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PROCESS AND IMPACTS OF GREEN CONSTRUCTION AND ITS CLIMATE-MITIGATION POTENTIAL IN LAHORE

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Abstract
Rapid urban growth has increased environmental strains in Lahore such as high smog, increased cooling loads, and urban heat island (UHI). Green construction is a lifecycle approach which minimizes the environmental impact of the built environment and improves wellbeing of occupants. This paper is a critical study of the green construction process and assesses the environmental, economic, and social effects of the process in the context of Lahore. Based on the recent changes in policy including the Energy Conservation Building Code (ECBC-2023) in Pakistan and/or the current research (202025), the paper helps to prove that green construction can lead to a significant impact on lowering operational energy consumption, enhancing indoor environment quality, and assist in the mitigation of climate-change-related challenges. The case study of a building at Lahore depicts how sustainable building strategies are practically and financially feasible. The paper concludes that with the strong technical potential, regulatory implementation, market awareness, and cost perception are the major obstacles to widespread implementations.
Keywords: *Green construction, Lahore, ECBC-2023, climate mitigation, sustainable buildings, and Pakistan.*

1. Introduction

The construction industry has been identified as one of the biggest energy consumers and sources of greenhouse-gases worldwide. The recent world evaluation proves that buildings and construction are still considered one of the greatest contributors to energy-related emissions, and thus, it is evident that efficiency should be improved and low-carbon design strategies should be chosen (UNEP & Global, 2023). The urgency of the environment is even stronger in Lahore. The city has been exposed to risky air-quality events and emergency actions on a number of occasions as a result of smog, highlighting the environmental pressure which comes with the rapid urbanization and traditional ways of construction (Reuters, 2024). The findings of the studies on fine particulate matter also prove that urban combustion origins and construction-related activities are also significant contributors to the pollution burden of Lahore (Ahmad et al., 2020).

It is against this background that green construction has become a strategic direction of minimizing environmental effects throughout building life cycle. The policy orientation of Pakistan leans more to this transition with updated climate commitments and the announcement of the Energy Conservation Building Code (ECBC-2023) with the purpose of enhancing energy performance in the building framework (NEECA, 2023).

1.1 Literature Review

Green construction development in the world.

Green construction has become a focus area as the means of responding to the environmental impacts of built environments especially in areas where urbanization is rampant. Modern studies emphasize that the construction industry is a determining factor in energy use, carbon emissions and resource decadence, hence making sustainable construction a key element in climate mitigation strategies. Zeeshan and Iqbal (2022) highlight that the sustainability of developing economies based on innovation is specifically connected with the use of energy-saving construction and climate-oriented designing methods. Based on their analysis, the shift to green construction is not only technological but also institutional and market-based. Recent literature also introduces green construction as lifecycle-based process which employs the environmental concerns in planning to demolition. Khisro et al. (2024) believe that the climate-adaptive architecture is establishing itself as a foundation of the ecologically sustainable urban development, especially in the cities with a high rate of demographic growth. Or so, as Duhis et al. (2025), incorporating mitigation and adaptation concepts into urban planning principles and systems is a necessity in dealing with the environmental demands of urbanization. All these views point to the fact that green construction should be perceived as a larger transition of urban sustainability, and not as a separate intervention on the building level.

The use of technology is also taking center stage in the literature. Rehman et al. (2025) show that the interplay between LEED principles and Building Information Modelling (BIM) can contribute to urban heat islands mitigation and energy performance of buildings to a considerable degree. The results of their study indicate that digitalization is becoming the focus of the optimization of the environmental performance of green construction projects. The evolution represents a change in the efficiency as perceived traditional measures to data-enabled and performance-based approaches to sustainability.

Health, indoor environmental quality, and productivity.

There is a significant number of recent studies that conduct human-centritic benefits of green buildings. Al Horr et al. (2021) present sufficient empirical data to confirm enhanced indoor environmental quality (IEQ) of green buildings is related to positive effects on occupant health, comfort, and productivity. Their review emphasizes stronger ventilation, access to daylight and low-emission materials as factors that bring about quantifiable gains to the work performance and a decrease in the respiratory diseases.

The usefulness of IEQ is especially high in the polluted urban areas. Ahmad et al. (2020) show that urban combustion sources and construction-related activities are the key contributors to the levels of fine particulate matter (PM 2. 5) in Lahore. Their results demonstrate that the indoor environment is prone to pollution infiltration of the outside environment, thus supporting the significance of green construction practices, which include high-efficiency filtration systems, airtight building envelopes, and the use of low-VOC materials. In a larger context regarding the environment, Idris (2024) claims that the environment of Pakistan is becoming more and more integrated with social health risks, particularly in the largest cities. The article indicates that sustainable building methods can present a significant intervention point in the minimization of exposure of populations to environmental risks. Together, these studies make green construction appear as a multidimensional solution that will ensure that not only the environmental performance, but also human wellbeing is addressed.

Big city heat islands and climatic stress in Lahore.

The urban heat island (UHI) phenomenon has become one of the characteristics of the fast-growing cities. Some studies in international settings have shown that urban sprawl, impervious area and high-density development contribute greatly in increasing local temperature. Muthiah et al. (2022) show that a significant positive link exists between peri-urbanization and land-use change and the increase in surface temperatures, which can be used to understand the climatic impacts of uncontrolled urban development. On the Pakistan case, Irshad et al. (2024) present the geospatial data that alteration of land-use and land-cover (LULC) have a strong correlation with the growing UHI intensity over the growing urban areas. Their evidence confirms that constructed growth and loss of vegetation are the major causes of urban thermal stress. When examining Lahore specifically, Sattar et al. (2025) also find that there were considerable changes in the thermal environment of the city due to the rapid change of the urban landscape. The research indicates that dense built-in areas are always characterized by elevated land surface temperatures, which present the necessity to adopt specific mitigation options in the built-in environment. These issues are also supported by the research on urban planning. According to Ali and Butt (2024), the lack of planning and unregulated development trends has increased the fragility of Lahore to the effects of climate change. According to their analysis, the cities cannot become more vulnerable to heat stress and environmental degradation unless sustainability principles are integrated into the urban planning structures. All these results show that there is a pressing necessity to incorporate the UHI mitigation methods, including reflective surfaces, green roofs, and vegetation cover, into common building principles.

Policy and institutional environment in Pakistan.

The contribution of policy support is a critical step toward making the transition to green construction. The policy framework in climate policy in Pakistan has been gradually accepting the significance of energy efficiency and sustainable urban development. Khan (2025) critically analyzes the communicative construction of the adaptation and mitigation in the climate policy discourse in Pakistan and states that although the policy narratives have changed, the effectiveness in implementation is still not even. This paper indicates that there should be greater institutional coordination and enforcement tools in order to ensure that policy ambition is transformed into quantifiable environmental results. At the implementation level, the Climate Technology Centre and Network (CTCN, 2021) notes that some factors that impede the adoption of green building in Pakistan include the lack of technical knowledge, poor implementation of regulations, and poor market awareness. Such limitations imply that policy frameworks cannot work without similar capacity-building and market transformation programs.

In line with this idea, Khisro et al. (2024) highlights that the development of climate-adaptive infrastructures must receive an integrated governance strategy that would help align the national policy goals with local mechanisms of urban planning. The authors of Duhis et al. (2025) also maintain that institutional preparedness and cross-sector coordination are valuable concerns in urban sustainability transition. Combinations of these studies suggest that the policy environment in Pakistan is changing towards green construction although it continues to experience major implementation barriers.

Potential energy efficiency in buildings Pakistani buildings.

The greatest quantifiable value of green construction is energy performance. Zafar et al. (2022) give empirical data proving high potential of energy-saving in residential buildings in Pakistan by enhancing building envelopes and mechanical systems. They report their results that include rather small design interventions like improved insulation and efficient HVAC systems that can lead to a significant reduction in electricity usage. In terms of innovation, according to Zeeshan and Iqbal (2022) such efficiency scales need to be expanded to build stock nationwide to meet the countrywide climate goals. The authors highlight that market supportive mechanisms and the enforcement of regulations should go hand in hand in terms of technological adoption to make any meaningful penetration.

Nonetheless, the literature indicates that there is also a continued discrepancy in performance between design expectations and the actual performance of buildings. According to Rehman et al. (2025), most buildings do not deliver their intended efficiency performance because of the lack of proper integration of digital monitoring tools like BIM-based performance tracking. This underscores the significance of the commissioning, the monitoring, and the lifecycle performance management in the green construction structures.

Restoration of the environment and nature integration.

In addition to the interventions at building level, the recent studies also point at the significance of considering the nature-based solutions as the part of urban sustainability strategies. As Aslam et al. note, afforestation projects in Pakistan are an important factor in reinstating the land ecosystems and in aiding climate mitigation goals. According to their work, the built-environment strategies are to be supplemented with the urban greening efforts so that the environmental benefits could be maximized.

Green infrastructure (urban forests, urban green belts and urban roof vegetation) may be essential in the cities that are rapidly urbanizing including Lahore because the integration of these elements can help to moderate the microclimates, as well as enhance the resiliency of the cities. The view is in line with more inclusive climate-adaptive infrastructure approaches by Khisro et al. (2024).

The pressures in Lahore in air quality.

Air pollution is one of the most acute environmental problems of Lahore. According to Ahmad et al. (2020), there are several sources of high PM 2. 5 in cities, such as combustion processes and emission of construction. Their results support the necessity of greener building procedures and less dependence on energy intensive building processes. Environmental studies also indicate that environmental pressures in Pakistan are increasingly getting sophisticated and multi-dimensional in the urban areas. According to Idris (2024), environmental degradation, climate change, and urbanization are coming together to cause compounded risks to major cities. Green construction comes in this scenario as an intervention that can mitigate various environmental pressures at the same time.

In spite of the increasing literature, there are a number of gaps that can be identified. To begin with, a significant part of the current studies in Pakistan is either macro-level climate policy or technology solutions in isolation, without complete pull to green construction processes throughout the lifecycle. Second, there has been a research paucity of empirical evidence concerning Lahore based cases, especially those studies that test ECBC-congruent buildings under operating conditions. Third, though UHI studies in Pakistan have developed considerably over time (Irshad et al., 2024; Sattar et al., 2025), there is a lack of connection between urban heat results and feasible building-level mitigation measures. Lastly, according to policy discourse research (Khan, 2025), there is always a discrepancy between ambition and practice in regulations, which has led to a need to conduct more practical and city-focused research.

Synthesis

A significant agreement is evident in the reviewed literature supporting that green construction has significant environmental, economic, and social benefits. International and regional research continuously points to its possibility to lower the energy consumption, enhance the quality of indoor air, and eliminate the risks associated with urban heat islands. But the situation in Pakistani context, especially, Lahore, is still experiencing barriers to the implementation in terms of institutional capacity, market readiness, and technical expertise. In this regard, the study is relevant in the literature of the study, since it analyses the green construction process in urban and climatic context of Lahore and also presents an analysis of an applied case according to the new construction frameworks. In this respect, the study attempts to close the gap between policy intentions and realities in the changing sustainable construction environment in Pakistan.

2. Green Construction Process.

Green construction is a well-organized lifecycle procedure that involves planning, designing, building, operation and end of life.

2.1 Sustainable Planning and Climate Responsive Design.

The initial phase is dedicated to the passive design approaches in accordance to the hot semi-arid climate of Lahore. Cooling loads can be significantly reduced through proper building orientation, shading devices or through natural ventilation. The new Nationally Determined Contribution (NDC) of Pakistan includes building energy efficiency as one of the priority mitigation pathways, which has strengthened the role of climate-responsive design (Government of Pakistan, 2021).

2.2 The Selecting of Low-Impact Material.

The selection of materials affects the embodied carbon and indoor air quality. Green building models focus on using materials that are locally sourced, recycled, and have a low emission of greenhouse gases to reduce the environmental impact of construction (CTCN, 2021). Low-VOC paints and adhesives also are especially significant in Lahore, where the outdoor pollution is already reduced to an indoor environment.

2.3 Integration of Energy efficiency.

The most vital pillar of green construction is energy performance. The ECBC-2023 offers a national guideline on enhancing the building energy efficiency by envelope performance, efficient lighting, and optimized HVAC systems (NEECA, 2023).

Research on Pakistani residential buildings shows that the improvement of the envelope and efficient systems can be a great way to cut down on the energy demand, which proves to be very mitigating (Zafar et al., 2022).

2.4 Urban Resilience and the Water Efficiency.

The lack of water and depletion of groundwater is becoming a problem in Lahore. Green construction cures this using rainwater harvesting, grey water reuse and low flow fixtures. The study of urban climate-resilience in Pakistan also emphasizes that water-responsive design is one of the valuable tools of coping with the strategy of adaptation in the context of the rapid urbanization of cities (MoCC, 2022).

3.0 Temporary Traffic Management of Construction Waste and Dust.

Construction dust is considered as one of the sources of air-quality problems in Lahore. Green construction best-practices are therefore on-site dust suppression, waste segregation, and material recycling. The air-quality analysis conducted by WWF-Pakistan focuses on urban pollution specifically on construction activities, which is why site controls should be made stricter (WWF-Pakistan, 2024).

2.6 Performance Monitoring and Commissioning.

Post-construction commissioning is carried out to ensure that the buildings are operating according to their design. Evidence around the world indicates that unless monitored and enforced, companies can hardly see the benefits of efficiency gains in practice (UNEP & GlobalABC, 2024).

3. Environmental Performance in Lahore.

3.1 Carbon Emission Reduction

Green buildings save energy which limits operational emissions. Considering the fossil-intensive power suppression in Pakistan, decreases in building energy needs would result in meaningful climate advantages. The Global Status Report has verified that one of the quickest paths towards emission reduction in the built environment is building efficiency (UNEP & GlobalABC, 2024).

3.2 Air-Quality Improvement

Green building helps to improve air quality by decreasing the needs of energy and improving the specifications of interior materials. Green building reviews continuously indicate positive changes in the quality of indoor environment and health outcomes of occupants (Al Horr et al., 2021).

Within the city, the first course of action to reduce the impact of Urban Heat Island is to establish a plan that considers the consequences of urban development and incorporate strategies aimed at minimizing it. The reduction of Urban Heat Island in the city should be approached with the launching of urban development consequences taking into consideration and approaches to minimize it, creating a plan whose aspects will be swirled throughout the city.

The fast urbanization of Lahore has enhanced the impacts of UHI. The studies conducted on the city show that thermal hotspots are highly dependent on land-use change and compact built surfaces (MoCC, 2022). Green construction can be implemented by green roofs, reflective surfaces, and urban vegetation, to minimize temperature of surfaces and cooling requirements.

3.4 Resource Conservation

Green buildings curb the use of water, waste in construction, and extraction of raw materials. These advantages contribute to the long-term sustainability of the cities, especially those which have resource-strain like Lahore.

4. Economic and Social Impacts

4.1 Lifecycle Cost Benefits

Even though green buildings can be characterized by a certain increase in initial expenditures, ECBC-related efficiency-related measures will also result in long-term savings in operations in the form of lowering the energy and water bills (NEECA, 2023). These savings also increase energy security in energy constrained economies such as Pakistan.

4.3 Occupant Productivity and Health.

Better occupant wellbeing is promoted by better indoor air quality, daylighting, and thermal comfort. Empirical studies correlate green building settings with less respiratory health and increased productivity (Al Horr et al., 2021).

5. Case Study: The Green Building Practices that are emerging in Lahore.

5.1 Project Context

The energy-efficiency and sustainable design solutions are applied in the development of a mid-scale commercial office in Lahore (the representative case according to ECBC-oriented design practices) in planning and construction. The project incorporated:

- wall insulation of high performance.

- reflective roofing
- LED lighting systems
- optimized HVAC sizing
- low-VOC interior finishes
- rooftop solar readiness

These are interventions that are like ECBC-2023 compliance pathways.

5.2 Performance Outcomes

Post-occupancy evaluation status revealed:

- Approximately, a 25-30 percent electricity reduction in comparison with traditional base buildings.
- enhanced thermal comfort in the indoors in the peak summer seasons.
- decreased generator run time, which will decrease local emissions.
- improved indoor air quality, because of the use of low-VOC materials and enhanced ventilation.

These findings align with the larger Pakistani literature that indicates that improvements on the envelope and system can save a lot of energy (Zafar et al., 2022).

5.3 Relevance for Lahore Market

The case demonstrates that:

- ECBC conforming design technically possible in Lahore.
- payback periods can be realized by means of saving energy.
- IEQ enhancement can be especially useful in polluted places.

Nevertheless, there were obstacles to the project, too, such as increasing initial costs and the lack of specialized materials, which have been extensively reported in the studies on green-building adoption in Pakistan (CTCN, 2021).

5.4 Project site and Urban surroundings.

The representative commercial office building chosen is situated in a fast-urbanizing region of the metropolitan area of Lahore where decreasing urban green cover, high vehicular emissions, and high-density building development have led to environmental stress together. Within the past ten years, Lahore has undergone massive land-use change that has led to an augmentation of the built-up density and a decrease in vegetative surfaces, which lead to a high intensity of urban heat islands (UHI) (Irshad et al., 2024; Sattar et al., 2025).

Urban planning studies also suggest that the developmental trend in Lahore has been characterized by the emphasis on horizontal and vertical development without considering the climate sensitive controls in the planning (Ali and Butt, 2024). That is why this setting makes the city a proper testing platform to assess the effective use of green construction approaches. The chosen building was created in the principles of the ECBC to determine whether the moderate interventions to the sustainability can provide a measurable environmental and working effect within the typical environment of the Lahore market.

Building design characteristics Building design characteristics are considered to encompass features that demonstrate how a building is constructed and perform effectively within the environment. Building design Characteristics Building design characteristics refer to features which illustrate the way a building is designed and which work well in the environment.

The case building is a midrise commercial office building which has been designed in a partially climate-responsive manner. The project had several green construction elements that were in line with the modern-day sustainable building guidelines. These included:

- increased insulation of exterior walls.
- reflective roof construction materials.
- double-glazed fenestration
- LED lighting systems
- optimized HVAC load sizing
- low-VOC interior finishes
- rooftop solar photovoltaic integration provision.

These were chosen due to the fact that previous studies have proven that envelope additions and effective mechanical systems have the greatest potential to save energy in Pakistani buildings (Zafar et al., 2022). The design approach was laid down with the main emphasis on high-return efficiency criteria, but not on a high cost of advanced technologies, which is realistic given the conditions of adoption of commercial construction market in Lahore. The direction of the building was altered in order to reduce direct solar heat intake on large glazed surfaces. On the western exposure passive shading elements were added in order to minimize peak afternoon cooling loads. These types of passive approaches are more frequently suggested as a part of climate-adaptive infrastructure planning frameworks (Khisro et al., 2024).

The following section is the performance assessment of energy.

Post-occupancy observations show that the building was estimated to cut down to 25-30 percent of electricity consumption when compared to normal office buildings of the same size in Lahore as the conventional office buildings. This enhancement was mainly due to the synergistic respite of envelope insulation, effective lighting and appropriately sized HVAC systems.

Such results are consistent with the national-level data demonstrating a significant potential of energy optimization with the help of comparatively simple design interventions (Zafar et al., 2022). The case thus contributes to the bigger argument that the major efficiency gains in Pakistan need not be the ones that are brought about with highly advanced technologies but can be made through disciplined implementation of the developed green construction principles. Climate wise, the issue of less electricity consumption is of much concern considering Pakistan energy scenario, urban buildings are a major contributor of peak load stress. Zeeshan and Iqbal (2022) note that the ability of urban building stock to be scaled with improvements in building efficiency may be a significant contributor to national emission reduction pathways. The case building has the observed performance thus showing meaningful replication potential.

5.7 Indoor Environmental Quality Results.

The building also demonstrated remarkable advances in indoor environmental quality (IEQ) along with energy performance. As observed on occupants and the environment, it was found that:

- better thermal comfort in hot summer seasons.
- stabilized indoor temperature characteristics.
- less use of auxiliary cooling systems.
- observable decrease in the interior chemical odours.

Better perceived indoor air quality was a result of the use of low-VOC paints and finishes. The given result aligns with the results of Al Horr et al. (2021), who found that the green building

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characteristics were strongly correlated with better occupant health and productivity. Since the Lahore area has some of the highest ambient particulate ratings as reported by Ahmad et al. (2020), the enhancement of indoor environmental control is especially useful. Structures with a low penetration of pollutants and stable thermostat conditions can greatly improve the wellbeing of those living in the polluted urban setting. The fact that the environmental health dangers in the big cities in Pakistan are progressively being mediated by indoor exposure pathways also supports the significance of the IEQ-based design, as observed by Idris (2024).

5.8 Urban Heat Island Minimization Contribution

Although the project was not initially structured as a mitigation pilot of UHI, a number of practiced features helped in an indirect localized reduction in heat. The reflective roofing and better building envelope decreased the heat absorption as compared to the traditional dark roofing systems. There was also passive shading that reduced the heat gain on the facade.

The urban climatic literature suggests that built-form alterations and the type of material used can be significant to address the body of surface temperatures in high-density cities (Irshad et al., 2024). Sattar et al. (2025) also show that the cumulative urban thermal behaviour can be very effectively affected by small scale improvements in the building, which implies city thermal behavior. Although the effect of the single building is inherently small, the case demonstrates the principle of scalability: mass implementation of the same action on the commercial building portfolio of Lahore could have a significant impact on the heat mitigation of the city.

5.9 Economic Performance and Payback Dynamics

Financially, the project recorded a slight rise in initial cost of construction mainly in terms of the enhancement of insulation materials used and the use of better-quality glazing. Nevertheless, early operational evaluation indicates that such extra expenses will be recoupled by savings in energy in reasonable payback period. One of the most popular excuses to avoid going green in Pakistan is the issue of cost sensitivity (CTCN, 2021). However, the performance of the case building observed justifies the assumption that medium-level green interventions could deliver favorable lifecycle economics without having to place prohibitive capital charges. Short-term minimization of capital costs by developers in Lahore is the norm, however, the case study shows that lifecycle cost framing can contribute to the business case of green construction greatly. This observation is aligned with the wider literature on sustainability transition that notes the need to move towards lifecycle-value approaches as opposed to first-cost approaches (Duhis et al., 2025).

5.10 Implementation Problems: Experiences.

The project had a few practical barriers, though it had good performance results and they reflect the general market conditions in Lahore.

To begin with, the chain of specialized green resources is not always regular. Some of the components that were of high performance took a long purchase cycle, legitimizing previous findings on the limitation of market readiness (CTCN, 2021).

Second, there was disparity in technical awareness amongst subcontractors. There were those construction teams that were not conversant with the right installation needs of insulation and air-sealing measures. The same capacity gaps have been pointed out in climate-adaptive infrastructure research in Pakistan (Khisrow et al., 2024). Third, there are no compulsory enforcement frameworks that made the external pressure stronger towards complete adherence to advanced energy standards. The past policy discourse studies have observed the disconnect

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between the desire to regulate and the reality in the Pakistani climate governance environment (Khan, 2025). These difficulties point to the fact that even though green construction can technically be practiced in Lahore, large-scale mainstreaming demands supporting the systemic ecosystem enhancements.

5.11 Replication and Implications to the Market

The case study reflects high prospects of replication in the new commercial and institutional building sectors in Lahore. The applied interventions were not very experimental but they were the best application of existing efficiency measures and thus suitable to be widely used in the market. According to Ali and Butt (2024), the planning system of Lahore should be more focused on adopting sustainability principles because of the need to control the risks of climate change. This argument can be supported by the current case since it demonstrates that building-level interventions can provide quantifiable environmental and functioning advantages when effectively undertaken.

But such practices will have to be scaled using concerted efforts of several stakeholders such as regulators, developers, consultants, and suppliers of materials. Unless there is extensive alignment in systems, green construction might not be turned into regular practice but remain a pilot project.

5.12 Case Study Synthesis

In general, the Lahore case study is very convincing that ECBC green construction strategies aligned with the environment and technically feasible and economically rational in the context of the local market. The building recorded significant energy optimization, enhanced indoor air quality, and insignificant heat mitigation. Simultaneously, the case points to the structural obstacles that have remained constant, in terms of supply chain constraints, technical capacity constraints, and poor enforcement systems, that should be overcome to open the door to mass adoption. These results join the literature consensus on the topic that the green construction transition in the developing city relies not just on technology but also on the institutional preparedness and market conversion.

6. Existence of Barriers to Large-Scale Adoption

Although the advantages are obvious, its use in Lahore is still low because of:

- laxity in building energy codes.
- low technical capacity among the construction workers.
- price-oriented developer attitude.
- lack of monetary incentives.
- disjointed acquiring of green materials.

The international evaluations point to the fact that the mechanisms of policy implementation and financing are the keys to unlocking the mitigation potential of the building sector (UNEP and GlobalABC, 2024).

7. Strategic Recommendations

To further speed up the shift of green construction in Lahore, a more synchronized multi-level approach to the problem must be applied, involving the simultaneous regulation enforcement, industry capacity, and market behaviour. The demonstrated technical feasibility of energy-efficient and climate-responsive buildings has been growing, but the rate of its use is slowed down by institutional lapses, a low level of stakeholder alignment. Recent studies note that the elements of

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policy integration and market incentives combined with professional capacity development are essential factors in achieving a successful transition to sustainability in fast urbanization (Khisro et al., 2024; Duhis et al., 2025). A policy and industry road map therefore needs to be integrated in the context of Lahore in order to transform the green construction out of the pilot projects to a mainstream practice. The most urgent priority as a policy measure is to enforce the Energy Conservation Building Code (ECBC-2023) on a mandatory and uniform basis in building approval of a building. Although the code will offer a technically viable system of enhancing building energy performance, its effectiveness will still be minimal unless compliance checking should be incorporated into planning permission and completion certification by the local development authorities. Intensifying the enforcement of ECBC would serve to harmonize the minimum energy performance of new development and gradually make the market demands oriented to efficient-oriented design. The strategy aligns with the general climate governance studies in Pakistan, where the lack of policy ambition and effectiveness in its implementation remains common (Khan, 2025). Simultaneously, fiscal incentives like tax rebates, lower approval fees or density bonuses on certified green buildings may have a powerful effect on enhancing developer motivation through overcoming the perceived premiums in upfront cost. Sustainable urban development research indicates that financial incentives are highly important in the initial phases of combating green technologies resistance in the market (Zeeshan and Iqbal, 2022). More so, the institutionalization of green building requirements as a part of the Lahore Development Authority (LDA) bylaws would make sustainability considerations institutionalized in the normal urban planning processes in reducing their dependence on voluntary implementation.

Industry wise, it is also important to have capacity building in the construction value chain. Among the frequently reported obstacles in the process of the green building transition in Pakistan, one can single out the disproportionate lack of knowledge about the technical aspects of the matter by contractors, consultants, and site supervisors (CTCN, 2021). Organized training programmes on ECBC compliance, performance of building envelope, air-sealing methods, and effective HVAC design would be of great help in enhancing the quality of implementation. The need to professional upskill is especially significant since green buildings can be constructed in a professional way, but only in this case, they can be truly effective. Besides human capacity, another important aspect of enhancing local supply chains to green materials is the need to have reduced cost volatility and procurement delays. The current lack of consistent supply of high-performance insulation, low-VOC finishes and efficient glazing systems limits the extensive use at present. The establishment of local sites of manufacturing and distribution of these materials would boost market confidence and increase the viability of the projects. In addition, systematic building commissioning practices should be promoted to be an industry standard practice. Commissioning is a process of performance verification that guarantees building operation and assists in bridging the gap that has been well documented between the design expectations and reality of the performance of those buildings in terms of energy consumption (Rehman et al., 2025).

The strategic repositioning must be done at the developer level to adopt the business models that focus on lifecycle value as opposed to raw minimum cost. The high return-on-investment (ROI) efficiency measures should be viewed as the point of entry into green construction and high-levels of sustainability-oriented development should be targeted by developers working in Lahore. According to evidence of studies of building performance in

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Pakistan, the improvement of envelope, effective lighting, and optimization of HVAC systems generally provide the shortest payback periods (Zafar et al., 2022). These interventions are financially appealing and by prioritizing them developers can gain confidence in the market and progressively grow in more sophisticated sustainability options. Also crucial is that it has to communicate the benefits of lifecycle cost savings in an effective manner to clients and investors. A significant number of project sponsors still base their project assessment on capital expenditure, even though they can make huge savings on their operations. Organized lifecycle cost analysis and post-occupancy performance statistics may be used to alter such impressions and improve the business case of green buildings.

In the future, pilot projects with the objective of achieving net-zero or near-zero energy performance in Lahore may be used as the demonstrators of the market. Demonstration projects well-chosen would offer performance evidence that is locally relevant and would be used to de-risk advanced green construction strategies. As Ali and Butt (2024) highlight, the urban planning system in Lahore needs to be transformed into more climate-sensitive patterns of urban development, and pilot projects that can be easily seen can become catalysts of this change. These would also be consistent with more general climate-adaptive infrastructure goals as identified in recent sustainability studies in Pakistan (Khisrow et al., 2024). Nonetheless, in order to achieve these pilots producing any meaningful change in the market, it is important that they are sustained with strong monitoring, transparent performance reporting, and knowledge sharing throughout the construction industry. In short, accelerating the process of green building in Lahore needs to be a concerted effort both in the implementation of the policies and the capacity of industries as well as the strategy of the developers. Enhanced ECBC execution, specific fiscal incentives, capacity building on a professional scale, supply chain maturation, and lifecycle-driven development models are all the pillars of a scalable transition footpath. Devoid of such a concerted effort, it is likely that green construction will continue to exist as a limited set of projects in Lahore instead of being integrated into the fabric of the rapidly growing built environment in the city.

Conclusion

This research has identified green construction as one of the strategically significant directions in the solution of the interrelated problems of the worsening air quality, increasing energy demand, and growing urban heat islands experienced in Lahore. The synthesized evidence on the basis of the recent literature and the case analysis conducted in Lahore proves that the built environment sphere has a significant untapped potential to play its role in mitigating climate and improving the urban environment. More specifically, the combination of climate-responsive design, efficient building envelopes, optimized mechanical systems and low-emission materials show quantifiable decreases in the amount of energy used by operations and increases in the quality of indoor environments. These results are in line with more general studies that suggest that the construction of efficiency interventions is among the most economical processes of minimizing the carbon intensity of urban areas in developing economies (Zafar et al., 2022; Zeeshan and Iqbal, 2022). In the Lahore context where the high urbanization process has been a source of thermal stress and exposure to the environment, the use of green construction practices is therefore not simply a preference in terms of the environment but rather a need in the city.

The paper also accentuates the fact that the dynamic policy environment in Pakistan especially the adoption of ECBC-2023 has a viable regulatory base to mainstream energy efficiency in construction. Nevertheless, it has also been found in the analysis that the presence of technical standards is not enough to bring about massive change. In line with the findings of Khan (2025) and Khisro et al. (2024), the implementation gap between the intent and on-ground enforcement is the major limitation. The lack of professional capacity evenness, the negligence and the lack of professional compliance monitoring and the ongoing cost-oriented construction development practices all slow down the process of green construction diffusion in the building market in Lahore. These institutional and market frictions will be very important to deal with as long as the city is to align regulatory achievements into concrete environmental achievement.

The case study of Lahore developed in the course of this study gives us some promising signs that ECBC-compliant green building policies are feasible and economically sound in the situation of local conditions. The results that were obtained related to the decreases in electricity use, the increase in comfort indoors and moderate cost of capital implication indicate that most of the sustainability solutions are within commercially viable areas once their lifecycle is considered. This is in line with the emerging literature that has highlighted that the observed cost premium of green construction is largely a perception of the market and not necessarily economic obstacles at their core (Duhis et al., 2025). However, internal ecosystem issues that include supply chain variability, lack of familiarity of high-performance construction practices by the contractor, and lack of performance verification criteria are also highlighted by the case.

In the future, mainstream green building in Lahore will require a concerted effort by the regulatory bodies, the industry players, and individual developers. Enhanced ECBC compliance, systematic financial incentives, professional upskilling and development of local green supplies market can all be seen as the most viable way out. It is also important to develop highly visible pilot projects that can show near-zero and net-zero building performance under the local climatic and economic conditions. According to the findings of the urban planning studies, the future climate resilience of the city of Lahore will rely more and more on the principles of sustainability that will be directly implemented into the development pattern of the city (Ali and Butt, 2024).

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