, a curvature-aware remote-sensing framework estimated earthwork volumes across five cities over eleven years to support the reuse of excavated material and more resource-efficient development, illustrating how digital methods can serve circular goals (Olagunju et al., 2026). Taken together, these studies show that material strategy spans design, procurement, awareness, policy, and data, and that no single intervention is sufficient on its own.

3.2 Urban-scale and digital strategies

Buildings do not sit in isolation; they form, and are formed by, the urban fabric. A central question for sustainable urban building is therefore whether density helps or hinders. A life-cycle analysis comparing agglomerated mixed-use high-rises with low-rise sprawl found that a city's urban form and building typology strongly influence which emission-reduction strategies are feasible, and examined the conditions under which compact, tall development can reduce overall carbon emissions relative to dispersed low-rise dwellings (Bin Thaneya et al., 2025). This connects directly to operational findings at the block scale, where morphological indicators such as density and height were shown to govern energy consumption in existing communities (Jiang & Zou, 2026).

Dense fabrics also create the urban heat island, in which built surfaces absorb and re-emit heat and raise local temperatures. A study in the United Arab Emirates used a hybrid Fuzzy Delphi and confirmatory factor analysis approach to identify and rank the building-structure factors, particularly material heat-absorption properties, that drive urban heat, providing a basis for targeting mitigation at the most influential factors (Almashhour & Alzaatreh, 2025). Greening is one of the most effective responses. The Lambrate Park District project in Milan, developed within an international design competition, combined high-performance buildings with extensive green space, using strategically selected trees and vegetation to mitigate the heat island, improve air quality, and enhance outdoor comfort, with performance verified through ecosystem, daylight, and thermal modelling (Ruta et al., 2024). The project demonstrates how building-scale and neighbourhood-scale strategies reinforce one another when planned together.

Resilience extends beyond heat to the broader capacity of the urban built environment to absorb and adapt to climate stress. A context-based, scenario-driven regeneration model developed for a neighbourhood in Antalya, Turkey, linked building-scale and urban-scale enhancement within a single multi-scalar framework, arguing that the upgrading of existing buildings must be integrated with wider urban sustainability goals (Ertürk & Kerestecioğlu, 2026). This multi-scalar, scenario-based logic is increasingly common and reflects a maturing recognition that resilient outcomes emerge from the relationships between buildings, precincts, and city systems rather than from any one of them alone.

Digital tools are reshaping how sustainable buildings are designed, delivered, and operated. Building information modelling (BIM) is a mature example. Work on the Malaysian construction industry explored BIM as an enabler for greening the large stock of existing non-green buildings through refurbishment, integrating information across the building life cycle and aligning with national Industry 4.0 strategies (Zulkefli et al., 2020). The significance is that the greatest sustainability gains often lie not in new buildings but in the existing stock, and digital information management is what makes systematic retrofitting tractable.

At the city scale, digital twins and urban building energy modelling are advancing quickly. A comprehensive review categorised digital-twin applications across small-scale assets, city-level systems, and global networks, and showed how real-time data, simulation, and predictive analytics can support decarbonisation, resource efficiency, and the mitigation of urban heat, including in green-building and climate-responsive construction (Ali et al., 2025). Urban building energy modelling is being enriched with new data sources. A framework that integrates geo-tagged social-media data with physics-based modelling demonstrated that social sensing can inform building-level analysis of urban energy use with greater spatial specificity, pointing to a hybrid data-driven and physics-based future for the field (Abbasabadi & Ashayeri, 2025).

Artificial intelligence, augmented reality, and smart infrastructure broaden the toolkit further. Artificial intelligence is increasingly applied to sustainable building technologies and to the wider question of how cities build the technical capability to support such innovation (Lin et al., 2024). Augmented reality has been used to guide self-builders through modular assembly in dense urban-village settings, improving the efficiency and safety of construction while supporting community-led regeneration (Han et al., 2025). At the energy-system level, a multitask deep-learning framework optimised electricity consumption across commercial, residential, and industrial buildings to support sustainable cities and smart grids (Zong et al., 2025), while the smart-city data on which such systems rely raises questions of trust and security that researchers are beginning to address through dedicated protection frameworks (Raman et al., 2024). The smart-campus concept extends these ideas to the scale of a university, treating the campus as a miniature city in which digital infrastructure improves efficiency and service quality (Elshapasy & Mohamed, 2024). The common thread is that digital technologies are most valuable when they connect scales and data sources, turning isolated measures into coordinated, evidence-based management.

3.3 Governance, social, and regional dimensions

Strategies only take effect if they are specified, verified, and incentivised, which is the role of assessment systems, governance, and policy. Green building rating systems translate broad sustainability goals into measurable criteria. A study in Indonesia examined the development of a green-building assessment system at the planning stage, comparing a government regulation with the independent GREENSHIP scheme and identifying the variables most relevant to local conditions, on the principle that performance is easier to secure when it is assessed early (Surya et al., 2024). Established international systems such as LEED provide a common language for comparison, as in the comparative study of Msheireb in Qatar, Masdar in the United Arab Emirates, and NEOM in Saudi Arabia, which used LEED-based categories to show how each development balances environmental standards, technology, and cultural identity in an arid setting (Hasan & AL-Salam, 2025).

Indicator systems perform a similar function at the city scale. A comparison of the China-Singapore Tianjin Eco-city with Bristol drew on international practice to propose an optimised low-carbon eco-city indicator system, recommending a greater share of renewable energy, green materials, and smart technologies alongside improvements in energy efficiency and carbon-sink capacity (Shao et al., 2025). Carbon measurement underpins such systems. A study of public buildings in Beijing established a bottom-up method to measure operational carbon emissions at the regional scale and found that public buildings emit roughly twice as much per unit area as civil buildings, highlighting where mitigation effort should be concentrated (Zhang et al., 2024). A decomposition analysis of Chengdu identified economic expansion as the main driver of rising carbon emissions, framing the central governance challenge as decoupling growth from emissions (Yu et al., 2024).

Governance is also about the rules and incentives that shape behaviour. The construction-waste study in Xi'an showed that weak enforcement and low market trust can blunt otherwise sound policy, and that a phased, incentive-based approach is needed to move from pilots to normal practice (Liu et al., 2025). A historical review of sustainable construction in Nigeria over a decade traced a progression from inception through transition to advancement, and concluded that further progress depends on the synergy and commitment of researchers, practitioners, policymakers, and government in enforcing existing green policies (Isang, 2023). Across these studies, a clear pattern emerges: technical standards and measurement methods are necessary, but enforcement, incentives, and institutional trust determine whether they change outcomes.

Sustainable building is a social as well as a technical project, and several studies in the corpus foreground the people who finance, build, occupy, and design green buildings. Affordability is a pressing concern, especially where urbanisation is rapid. A rapid review of sustainable, innovative, affordable housing for low-income families in Africa identified a portfolio of overlapping strategies, including mixed-use and incremental development, micro-housing, community-led and co-housing models, upcycling, three-dimensional printing, and green building practices, and argued that their success depends on policy support, public-private partnerships, community engagement, financial incentives, and capacity building (Bhanye et al.,

2024). The lesson is that affordable and green need not be opposed, but that aligning them requires deliberate institutional design.

Stakeholder awareness and behaviour shape adoption. A study of Malaysian construction stakeholders found that awareness of green residential building was moderate to high, yet governmental and policy constraints were the most significant barriers, followed by economic and financial challenges, and that stakeholders favoured financial incentives, low-interest loans, and subsidies as the most effective remedies (Chong et al., 2026). The workforce that delivers green buildings also matters. A survey of construction artisans in Enugu, Nigeria, identified irregular income, poor working conditions, and lack of access to tools as the most significant barriers to their productivity, structural problems that affect the quality and sustainability of what gets built (Ozigbo et al., 2025). Effective risk management is part of the same picture, since it helps projects minimise environmental and social harm while remaining economically viable, as shown in a study of private construction projects in Benghazi (Elkrghli & Almansour, 2024).

Education sits at the root of long-term change. A survey of architecture curricula across thirty countries found that sustainability is now widely considered, with an emphasis on the environmental dimension, but that progress is held back by a lack of sustainability training for educators and limited time within crowded programmes (Leal Filho et al., 2026). The campus itself can be a teacher. A review of green campuses set out the strategies and challenges involved as higher education institutions pursue sustainability, treating the campus as both a site of practice and a model for the wider city (Barnett-Itzhaki et al., 2025). Indoor environmental quality connects the social and technical strands directly to health. Monitoring in a shopping mall in Ajman, in the United Arab Emirates, found that carbon dioxide and volatile organic compounds in the food court and parking areas frequently exceeded recommended limits and were associated with occupant symptoms, a reminder that sustainable buildings must protect the people inside them, not only the environment outside (Kaied et al., 2025).

Sustainable building strategies are not climate-neutral or context-neutral, and the corpus is notable for its geographical breadth. In hot arid and Gulf settings, the dominant challenge is cooling, and the evidence points to envelope optimisation, shading, and the reinterpretation of vernacular devices, as seen in Kuwait, the wider Gulf, and Turkey (Edbais & Hossain, 2025; Hasan & AL-Salam, 2025; Ergün, 2025). In tropical and humid climates, the emphasis shifts towards ventilation, daylight control, and behavioural adaptation, as illustrated by studies in Indonesia (Zuraihan et al., 2025; Bramiana et al., 2025). In temperate and continental climates, heating can dominate, as in the Australian and Iranian cases, changing the balance of priorities (Li et al., 2026; Bagheri et al., 2024).

Rapidly urbanising and developing economies face an additional layer of challenge, because they must expand their building stock quickly while keeping it affordable and low-carbon. Evidence from China stresses carbon measurement, low-carbon city planning, and renewing older communities (Zhang et al., 2024; Shao et al., 2025; Jiang & Zou, 2026). Evidence from Africa stresses affordability, the informal and artisanal workforce, and the historical trajectory of sustainable construction (Bhanye et al., 2024; Ozigbo et al., 2025; Isang, 2023). Evidence from Southeast Asia stresses rating systems, vertical housing, and the greening of existing stock (Surya et al., 2024; Suprijanto et al., 2025; Zulkefli et al., 2020; Chong et al., 2026). Latin American work adds scenario-based greenhouse-gas mitigation for housing, drawing on bioclimatic and envelope strategies (Poma García et al., 2025). The clear implication is that strategies must be adapted to climate, culture, and capacity, and that evidence generated in one context cannot simply be transplanted to another.

4. Discussion

4.1 Towards an integrated framework

Read together, the literature supports a synthesis built around three propositions. The first is the primacy of the design hierarchy. Across climates and building types, passive and bioclimatic strategies, optimised window-to-wall ratios, shading, high-performance envelopes, thermal mass, and orientation, deliver substantial savings at modest cost and should be exhausted before mechanical and renewable solutions are added (Edbais & Hossain, 2025; Ergün, 2025; Chiu et al., 2025; Bera & Nag, 2025). Efficient systems and clean energy then meet the reduced demand, and digital tools verify and manage performance over time (Ali et al., 2025; Abbasabadi & Ashayeri, 2025). This ordering is not merely tidy; it reflects the consistent finding that demand reduction is the most cost-effective and durable lever available.

The second proposition is the connection of scales. Building performance is amplified or eroded by the precinct and the city. Urban form and density shape both operational energy and life-cycle carbon (Bin Thaneya et al., 2025; Jiang & Zou, 2026); the heat island is a property of the fabric rather than of any single building (Almashhour & Alzaatreh, 2025); and the most convincing exemplars, such as the Lambrate district, succeed precisely because they integrate building-scale and neighbourhood-scale strategies (Ruta et al., 2024; Ertürk & Kerestecioğlu, 2026). A practical consequence is that green-building policy and urban planning should be designed together, not in separate silos.

The third proposition is the centrality of enablers. Technology and rating systems are necessary but not sufficient. Whether a strategy is implemented depends on governance and enforcement (Liu et al., 2025; Isang, 2023), on finance and incentives (Chong et al., 2026; Bhanye et al., 2024), on awareness of materials and behaviours (Sequeira et al., 2026; Zuraihan et al., 2025), and on the skills of the workforce and the content of professional education (Ozigbo et al., 2025; Leal Filho et al., 2026). An integrative framework for sustainable urban building therefore has three layers that must be aligned: a design and technology layer that reduces and then efficiently meets demand; a spatial layer that coordinates the building, the precinct, and the city; and an enabling layer of governance, finance, awareness, and skills that determines whether the other two layers are realised. The contribution of a synthesis like this one is to show that these layers are interdependent, and that interventions which ignore any one of them tend to underperform.

4.2 Barriers, gaps, and future directions

The same literature that maps strategies also reveals why they are not adopted more widely. Economic and financial barriers are prominent, including higher perceived upfront costs and limited access to affordable finance, which weigh especially heavily on low-income housing and on developing economies (Chong et al., 2026; Bhanye et al., 2024). Governance and policy barriers follow closely, with weak enforcement, fragmented regulation, and low institutional trust repeatedly identified as constraints, even where standards exist on paper (Liu et al., 2025; Isang, 2023). Knowledge and awareness gaps affect both the public, as in limited awareness of sustainable materials, and occupants, who may be unaware of the energy consequences of their behaviour (Sequeira et al., 2026; Zuraihan et al., 2025).

Capacity constraints are a further barrier. Shortages of skilled labour, poor working conditions, and limited training undermine the quality of construction, while gaps in educator training limit the pipeline of sustainability-literate professionals (Ozigbo et al., 2025; Leal Filho et al., 2026). Technical and methodological challenges persist as well, including the difficulty of measuring embodied carbon, the gap between current performance and ambitious future targets, and the context-dependence of results that complicates the transfer of evidence between settings (Li et al., 2026; Bin Thaneya et al., 2025). The novelty of some digital tools also introduces challenges of data quality, integration, and security that are only beginning to be addressed (Raman et al., 2024; Abbasabadi & Ashayeri, 2025). These barriers are interconnected, which means that piecemeal interventions are unlikely to succeed and that coordinated action across the enabling layer is required.

Several gaps emerge from the synthesis and suggest priorities for future work. First, the field would benefit from more consistent life-cycle thinking that treats embodied and operational impacts together, since strategies that reduce one can increase the other, and embodied carbon is rising in relative importance as operational energy falls (Li et al., 2026; Zhou, 2024). Second, more research is needed at the interface of the building and the city, because the strongest evidence already shows that urban form, density, and microclimate condition building performance, yet integrated building-and-precinct studies remain comparatively rare (Bin Thaneya et al., 2025; Ruta et al., 2024).

Third, the social and behavioural dimensions deserve greater attention. The willingness of occupants to adopt energy-conserving behaviour, the awareness of sustainable materials, and the conditions of the construction workforce all shape real-world outcomes, but they are studied less systematically than physical measures (Zuraihan et al., 2025; Sequeira et al., 2026; Ozigbo et al., 2025). Fourth, context-specific evidence is needed for under-represented climates and economies, so that strategies can be adapted rather than transplanted, and so that affordability and decarbonisation can be pursued together in rapidly urbanising regions (Bhanye et al., 2024; Poma García et al., 2025). Fifth, the responsible integration of digital technologies, including digital twins, urban building energy modelling, artificial intelligence, and new data sources, warrants further work on data quality, interoperability, security, and the translation of model insight into decisions (Ali et al., 2025; Abbasabadi & Ashayeri, 2025; Raman et al., 2024). Finally, the governance and finance of implementation remain under-theorised relative to design and technology, and research that clarifies which incentives and institutional arrangements actually accelerate adoption would have high practical value (Liu et al., 2025; Chong et al., 2026).

5. Conclusion

Urban buildings are at the centre of the global sustainability challenge because of their large and rising share of energy use and emissions, and because they shape the health, comfort, and affordability of urban life. This review has synthesised recent international evidence on the strategies through which green buildings are pursued in cities, spanning passive and bioclimatic design, operational energy efficiency, materials and the circular economy, urban form and climate resilience, digital technologies, assessment and governance, and the social dimensions of housing, skills, and education.

Three conclusions stand out. Passive and bioclimatic design should come first, because it reduces demand durably and affordably across the life of a building. Building strategies and urban strategies must be planned together, because the precinct and the city amplify or erode what individual buildings can achieve. And technology and standards must be matched by enablers, namely governance, finance, awareness, and skills, because these determine whether good strategies are actually implemented. The integrative framework proposed here, linking a design-and-technology layer, a spatial layer, and an enabling layer, is offered as a way to hold these strands together. Realising sustainable buildings in urban environments is not a single technical fix but a coordinated programme across scales and disciplines. The evidence reviewed here suggests both that the strategies exist and that their wider adoption now depends as much on institutions and people as on design and technology.

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