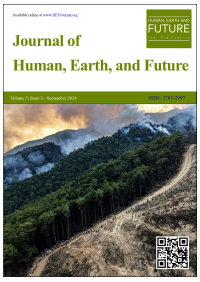
Available online at www.HEFJournal.org

ISSN: 2785-2997

Journal of
Human, Earth, and Future

Vol. 5, No. 3, September, 2024



Evaluating the Implementation of Green Building Materials in the Construction Sector of Developing Nations

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Received 18 May 2024; Revised 19 August 2024; Accepted 27 August 2024; Published 01 September 2024

Abstract

The use of conventional building materials in the construction sector significantly contributes to air pollution and greenhouse gas emissions, resulting in considerable environmental damage across Pakistan. Embracing sustainable building materials is crucial for mitigating pollution, conserving energy, and enhancing indoor air quality through the utilization of recycled and renewable resources, reducing environmental pollution. The focus of this study is to explore the adoption of green building materials within Pakistan's construction sector, particularly aiming to mitigate environmental impacts, including air pollution and greenhouse gas emissions. The objectives include identification of sustainable materials, evaluation of their benefits and drawbacks, and the provision of recommendations for effective implementation. The research methodology includes the administration of closed-ended questionnaires, the conduct of interviews, and the observation process, utilizing both planned and random sampling techniques to ensure the collection of reliable data. The findings indicate a limited interest in eco-friendly materials, constrained by factors such as high costs, low market demand, and logistical challenges. Cronbach's alpha value is 0.926, which shows high internal consistency and reliability. The study highlights that 73% of construction firms in Pakistan do not use green building materials. This research distinguishes itself through a thorough evaluation of sustainable materials specifically suited to Pakistan's industry, providing strategic insights to address current challenges and foster green building practices.

Keywords: Green Building Materials; Sustainable Construction; Energy Efficiency; Environmental Standards; Building Codes and Regulation; Eco-Friendly Materials; Construction Industry; Environmental Footprint.

1. Introduction

In recent decades, Asian nations have witnessed rapid economic expansion, bringing with it substantial environmental challenges. The accelerated pace of industrialization, urbanization, and population growth has led to ecological degradation, a critical issue that requires urgent action [1]. Tree cutting and the use of toxic chemicals are prevalent in construction, which also contributes significantly to greenhouse gas emissions. Various strategies reduce the environmental impact of construction by conserving electricity, lowering pollution levels, and enhancing indoor air quality. Energy conservation in construction can mitigate environmental impact. Buildings that are energy-efficient not only reduce greenhouse gas emissions but also decrease monthly energy costs. As reported by Doan et al. [2], the building

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http://dx.doi.org/10. 28991/HEF-2024-05-03-015

industry utilizes 30% of global resources, 15% of worldwide freshwater withdrawals, a quarter of the wood harvested, and nearly half of all raw materials consumed. Both architecture and construction have far-reaching impacts on energy use, the environment, and future generations. Global carbon dioxide (CO_2) emissions from energy-related activities are projected to rise from 32.3 billion metric tons in 2012 to 43.4 billion metric tons by 2040 [3]. Moreover, the building sector accounts for 40% of the total solid waste generated in developed countries [4]. Green building is defined as "the practice of designing structures and utilizing processes that are environmentally responsible and resource-efficient throughout the entire lifecycle of a building" [5]. Green building practices utilize sustainable materials and techniques to minimize waste, cut energy and water consumption by 30%, and enhance tenant productivity. These buildings are also effective in reducing solid waste by 70%, water usage by 40%, and CO_2 emissions by 39%. The Economic Survey of Pakistan reports that the construction industry expanded by 9.1% during the 2019 fiscal year, making a notable contribution to the nation's GDP [6]. Eco-friendly building materials are relatively new to Pakistan, primarily due to their high cost. These materials are characterized by their recyclability or renewability. Bamboo and recycled wood are more expensive than readily available alternatives due to the required careful planting and harvesting processes. Rasheed et al. [7] stated that by embracing green growth as a strategic approach, it can align economic development with ecological principles, reinforcing sustainable practices within the economy.

The eco-friendly building materials are complex, requiring advanced technology, specialized equipment, and expertise. The higher cost of sustainable materials can be attributed to extensive research and development as well as manufacturing processes [8]. In Pakistan, the higher cost and limited popularity of green building supplies can be attributed to a lack of experience and inadequate equipment. Demand for sustainable construction is hindered by a preference for traditional methods, limited awareness of their advantages, and the absence of government incentives [9]. Additionally, the low availability of green construction materials impacts their prices, and issues with shipping and transit intensify shortages. Locating local eco-friendly materials can be time-consuming and challenging. Importing these items is often costly due to lengthy delivery times, stringent customs procedures, and high transportation expenses. The absence of a dependable supply network for green building products in Pakistan can lead to inefficiencies that drive up costs [10]. Despite the challenges, incorporating eco-friendly construction materials remains a valuable endeavor. Recycling, the use of renewable resources, specialized production, limited demand, transportation constraints, and inadequate distribution networks all contribute to higher costs. Green materials contribute to energy savings and environmental protection, representing a valuable investment. With government support, incentives, and increased awareness, financial barriers can be addressed, potentially creating widespread adoption of green development across the country. In Pakistan, the lack of awareness about green construction materials hampers their adoption. Many individuals are not familiar with the environmental and economic advantages of green buildings [11], and the complexities of eco-friendly building methods and materials are difficult to communicate. Lawmakers, architects, builders, and homeowners have limited knowledge about sustainable building materials. Green buildings offer benefits such as reduced energy consumption, environmental improvement, and enhanced health. The small size of the eco-friendly construction materials industry restricts its use, while inadequate government regulations and a lack of incentives hinder awareness and adoption. Insufficient information and the perception of higher costs may deter individuals and organizations from exploring green construction solutions or investing in eco-friendly materials.

Government policies and financial incentives can significantly boost the adoption of green building materials. Measures such as tax rebates, subsidies, and grants encourage sustainable living while providing cost savings. Additionally, approximately one-third of global greenhouse gas emissions originate from buildings [12], which is expected to double by 2050 if no corrective measures are implemented. These factors highlight the substantial potential of buildings to reduce energy consumption and greenhouse gas emissions. This shift supports the transition to low-carbon cities and plays a significant role in enhancing economic productivity and mitigating climate risks at both regional and national levels [13]. Industry associations, environmental organizations, and professional networks can advocate for eco-friendly building materials and ethical construction practices through seminars, workshops, and conferences. These platforms facilitate networking, knowledge sharing, and the promotion of green building projects to enhance construction sustainability. Raising awareness about the benefits of eco-friendly building materials is crucial in Pakistan, as the current lack of understanding hampers their widespread use.

Green building construction prioritizes energy efficiency and carbon reduction. This demand is intensified by heightened awareness of climate change, rising energy costs, and government sustainability initiatives. Currently, Pakistan is among the countries heavily reliant on thermal sources, with the majority of its electricity generated from non-renewable sources [14]. In Pakistan, higher electricity tariffs encourage the adoption of green building materials. As energy costs rise, both companies and consumers seek to reduce their energy consumption and expenses. To avoid electricity shortages, it is crucial to shift current construction practices toward energy-efficient buildings, which have the potential to save up to 30% of energy [14]. Minimising greenhouse gas emissions and mitigating environmental damage from construction are increasingly crucial concerns for both businesses and individuals. The use of energy-efficient insulation, recycled materials, and sustainable wood significantly cuts carbon emissions and conserves resources. Such materials play a crucial role in addressing climate change and preserving the environment**.** Green design

materials substantially mitigate the environmental impact of construction, reducing solid waste generation by 70%, water consumption by 40%, and carbon dioxide emissions by 39% [15]**.** Enhancing capacity and education helps architects, engineers, builders, and homeowners understand green construction materials. Additionally, researchers are working to develop cost-effective, sustainable building materials tailored to specific regions.

While employing sustainable construction materials in Pakistan poses challenges, it offers significant advantages. The demand for energy-efficient buildings is driven by increasing energy prices, heightened awareness of global warming, and governmental commitment to green development. This trend not only stimulates market growth but also reduces environmental impact. According to Tan [16], subsidies for green building materials provide cost savings for both homeowners and builders. Pakistan also has an active organization dedicated to helping green development, known as the Pakistan Green Building Council (PGBC). Its mission is to improve environmental performance, enhance human health benefits, and expand industries to achieve sustainability at all levels. They also offer guidance on observing Leadership in Energy and Environmental Design (LEED) certification standards in the construction of building surfaces.

Numerous countries are adopting effective strategies to enhance environmental quality and mitigate further damage. Both direct and indirect government regulatory measures play a crucial role in shaping these approaches [17]. Various approaches, such as environmental education focusing on energy efficiency, societal standards, behavioral changes, and ethical advocacy, can be employed to foster greater environmental awareness and promote more sustainable living among the public [18]. Historically, Pakistan has struggled with energy demand constraints because of limited supplies and insufficient infrastructure development for the industrial sector. As a result, the country endures a substantial demand-supply gap in the power sector, which was 5,000 MW in 2022 [19].

A World Bank report identifies the China-Pakistan Economic Corridor (CPEC) as a significant driver of economic growth [20]. Conversely, increased construction activities contribute to higher fuel and energy consumption, depletion of natural resources, increased waste generation, and environmental degradation. Thus, it becomes essential to implement measures aimed at improving construction practices. Enhancing construction quality while minimizing its negative impacts will lead to better project outcomes. Globally, the use of green materials has been adopted to elevate construction practices [21]. Green materials are fundamental to green buildings and represent the initial step towards sustainable construction [22]. Subsequently, it guarantees enhanced financial and environmental performance.

Sustainable building necessitates government tax refunds or incentives for green construction. Providing credits or exemptions for green building practices can further support this initiative. Reducing the cost of these resources and promoting their use can significantly enhance the adoption of green construction practices. Nation's construction industry encounters environmental challenges due to rapid expansion and the use of non-environmental materials as increased urbanization results in higher consumption of building materials [23]. The production and use of these materials contribute to water pollution, greenhouse gas emissions, and resource depletion. Further research is needed in Pakistan to explore the economic advantages of eco-friendly building materials. Additional research is essential to address policy barriers to green construction materials. Relevant studies support the proposed investigation into these issues [24]. This research aims to address knowledge gaps and propose policies for the use of eco-friendly construction materials. Moreover, investigations into eco-friendly construction materials in Pakistan should extend beyond existing literature to provide deeper insights. In Pakistan, green buildings utilize eco-friendly materials to reduce environmental impact. This research seeks to evaluate the advantages of these materials and to develop policies that encourage their adoption.

2. Literature Review

In recent years, the construction industry has increasingly focused on sustainability issues. Although the construction sector significantly contributes to national economies, it has also become a key contributor to economic, social, and environmental challenges [25]. The construction industry acts as a fundamental pillar in modern society, shaping regional infrastructure and offering essential support to the everyday lives of inhabitants. Nonetheless, its significant environmental impact has necessitated a critical reevaluation of conventional construction methods. The extraction of raw materials, energy-concentrated manufacturing, and elevated emissions throughout construction and operation have revealed the urgent need for a fundamental shift in practices. The concept of sustainable construction involves adopting eco-friendly, recycled, or renewable materials, employing waste minimization techniques, and focusing on long-term performance. Nodehi & Taghvaee [26] discussed that green construction materials focus on utilizing recycled resources, such as recycled concrete, steel, and glass, which divert trash from landfills and reduce the need for extraction of raw materials. Green building materials minimize landfill waste and decrease the exploitation of raw resources.

2.1. Sustainable Building Materials

Sustainable building design has evolved into a broad field surrounding mechanical, electrical, electronic, and structural engineering disciplines. In recent years, significant attention has been focused towards green or sustainable

building materials. Most research studies were conducted on energy and water conservation, as well as enhancing environmental impact by reducing carbon footprints [27]. Sustainability has increasingly emerged as a central focus within the global construction industry, aiming to mitigate its adverse impacts. The concept of sustainable building materials is widely adopted globally and has been incorporated into various development projects. Sustainable building construction is a key strategy for enhancing resource efficiency and management. It emphasizes recycling within projects to mitigate negative environmental impacts [25].

According to studies, there are three primary advantages of sustainable construction materials. Firstly, sustainable materials play a crucial role in minimizing the environmental footprint of buildings and achieving the United Nations' Sustainable Development Goals (UNSDGs). Secondly, they line up environmental and financial sustainability while promoting social well-being and equity. Thirdly, these materials contribute to the development of healthier and more energy-efficient living spaces for future generations [28]. In construction, civil engineering and building projects account for 60% of the raw materials extracted from the Earth's crust [25]. In 2010, the global extraction of non-metallic minerals, including gravel, sand, clay, limestone, and gypsum, amounted to around 35 billion tons [29]. Infrastructure projects and construction activities are the primary consumers of these materials.

Despite its advantages, sustainable building construction has encountered numerous obstacles as an innovation striving to enter a market predominantly dominated by conventional structures. To achieve sustainability in the built environment, it is essential to prioritize key elements, including energy and water conservation, emission reduction, pollution control, and the efficient use of natural resources. Balancing efficiency with sustainable benefits requires integrating eco-friendly materials at every stage of the construction lifecycle. Buildings intended for human use need to prioritize enhancing health, well-being, and overall quality of life. To achieve this, this involves implementing strategies such as selecting low-VOC paints, ensuring proper ventilation, and prohibiting asbestos-containing materials [30].

2.2. Pakistani Green Building Initiatives

A decade ago, Pakistan realized the need for eco-friendly building standards. Similar to global trends, Pakistan has introduced various measures, including the development of climate adaptation policies for urban areas, climate action plans, and comprehensive urban policies [31]. The Green Building Council of Pakistan (GBCP) was founded in 2013 to promote green building. The GBCP's Green Building Certification Program promotes renewable energy, energy efficiency, and green building materials. It introduced the Green Building Standards and Certification System to promote green building. The research employed a UTAUT-based framework to investigate the role of green buildings in integrating and addressing climate crises within today’s complex business environments in Pakistan [32]. Multiple factors contribute to slow adoption, including industry professionals, stakeholders, and the public needing to be made aware of green construction methods. Drawing inspiration from Germany's energy efficiency incentive programs, which provide financial incentives and low-interest loans for energy-efficient buildings [33]. A similar approach could be adapted in Pakistan to encourage sustainable practices.

The implementation of Building Information Modeling (BIM) in the UK construction industry is a benchmark for stakeholder collaboration. BIM facilitates better collaboration between architects, engineers, and contractors by providing a shared digital environment where all parties can work together in real-time, reducing errors and improving decision-making [34]. Lessons from the UK show that technology adoption, when coupled with collaborative frameworks, can enhance project coordination and efficiency. Similarly, the Netherlands' focus on sustainability through supply chain collaboration offers a roadmap for Pakistan to prioritize eco-friendly practices [35]. Long-term partnerships that focus on reducing environmental impact can align with Pakistan's goals for sustainable development.

Construction-related industries account for approximately 40% of global energy consumption and contribute significantly to the production of waste materials [36]. In China, construction-related activities and projects consume an even larger share of energy, amounting to 45.5%, while in Kuwait, 10% of total construction materials are utilized, generating 1.6 million tons of construction and debris waste annually from construction sites [37]. Moreover, in Pakistan, various construction activities are impacting approximately 67.5% of the ecosystem and 34% of natural energy resources [38]. Pakistani construction professionals need to gain knowledge of eco-friendly building materials' benefits and processes, preventing their use. Sustainable building materials may be scarce locally, making it difficult for construction professionals to find. Green imports complicate and expense supply chains. More local manufacturing and transport infrastructure is needed to maintain material availability. Pakistani green building materials are more expensive than standard ones, limiting their use. Although many construction projects in this country stress cost reduction, environmentally friendly building materials are generally more expensive. Sustainable materials cost more upfront but save money and enhance building performance. Furthermore, reluctance must be overcome by educating people about the long-term benefits of eco-friendly building materials. Enhancing the expertise of managers and construction personnel can be achieved through targeted training and development on optimal environmental practices and sustainable building materials. In Pakistan, existing environmental regulations and regulatory bodies lack the effectiveness and consistency needed for proper implementation [39]. Hence, it is vital to exercise regulatory pressure

to create the adoption and implementation of green building materials while also enhancing stakeholder awareness. Government agencies need policies, financial incentives, and guidelines to promote green building materials.

2.3. Challenges with Eco-Friendly Building Materials

In residential settings, there is growing awareness of eco-friendly practices. Specifically, there is a growing trend to manufacture green insulating materials through waste recycling, aligning more closely with circular economy principles [40]. Many Pakistani construction experts need to be made aware of eco-friendly building materials' benefits, techniques, and availability. Lack of awareness prohibits construction projects from employing eco-friendly materials [41]. Secondly, external influences, including government financial incentives, trust in eco-block suppliers, and promotional offers or substantial discounts from suppliers, can significantly affect the decision to adopt eco-friendly materials [42]. Sustainable building materials are more expensive, limiting their adoption. Although environmentally friendly materials cost more initially, they may lower operational costs and enhance building performance over time. The focus on cost-cutting and hesitation to adopt innovative construction techniques in Pakistan hinders the promotion of green building materials [6]. Due to its traditions, this country's building sector resists new ideas and materials. Overcoming concerns requires a mindset shift and education on the long-term benefits of eco-friendly building materials.

Poor government backing and regulation limit green construction material use. The Green Building Council of Pakistan (GBCP) has green building standards and certification systems. However, they need stronger implementation and enforcement. Singapore's Green Mark certification provides a framework for assessing building sustainability [43]. Pakistan could develop a similar certification tailored to local needs. Policy support, incentives, and clear government requirements should promote eco-friendly construction materials. Government, industry, and education must collaborate to address these concerns. Workshops, awareness campaigns, and training can promote eco-friendly building materials and reduce the knowledge gap. Customer access to eco-friendly materials should be the prime goal of research and development. Green products may cost more, but tax exemptions or subsidies can help [44]. Limited awareness and understanding, lack of availability of eco-friendly products, higher initial prices, resistance to change, and inadequate regulatory aid are all obstacles in the adoption of green materials. These issues would enable Pakistan to adopt greener building materials and encourage sustainable development, making its built environment greener.

3. Research Methodology

The research technique used to assess the utilization of eco-friendly building materials in Pakistan's construction industry includes the research strategy, data collection methods, sample selection processes, and analysis procedures. The efforts were made to achieve objectives while maintaining the reliability and validity of the findings (see Figure 1).

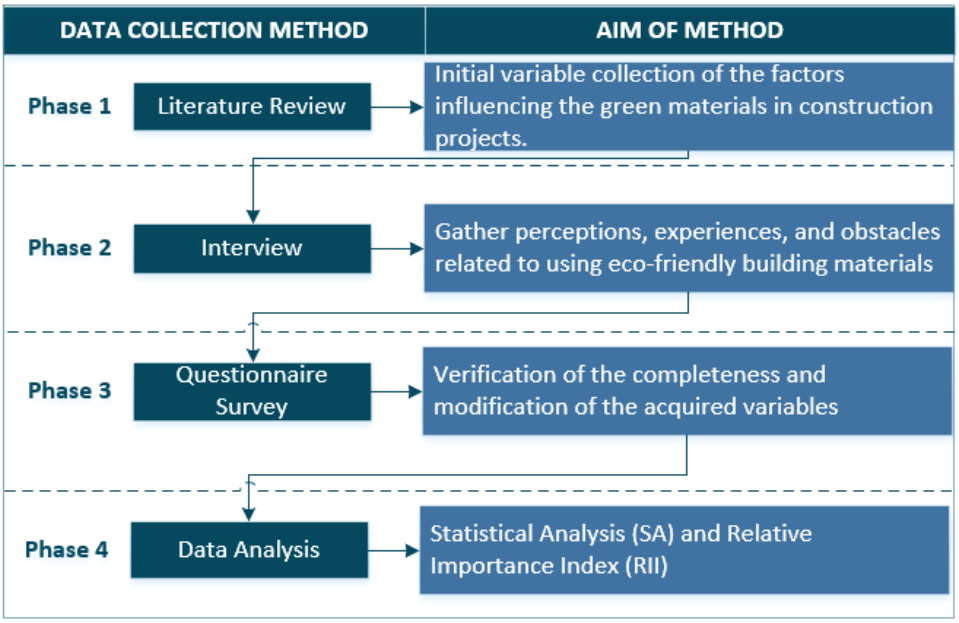

Figure 1. Flowchart for data collection and methodology

3.1. Designing Research

This study uses a descriptive research design to examine the use of eco-friendly building materials in Pakistan's construction industry. Descriptive research is suitable for this study as it provides a full and accurate depiction of the current condition of affairs. The study aims to gather and analyze data using a systematic approach, revealing current

practices and trends in green construction materials in Pakistan. Various data-gathering methods can be utilized to implement this research design successfully. Possible examples include questionnaires, chats, and observations. Surveys among construction professionals, architects, engineers, and stakeholders are conducted to gather quantitative data on the use and awareness of eco-friendly building materials. A deeper knowledge of major industry participants' opinions and experiences was acquired via 31 interviews. This research also observed nationwide data to employ eco-friendly materials in construction projects.

The research utilized a blend of qualitative and quantitative methods to gather data, offering a comprehensive understanding of the subject and reinforcing the credibility of the results. After collecting all the data, it underwent rigorous analysis employing statistical and qualitative techniques. Subsequently, a comprehensive report was crafted, focusing on the utilization of environmentally sustainable building materials. The findings of the study are intended to inform policymakers, industry professionals, and researchers about existing practices and potential avenues for improvement.

3.2. Qualitative Data Collection

The study collected quantitative data through surveys and observations, as well as qualitative data through semi-structured interviews and focus group discussions. Qualitative approaches were used to gather perceptions, experiences, and obstacles related to using eco-friendly building materials in Pakistan's construction sector. The interviews of relevant stakeholders, such as architects, engineers, contractors, and government officials, were conducted in the construction business. In-depth interviews were also conducted to explore participants' knowledge, attitudes, and actions about environmentally friendly building materials. Additionally, the research had focus group conversations with individuals from several industries, including manufacturers, suppliers, and environmental sustainability experts. These discussions aimed to foster dynamic and interactive discussions among participants about environmentally friendly building materials and sharing thoughts, experiences, and concerns. Incorporating diverse backgrounds in focus groups enabled a comprehensive understanding of the topic, considering multiple perspectives and enhancing appreciation of the environment.

Qualitative data from interviews and focus group discussions was evaluated using thematic or content analysis methodologies. Interviews and focus group discussions were conducted to acquire information. This analysis reveals key themes, trends, and insights on the views, experiences, and challenges of adopting green building materials. Using qualitative research approaches in this study allows for a more nuanced and comprehensive investigation of the topic. Researchers can acquire insights into human factors, attitudes, and contextual factors that impact the adoption and implementation of green building materials beyond just statistical data.

3.3. Quantitative Data Collection

This research collected qualitative data through interviews and focus group discussions and quantitative data using a standardized survey questionnaire. The study incorporated both types of data. The survey aimed to gather data on the use of eco-friendly building materials in Pakistan's construction industry, including methodologies, awareness, and barriers. The survey questionnaire was carefully designed to obtain reliable and relevant quantitative data. The survey covered topics such as eco-friendly building materials' use, frequency, professional awareness, and challenges in incorporating them into construction projects. The survey questionnaire was provided to various building industry groups and specialists. Architects, engineers, contractors, and developers were among the individuals and organizations involved. The researchers utilized this sampling strategy to get diverse perspectives and experiences from industry professionals. Participants were selected using a combination of random and purposive sampling approaches to provide a representative sample. Statistical analysis was conducted on the quantitative data after compiling survey responses. Data analysis and numerical insights were obtained using statistical methods like descriptive statistics, correlation analysis, and inferential statistics (where appropriate). The statistical studies gave a quantitative insight into applying eco-friendly building materials throughout Pakistan, enabling generalizations and comparisons.

Combining qualitative and quantitative data collection approaches enhances the study's robustness and comprehensiveness. Quantitative approaches, like survey questionnaires, capture numerical data to analyze and interpret trends, patterns, and statistical relationships. In contrast, qualitative methods offer in-depth insights into individuals' perceptions and experiences. This technique uses multiple research approaches to gain a thorough understanding of the utilization of eco-friendly building materials in Pakistan's construction industry.

3.4. Questionnaire Target Population

This study used a combination of purposive and random selection approaches to choose the sample. A representative sample of construction stakeholders was gathered to ensure a thorough survey. Depending on their selection process, architects, engineers, contractors, and government officials were selected for their industry

responsibilities and involvement. Two selection criteria were utilized by the researchers to identify appropriate respondents: (1) holding a degree in civil engineering or environmental engineering, and (2) having a minimum of five years' experience in these fields. The study utilized purposive sampling to include participants with distinct viewpoints on the topic under examination. The purposive sampling strategy ensured a sample of informed and experienced individuals in the subject topic. The credibility and depth of qualitative data from interviews and focus group discussions were greatly enhanced. In contrast, the survey participants were selected using random sampling. Random sampling was used to gather a representative sample from various professional backgrounds and regions in the construction sector. This strategy reduces prejudice and makes findings more applicable to a wider audience. The survey results likely reflect Pakistan's construction industry's comprehensive perspectives and practices due to the random selection of active professionals.

Combining purposive and random sampling strategies in this investigation obtained a thorough and representative sample. This allowed for insights from experts in green construction practices and a diverse range of professionals from various locations and backgrounds. This sampling strategy enhanced study validity and reliability by embracing diverse perspectives and minimizing biases.

3.5. Data Analysis

This research evaluated data using qualitative and quantitative methodologies to gain valuable insights and discoveries. The qualitative data was analyzed using thematic analysis. The popular thematic analysis method identifies and interprets qualitative data's key themes, patterns, and trends. Interview and focus group transcripts were evaluated and coded to identify prevalent themes, concepts, and patterns across the data collection. Codes were grouped into topics to gather key information on using eco-friendly building materials.

Statistical software was used to examine quantitative data from the survey. The software simplifies statistical calculations, such as correlations, frequencies, and percentages. Frequency data revealed response distribution for each survey item. This information shows the prevalence of specific activities or beliefs among respondents. The percentages were used to ascertain the percentage of respondents who supported specific actions or viewpoints. The use of correlations provided insight into the relationships between variables, revealing dependencies and interconnections. A statistical examination of quantitative data on the use of eco-friendly building materials in Pakistan's construction sector provided insights and understanding.

Combining theme analysis for qualitative data and statistical analysis for quantitative data allowed researchers to analyze and gain insights from both perspectives thoroughly. The researchers were able to analyze the data more thoroughly. The mixed-methods methodology enhanced the research findings and provided a deeper insight into the existing situation of using eco-friendly building materials in Pakistan's construction industry. Data from the questionnaire survey was evaluated to aid in respondent analysis, followed by statistical analysis using SPSS software while respondent analysis is conducted in MS Excel. The relative Importance Index (RII) is calculated for each of the indicators and ranked accordingly. The RII is derived to summarize the importance of each indicator:

$$RII = \Sigma W / (A \times N) \quad (1)$$

where, W = weighting as assigned on Likert's scale by each respondent in a range from 1 to 5 (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree A = Highest weight (here it is 5)); N =Total number in the sample.

4. Results and Discussion

The questionnaire, structured into seven sections, was developed following an extensive literature review. Respondents' perspectives were measured using a five-point Likert scale, where one indicates the lowest level of agreement and five the highest. The primary purpose of a Likert scale is to gauge respondents' level of agreement or disagreement with a given statement or perspective [45]. Following this, the RII is computed based on responses, with values ranging from 0 to 1. The survey targeted key professionals in the construction industry, including CEOs, project managers, site engineers, architects, and academic officials. Out of 70 questionnaires distributed, 65 were returned, yielding a 76% response rate. The final analysis, conducted using the returned questionnaires, achieved a 95% confidence level. The survey involved 14 architects, 24 consultants or engineers, 18 general contractors, 8 trade or specialist contractors, 16 design builders or project managers, 22 academics or researchers, and 8 trade or specialty contractors (see Figure 2).

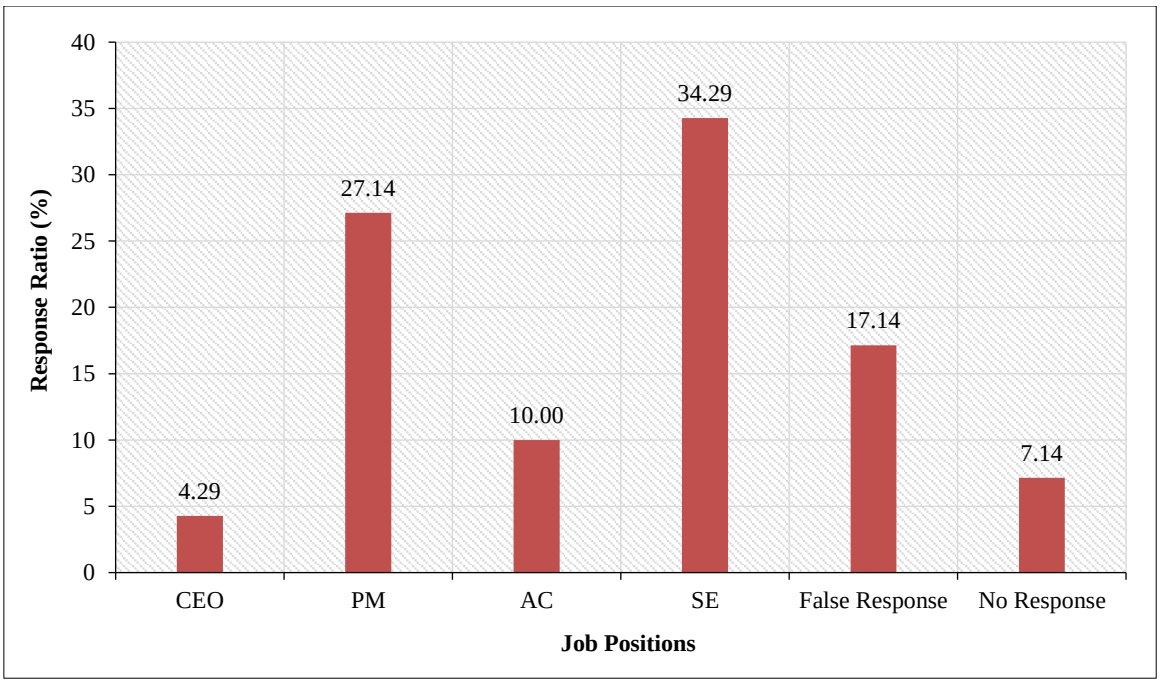

Figure 2. Illustration of detailed responses of different job position

The respondents possess varied experience in the construction sector. Approximately 41% (22 respondents) have over 10 years of experience. Among the professionals, 21.6% (11 respondents) have 6-10 years of construction experience, while 37.3% (20 respondents) have 1-5 years of experience, with those graduating post-2009 being more familiar with green building materials. Due to their credibility and reliability, the insights provided by these experts warrant careful consideration. The survey on sustainable construction materials among stakeholders indicated that 54.9% (56 respondents) lack professional experience with green building materials, 25.5% (26 respondents) have one year or less experience, 11.8% (12 respondents) possess 1 to 3 years of experience, and 7.8% (8 respondents) have 3 to 5 years of experience. The participants in this study are employed by various construction firms, working on a range of projects. Among the respondents, 13.7% (14 individuals) are associated with very small organizations, while 17.6% (18 individuals) represent small organizations. This distribution of respondents is dependent on their size. A number of 68.7% of respondents associated to 43 organizations are linked with huge or very large organizations (see Figures 3 and 4).

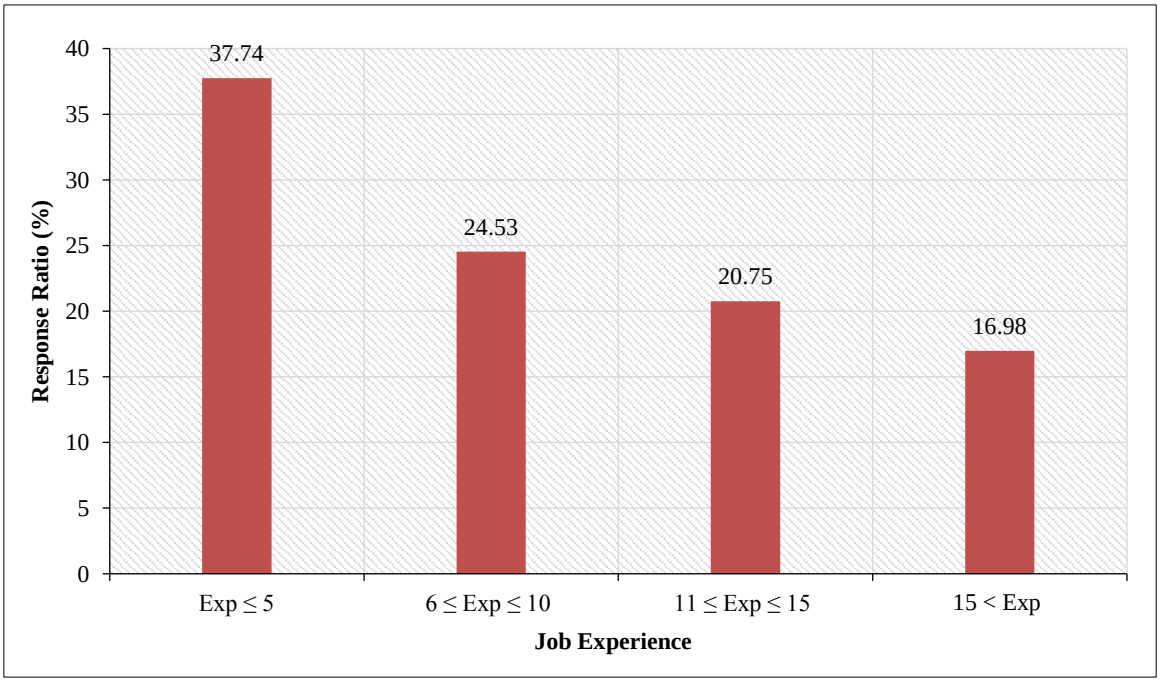

Figure 3. Analysis of respondents based on job experience

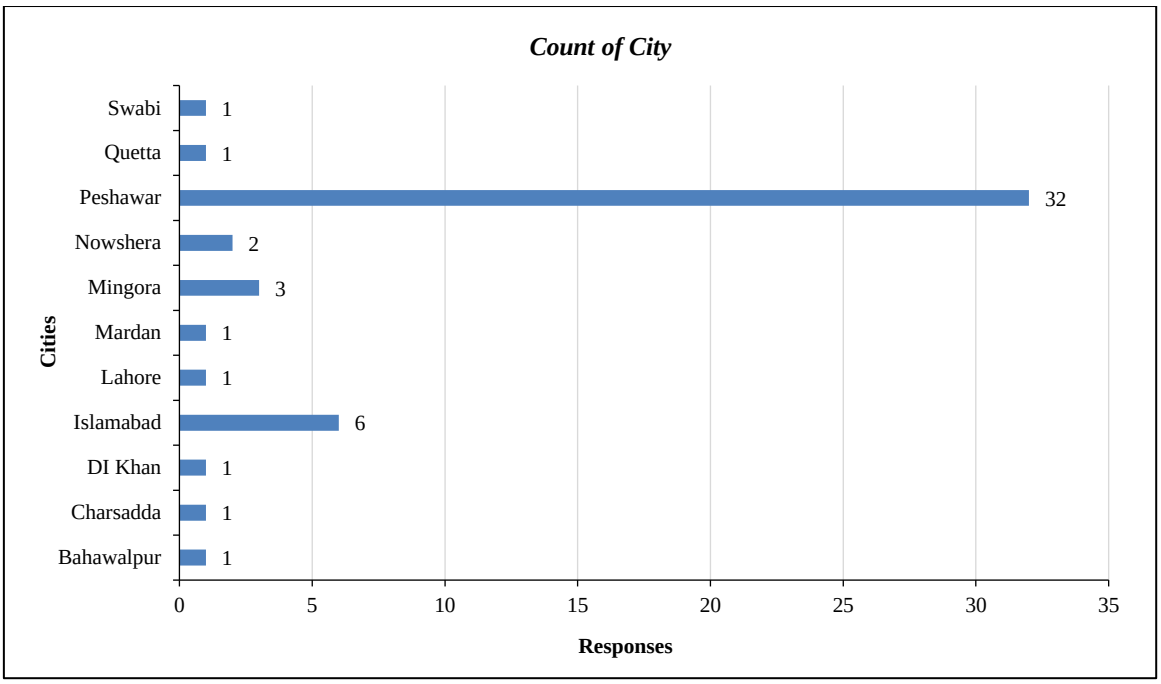

Figure 4. Analysis summary of responses from different cities

4.1. Reliability of Data

The reliability of the pilot questionnaire was assessed using Cronbach's alpha coefficient, a metric that indicates consistency. Cronbach's alpha is widely regarded as the standard method for assessing the internal consistency, or reliability, of survey data [46]. It is particularly common to apply this measure to evaluate the reliability of Likert scale responses. Data is considered statistically reliable for analysis when Cronbach's Coefficient Alpha exceeds 0.7. In this study, Cronbach's alpha based on standardized elements is 0.926. This statistic represents the reliability of the scale after standardizing the items. A Cronbach's alpha value above 0.9 is considered excellent and suggests a high level of internal consistency among the items in the scale. This indicates that the items are highly correlated and measure the same underlying construct consistently. To verify the normality of the data, the 'Shapiro-Wilk normality test' was conducted, assessing whether the data followed a normal distribution and identifying whether it is parametric or nonparametric. The Cronbach's alpha value without standardization is 0.925. This value is very close to the standardized Cronbach's alpha, suggesting that the internal consistency remains high even without standardizing the items. According to Berawi et al. [47], Cronbach's alpha value may often be underestimated or fall significantly below the acceptable threshold for consistency; hence, the consistency of the measurement model is confirmed by a Composite Reliability value of discriminant indicators greater than 0.60. This assures that all construct indicators are upheld and ready for the validity testing phase. This further confirms the robustness of the scale and its items in measuring the intended construct. The significance value of 0.06 or above was less than 0.05. Data should have a significance value greater than 0.05 for normality. Thus, the data follows a parametric normal distribution (see Tables 1 and 2).

Table 1. Statistical Analysis of Elements

No of Elements	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance
Element Means	3.339	2.189	4.038	1.849	1.845	0.194
Element Variances	1.167	0.883	1.575	0.692	1.784	0.036

Table 2. Reliability Statistics

No of Elements Analyzed	Cronbach's Alpha Based on Standardized Elements	Cronbach's Alpha
27	0.926	0.925

4.2. Scenario of Green Building Materials

A considerable number of industry professionals perceive interest in environmentally responsible buildings as moderate (25.5%) or low (39.2%). When it comes to construction materials, 21.6% believe there is little enthusiasm for eco-friendly options. While 11.8% of respondents reported significant interest, only 2% rated it as very high. Participants were also asked to evaluate their knowledge of eco-friendly building materials, with responses ranging from beginner

to expert levels. Only 20% of respondents lacked awareness of eco-friendly building materials. The survey revealed that merely 27% of firms have adopted or are in the process of adopting eco-friendly materials. In contrast, 73% of organizations neither use nor are involved in adopting eco-friendly building practices. Most construction workers have a favorable outlook on the future of eco-friendly building materials. An overwhelming 96% of industry experts advocate for the introduction of eco-friendly building materials in Pakistan. When asked about the future of green building materials, only 2% of Pakistani respondents opposed the idea, whereas 52.9% expressed support.

4.3. One-Way ANOVA

A one-way ANOVA was used to examine potential differences in respondents' perceptions based on their education levels. The study found no significant variations in respondents' educational levels for the seven questions. This suggests that education level does not significantly influence the responses to these questions, indicating a uniform perception across different educational backgrounds. Further analysis could explore other demographic factors or combine multiple variables to assess their collective impact on perceptions.

4.4. Relative Important Index (RII)

In the dataset, the RII serves as a key measure of significance and dependability. Its primary role is to assess the importance and reliability of each element or question. The RII values are computed by summing the weighted scores for each item and then dividing by the maximum possible weighted total, which is five times the number of respondents. The RII values range from approximately 0.438 to 0.792. An increased RII indicates greater importance or credibility of an item according to the respondents' feedback. This evaluation is based on thorough data analysis. Overall, questions with higher RII values had more positive and consistent replies, indicating their perceived importance or reliability in the survey or assessment context. The RII is a great tool for prioritizing and focusing on problems that survey participants deem most important or trustworthy.

The variation in RII values across the dataset highlights the relative emphasis placed on different elements by respondents. Elements with higher RII scores are perceived as more critical or credible [48], which could be reflective of their relevance to the respondents' experiences or priorities. For example, items with an RII closer to 0.792 may represent core areas of concern or importance that warrant more attention and action. Conversely, items with lower RII values, closer to 0.438, might indicate areas that are perceived as less significant or less reliable. This could suggest a need for further investigation to understand why these items are rated lower [48]. It may be beneficial to examine the context or specific details of these lower-rated items to identify potential gaps or misunderstandings that could be addressed in future research or surveys. Additionally, the RII provides a quantifiable metric that can aid in decision-making processes by highlighting which issues or elements are deemed most crucial by the respondents [49]. This can help prioritize resources and efforts towards areas that are most valued or seen as problematic. The broader interpretation of RII results can also support strategic planning and targeted interventions based on the aggregated feedback from the survey participants (see Figure 5).

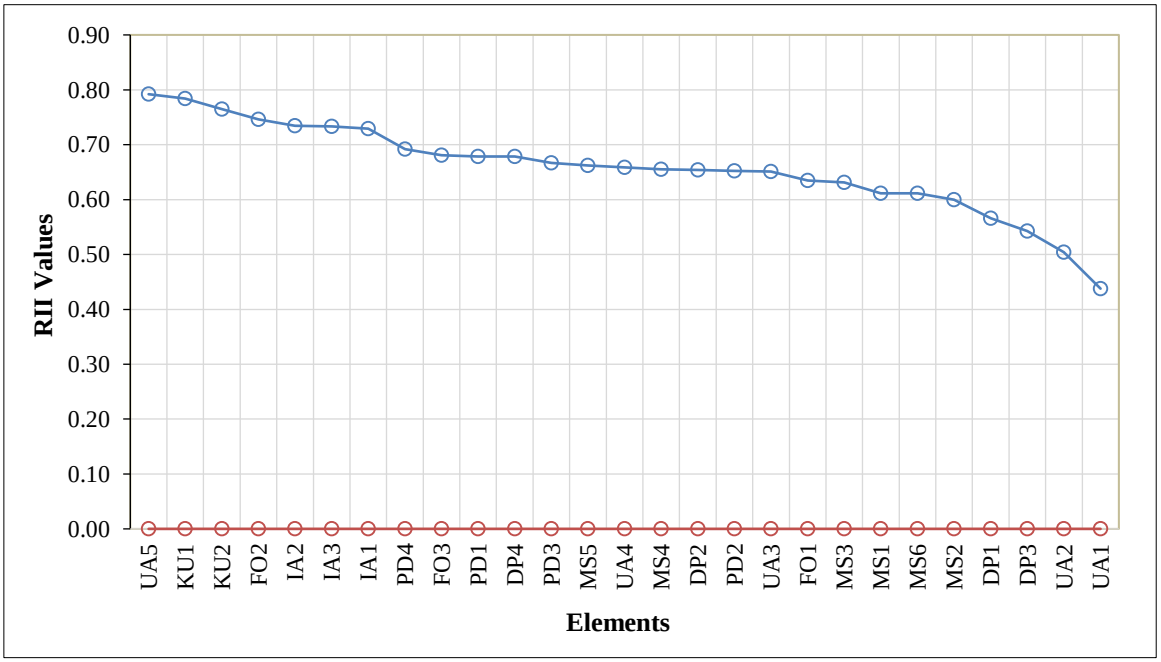

Figure 5. Overall RII of variables involved in research

4.5. RII Analysis of Elements

The 'benefit-cost ratio' concept for green construction materials frequently emerges in discussions. It was rated by respondents as a highly significant and credible factor, with an RII of 0.792. Green building materials promote sustainable construction, mitigate environmental impacts, conserve resources, and enhance living conditions. The substantial RII of 0.659 underscores the importance and reliability of this factor. This item has a high RII, reflecting its significance. However, despite its importance, its RII value of 0.438 suggests lower reliability compared to other factors. Most respondents in Pakistan have utilized green building materials in their projects, but this lower RII indicates less consistent confidence in this aspect. Key drivers for green building demand encompass sustainability objectives, energy savings, government incentives, and corporate social responsibility. With an RII of 0.566, this factor has a lower relative significance compared to other more impactful elements in the dataset. Green construction materials have one of the lowest RII ratings (0.542). Are there any misconceptions or impediments to customer perception? This indicates that it is one of the least significant components. Overall, the feedback for all elements is positive. Several items exhibit substantial and dependable RII values, with a high proportion of affirmative responses. The level of positivity the survey or evaluation desires depends on its context and purpose. It is essential to consider aims and expectations while analyzing answers.

4.6. Validation

After analysis, the findings and outcomes underwent comprehensive validation. This process entails evaluating the method's effectiveness in fulfilling its intended purpose. Consequently, expert validation was carried out to assess the study’s accuracy and validate the results. This method was employed to ensure that the research outcomes were thorough and unbiased. To verify the research findings, a structured questionnaire survey was employed as the preferred method. It was distributed to 10 experts who participated in the pilot test and showed significant interest in the topic. A Likert scale was used to gauge participants' agreement with each survey question, thereby aiding the validation process. The survey questionnaire was structured to assess resilience and accessibility, with the additional goal of pinpointing areas that may require further enhancement. Closed-ended questions were employed in the survey to gauge the participants' level of agreement.

5. Conclusion

Pakistan's construction industry needs to use green materials. A mere 27% of construction firms nationally employ green building materials, but 73% of Pakistani construction companies do not use green building materials. Pakistan's construction industry needs technology transfer to promote eco-friendly building materials. Employers, designers, contractors, and suppliers need more cooperation in the building industry. Mismanagement and performance evaluation can result from project life cycle coordination issues. The report found that Pakistani consultant and contractor websites are poorly constructed and lack progress monitoring. Limited awareness and expertise among professionals further impede progress, as does the high cost and limited access to financing for sustainable technologies. Additionally, complex regulatory barriers and cultural resistance to change from traditional practices pose significant challenges. Capitalizing on existing initiatives such as the CPEC projects, which include infrastructure development, alongside partnering with the Pakistan Green Building Council, can advance sustainable practices. Integrated design and better communication are needed to solve construction coordination issues. Green construction materials are becoming more popular despite hurdles.

As knowledge grows, the RII for advantages is around 1, indicating gradual adoption barrier elimination. Formal and informal schooling in Pakistan needs an understanding of green building materials. Pakistani civil engineering graduates may need to learn more about green building materials due to lacking construction engineering and management education. This could involve creating dedicated courses on sustainable construction and eco-friendly materials, alongside integrating these subjects into current courses such as materials science, construction technology, and environmental engineering. Encouraging research projects that focus on local applications of sustainable materials can further enhance students' understanding and innovation in this field. Green building materials education at universities can better prepare future specialists for implementing these technologies. Universities and continuing education organizations could offer green building materials technology workshops and training. According to the report, employers, especially public sector ones, should promote green building materials, which may be included in architect, consultant, and contractor contracts for design and planning.

Pakistani architects use green building materials more than other construction professionals. Karachi, Pakistan also adopts more than the nation. Establishing a regulatory framework with strict building codes mandating eco-friendly materials and setting environmental standards would ensure compliance and drive industry change. Promoting innovation and local sustainable materials can be achieved by supporting research and development through funding and fostering public-private partnerships. Larger-scale and peer monitoring systems help these projects use green

construction materials. Pakistan is vulnerable to natural and man-made disasters. Thus, sustainable building methods are crucial for its future. The workplace culture may impact construction operations. Awareness campaigns and academia need to adopt new technologies gradually that can reduce change resistance. Cultural factors that hinder the adoption of green building materials in Pakistan include a strong preference for traditional construction methods, driven by familiarity and perceived reliability. Builders and consumers frequently exhibit resistance to change, with skepticism surrounding the effectiveness and durability of novel materials. Demonstration projects can showcase their effectiveness and cost-efficiency, while community engagement can build trust and acceptance. Notably, 80.5% of participants expressed a need for deeper expertise in green construction materials. The internet has leveled the playing field, providing equal access to information for professionals worldwide. Many Pakistani engineers and workers, particularly those working in the Middle East and South Asia, bring valuable insights into advanced building technologies. While these professionals understand the benefits of green materials in enhancing design quality and project efficiency, they may underestimate the impact on cost, time, and labor savings. However, there is overwhelming support for green materials, with 96% in favor. To further promote their adoption, stakeholders should review completed projects, identify challenges, and propose targeted solutions specifically involving green materials. This practical approach will not only enhance understanding but also encourage the broader application of green materials in Pakistani construction projects.

5.1. Recommendations

A multi-layered approach is needed to boost Pakistan's construction industry towards sustainability. Firstly, conducting comprehensive surveys among builders, suppliers, and architects is crucial. These surveys will unveil the current utilization of green building materials, highlighting areas for improvement and investment. Secondly, initiating workshops and educational programs targeting stakeholders is vital. By spreading knowledge about the benefits and accessibility of green materials, stakeholders can be empowered to make informed choices, thus developing a culture of sustainability. Furthermore, incentivizing the adoption of eco-friendly materials is pivotal. Offering tax exemptions and subsidies incentivizes the integration of these materials into construction projects, thereby driving market demand and affordability. Lastly, establishing a robust monitoring system is essential for long-term evaluation. This system will track green materials' environmental impact and cost-effectiveness over time, ensuring accountability and guiding future policy decisions. By implementing these recommendations, Pakistan can navigate towards a greener, more sustainable construction sector, benefiting both the environment and the economy.

6. Declarations

6.1. Author Contributions

Conceptualization, M.T.B. and A.B.K.; methodology, M.T.B., A.B.K., K.R., F.F., and S.S; software, M.T.B., K.R., S.S., M.H.K., and S.S.; validation, K.R., and S.S.; formal analysis, F.F.; investigation, A.B.K.; resources, M.H.K.; data curation, M.T.B.; writing—original draft preparation, A.B.K. and M.T.B; writing—review and editing, K.R.; visualization, S.S.; supervision, A.B.K., M.T.B., and M.H.K.; project administration, F.F.; funding acquisition, M.H.K. and M.T.B. All authors have read and agreed to the published version of the manuscript.

6.2. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

6.3. Funding and Acknowledgments

This study appreciates the contributions of all the authors and the generous resources provided by CECOS University and INTI International University.

6.4. Institutional Review Board Statement

Not applicable.

6.5. Informed Consent Statement

Not applicable.

6.6. Declaration of Competing Interest

The authors declare that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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