Environmental Challenges 14 (2024) 100841

Contents lists available at ScienceDirect

Environmental Challenges

journal homepage: www.elsevier.com/locate/envc

Sustainable leadership practices in construction: Building a resilient society

Ahsan Waqar[a,*], Moustafa Houda[b], Abdul Mateen Khan[a], Abdul Hannan Qureshi[c], Gremina Elmazi[b]

[a] Department of Civil and Environmental Engineering, Universiti Teknologi PETRONAS, Bandar, Seri Is-kandar, Tronoh, Perak 32610, Malaysia
[b] College of Engineering and Technology, American University of the Middle East, Kuwait
[c] Department of Building and Real Estate, Faculty of Construction and Environment, The Hong Kong Polytechnic University, Kowloon, Hong Kong 999077, China

ARTICLE INFO

Keywords:
Green building design
Certification standards
Life cycle assessment
Renewable energy integration
Resilient infrastructure
Social equity and inclusion
Waste management

ABSTRACT

While pivotal for economic growth, the global construction sector confronts critical challenges due to its resource-intensive practices and environmental impact. Leadership within this industry becomes essential as the imperative for sustainable development gains prominence. This study addresses a significant knowledge gap by investigating the nexus between sustainable leadership practices and the construction sector, focusing on Pakistan. A comprehensive framework is developed by combining literature review, expert analysis, and robust statistical methods. Data collection involved questionnaire involving 206 participants from construction industry professionals in Pakistan. The study examines the relation of green building design, certification standards, life cycle assessment, renewable energy integration, resilient infrastructure, social equity and inclusion, and waste management with sustainable leadership practices. The findings affirm the positive and significant relationships between these dimensions and sustainable leadership. The study contributes to academia and industry, offering a novel understanding of how sustainable leadership can drive resilient and eco-conscious practices in construction. These insights hold implications for shaping policies, fostering industry transformation, and creating a sustainable and resilient built environment for the future.

1. Introduction

The construction sector is essential to developing global infrastructure and contributes to economic expansion and social progression. However, traditional methods have come under investigation due to the extensive use of resources they need and the significant damage they do to the environment (Foldy and Ospina, 2023). For example, the building industry uses almost half of the world's steel, cement, energy, and other raw materials, significantly depleting limited resources (Indrayana and Pribadi, 2023; Ghorbani, 2023). In addition, building and construction activities are also responsible for around 36 % of the world's total greenhouse gas emissions and almost 40 % of the entire energy used globally. In addition, it is believed that somewhere between 25 and 40 percent of the world's solid waste is the result of activities related to building and demolition (Gordeev, 2023).

Concurrently, the 21st century has witnessed an unparalleled focus on sustainable development, urging many businesses to match their practices with the sustainability of the environment, society, and the economy (Anon, 2023; Nguyen and Nguyen, 2023).

When seen in this light, the function of leadership within the construction industry is increasingly important. Leaders have the power to influence decision-making, be the driving force behind innovation, and chart the direction for the culture of their organizations. On the other hand, traditional forms of leadership often prioritize short-term profits more than long-term sustainability (Das et al., 2023; Othman and Elwazer, 2023). This contrast has generated a general recognition that leadership methods need to develop to meet the business's myriad of difficulties and possibilities (D'Ambrosio and Longobardi, 2023; Waqar et al., 2023).

Building a resilient society is inextricably linked to the shift toward more sustainable leadership, which should not be seen as only an idealistic goal but a practical requirement. In an age characterized by environmental instability, resource scarcity, and social complexity, it is vital for society's flexibility to have robust infrastructure (Oyewobi and Jimoh, 2022). The growing frequency and severity of climate-related catastrophes have resulted in worldwide losses totaling over $3 trillion over the last decade, highlighting the critical need for robust infrastructure. Furthermore, around 70 percent of the world's

* Corresponding author.
E-mail address: ahsan_21002791@utp.edu.my (A. Waqar).

https://doi.org/10.1016/j.envc.2024.100841
Received 31 August 2023; Received in revised form 3 January 2024; Accepted 11 January 2024
Available online 12 January 2024

population will reside in urban regions by 2050. This will pressure buildings to provide sustainable urban settings (Waqar et al., 2023; Zaman et al., 2023).

Despite the apparent need for sustainable leadership in the construction sector, there still needs to be a discernible knowledge gap about integrating and executing sustainable leadership principles successfully (Hashim et al., 2022; Banmairuroy et al., 2022). This is the case even though the need for sustainable leadership is urgent. Researching the dynamic interaction between conventional leadership structures and the creative requirements of environmentally friendly development is necessary within the building industry. The present body of literature offers some insightful takeaways, but there is yet to be a complete framework that can fill up this knowledge vacuum (D'Ambrosio and Longobardi, 2023; López Paredes et al., 2023). This paper explores the complex confluence between sustainable leadership practices and the construction industry to fill the gap left by previous research.

The construction industry, which plays a significant role in global economic progress, is confronted with an increasingly pressing issue of ensuring environmental sustainability and optimising resource utilisation. The present difficulty, which is further intensified by the resource-intensive characteristics of building practices, necessitates the development of novel solutions that transcend simple acknowledgement of the issue. The need to address the disparity between challenges and resolutions is of utmost importance, with sustainable leadership emerging as a potentially crucial factor. The primary objective of this research is to provide a comprehensive understanding of the relationship between sustainable leadership practices and the sustainability issues faced by the construction industry, with a specific focus on the unique circumstances of Pakistan. By examining the interplay between sustainable leadership attributes and several facets of sustainable construction practices, our objective is to create a complete conceptual framework that may provide guidance for the transformation of the industry.

Further there is an urgent need for environmental sustainability and optimised resource utilisation in the construction industry, which is a cornerstone of global economic success. There has been a need for creative solutions that go beyond just recognising the problem, since the industry's traditional practises are resource-intensive. In light of the pressing need for sustainable development in the modern period, our study fills this knowledge gap by investigating the complex relationship between sustainable leadership practises and the many obstacles faced by the construction sector.

This study is notable for its originality because it investigates the relationship of sustainable leadership and the construction industry and delves into relatively uncharted territory in Pakistan. This research stands out as one of the few committed attempts in Pakistan's academic community to systematically concentrate on sustainable leadership practices in the construction sector. In an area where the construction industry significantly contributes to economic development, this study stands out as one of the few focused efforts. In addition, this study uses cutting-edge research methods, such as an in-depth Structural Equation Modeling (S.E.M.) analysis, which contributes to the research's overall level of rigor and supports its conclusions.

The study's unique contribution is its original method to examining sustainable leadership practises in the construction industry of Pakistan. Prior studies have investigated sustainable leadership in the construction industry. However, the research distinguishes itself by integrating a literature review, expert analysis, and rigorous statistical methods, providing a complete and multifaceted viewpoint. The research distinguishes itself by encompassing a wider range of sustainability dimensions through the incorporation of various factors, including green building design, certification standards, life cycle assessment, renewable energy integration, resilient infrastructure, social equity and inclusion, and waste management.

By delving deeply into sustainable leadership practises within Pakistan's specific environment, this study is a trailblazer in the field of construction industry research. There is a significant lack of research on the unique possibilities and threats faced by the Pakistani construction industry, despite the abundance of literature on sustainable building practises. To fill this need, this study developed a thorough framework that accounts for the complex dynamics of sustainable leadership within a given geographical context in addition to the more traditional sustainability components. The research sheds new light on the complex issues faced by the construction sector in Pakistan and how sustainable leadership practises interact with them. This study lays the groundwork for a more sophisticated understanding of how sustainable leadership may create transformational change within a given geographical setting by using advanced analytical tools and conducting a wide-ranging assessment of sustainability factors.

This article results from coming to terms with the complexities involved in the building sector influencing the world's landscape. It aims to contribute to closing the gap on sustainable leadership, specifically for the building and construction industry. This research aims to illuminate a pathway for leadership practices that not only construct physical structures but also build the foundation for a resilient and sustainable society, meeting the demands of the present without compromising the future. This will be accomplished by analyzing the industry's challenges and opportunities. Fig. 1 shows the hypothesis of the study on which the study is based, indicating green building design, green certification standards, life cycle assessment, renewable energy integration, resilient infrastructure development, social equity and inclusion and lastly, waste management and recycling have significant relation with the sustainable leadership practices implementation.

2. Literature review

Sustainable leadership (S.L.) is a concept that has emerged in response to the changing and challenging market scenario, which is influenced by factors such as globalization, complexity, instability, technical advances, high-performance pressure, fatigue, and deviant actions. S.L. aims to create innovative and sustainable solutions by enhancing the awareness, perspectives, thinking and interactions of leaders and their followers (Oyewobi and Jimoh, 2022; Waqar et al., 2023). S.L. also motivates and influences employees to take sustainability actions for a better world in the present and the future and to achieve organizational goals beyond the usual business practices. S.L. applies sustainability principles to all levels of responsibility, from individuals to groups, organizations, and societies, and requires a personal contribution from everyone involved in the process, such as changing their thinking (Phinias, 2023). Sustainable development is a critical global issue that demands reducing the environmental impact while increasing the efficiency and competitiveness of industry and business (Waqar and Othman, 2023; Dubljević et al., 2023). However, many leaders and practitioners agree that sustainability should be implemented more. Therefore, integrated planning and management 4.0 is needed, which involves educating people, developing people, innovating, connecting access to resources, and transforming (Mohamed and Eltohamy, 2022; Khan et al., 2023). Leadership is one of the factors that facilitate the success of project managers, but it also depends on the collaboration of subordinates. A new leadership approach, like S.L., is needed to overcome these problems and guarantee the survival of construction industry organizations and communities (Khahro et al., 2023; Gbedemah, 2023).

Pakistan's construction industry is critical for the country's economic development and social welfare. However, it faces many challenges, such as low productivity, inferior quality, cost overruns, delays, lack of skilled workers, environmental degradation, and corruption (Khan et al., 2023; Waqar et al., 2023). These challenges hinder the adoption of green building practices, which are voluntary but believed to set sustainable building standards and awareness among the masses. The Building Code of Pakistan Energy Provision 2011 is the only regulatory framework that promotes energy conservation in buildings, but it

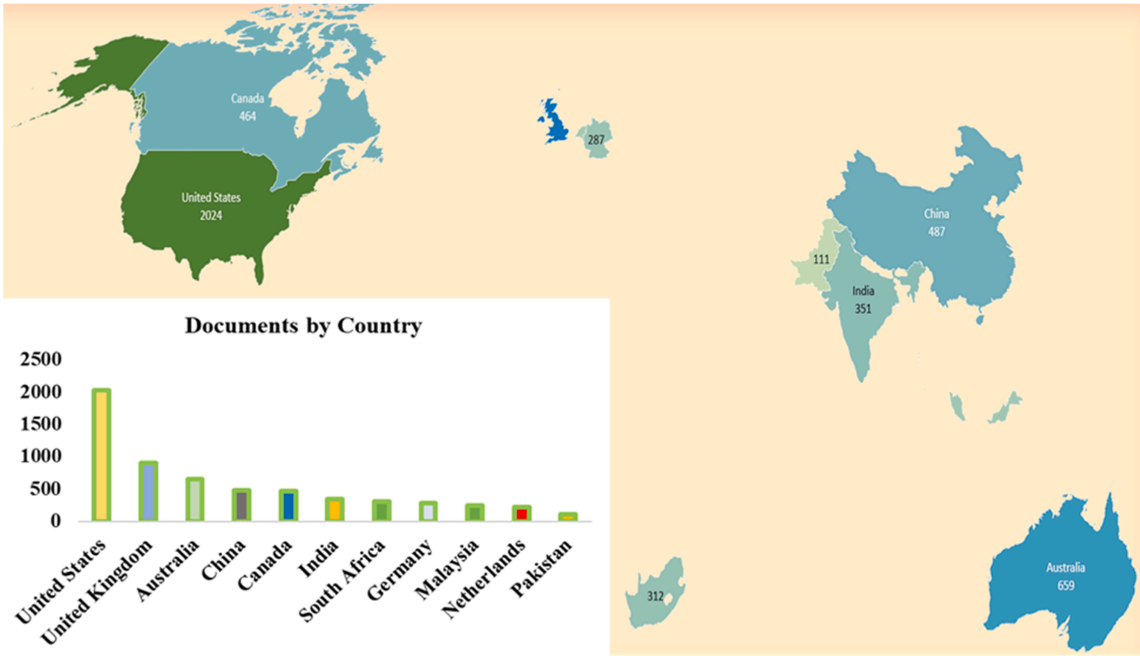

Fig. 1. Documents by country 20133–2023 (Source SCOPUS database).

has yet to be widely implemented or enforced. Therefore, there is a need for S.L. in the construction industry in Pakistan to address these issues and ensure long-term prosperity for the industry and society (Khahro et al., 2023; Deng et al., 2023). However, there needs to be more empirical research on S.L. in the construction industry in Pakistan, which limits the understanding of its benefits, barriers, drivers, and practices (Madson et al., 2022; Bouhmoud et al., 2023).

The materials retrieved from the Scopus database included scholarly papers, research articles, and conference proceedings pertaining to sustainable leadership and its implementation within the construction industry, with a specific emphasis on the context of Pakistan. It established inclusion criteria to incorporate materials that specifically addressed sustainable leadership practices within the construction sector. Conversely, exclusion criteria were used to filter out documents that were not related to the study's particular topic and did not contribute to the research. Fig. 1 is used to visually depict the geographical distribution of published research articles pertaining to sustainable leadership within the construction industry across several nations. The nations have been arranged in a hierarchical order according to the quantity of scholarly articles published, with the United States occupying the highest position and Pakistan situated at the lowest rank. The purpose of this graphic depiction is to provide a comprehensive overview of the worldwide research environment on this particular topic. The result highlights the United States as the primary donor and Pakistan as a comparatively under-researched country, underscoring the necessity for a targeted examination of Pakistan in our study. Further sustainability differs from the conventional notion of leadership in that it prioritizes long-term prosperity over short-term benefits. This means the leader's role is to boost production output and ensure it is produced sustainably (Waqar et al., 2023; Quyen et al., 2023). Organizations frequently need help creating a sustainable pool of people who can work efficiently in various cultural contexts (Karayel et al., 2023; Samuelsson et al., 2023). The organization must apply effective succession strategies to achieve effective leadership and create a sustainable management structure across the different functional units (Waqar et al., 2023). Leaders also need to learn leadership skills and knowledge and improve their self-perception of their abilities. Sustainable leadership comprises three aspects: sustainable management, sustainable projects, and sustainability activity (Das et al., 2023). Fig. 1 shows the distribution of published documents related with the scope and theme of this paper. It can be clearly seen that USA and other developed countries are taking the lead more significantly.

This literature review examines sustainable leadership practices in construction and their role in constructing a resilient society. Sustainable construction leadership practices employ a long-term vision, balance the constructed environment's economic, social, and environmental aspects, and involve diverse and inclusive stakeholders (Ma et al., 2023; Ramis et al., 2023). These practices can assist in coping with the challenges and opportunities that arise in the end-of-life decision phase of complex structures, which entails selecting the best option for the disposal or reuse of the built asset (Ma et al., 2023; Cheung et al., 2023). To support this examination, a document search was undertaken using the Scopus database and the relevant publications were evaluated and classified using V.O.S. Viewer, a tool for visualizing bibliometric networks. Fig. 2 displays the visual representation of the keywords related to sustainable leadership practices in construction and end-of-life decision phases. The review summarizes the current knowledge on this topic and highlights the voids and challenges that need to be addressed in future research.

The pursuit of sustainability within the construction industry is driven by a significant issue that extends beyond geographical limitations: the industry's reliance on resources and its consequential environmental consequences (Latiffi and Zulkiffli, 2022; Larsen and Brandenburg, 2023). Construction activities contribute significantly to the overall use of resources and creation of trash on a worldwide scale (Oyewobi and Jimoh, 2022; Hashim et al., 2022). The industry's significant dependence on energy and materials, often obtained from finite sources, not only puts pressure on natural resources but also plays a role in the release of greenhouse gases and the occurrence of climate change (Banmairuroy et al., 2022; Egwunatum et al., 2022). In addition, the industry has historically had challenges in the realm of waste management, resulting in adverse environmental impacts such as pollution and the depletion of resources (Maqbool et al., 2023; Górecki et al., 2022). In light of the growing global recognition of the significance of environmental and social responsibility, the construction sector is confronted with increasing demands to embrace sustainable methodologies (Das et al., 2023; Bouhmoud et al., 2023). This challenge requires an examination of sustainable leadership as a feasible approach to address these

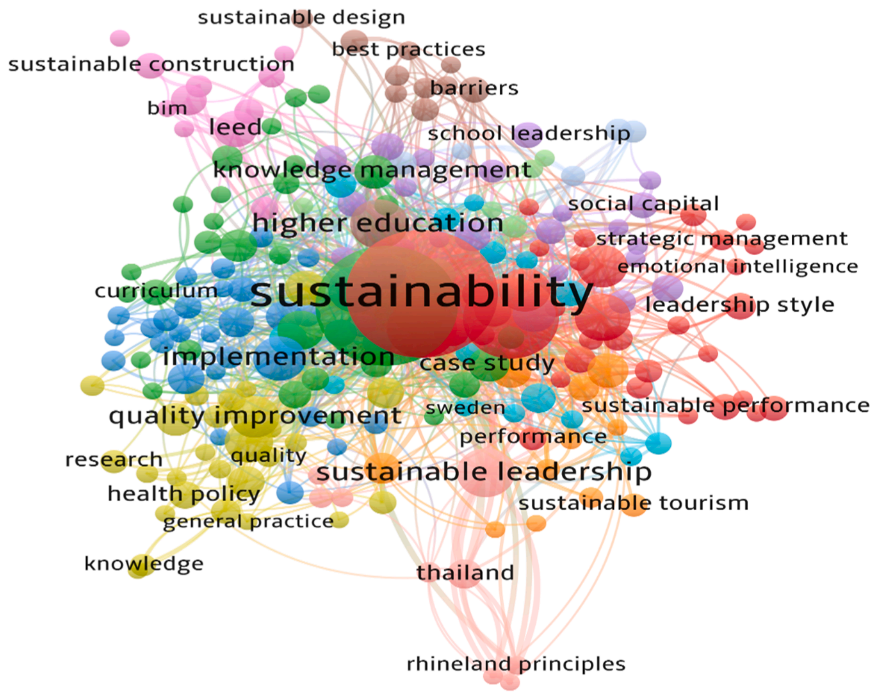

Fig. 2. Visual representation of the keywords.

urgent problems and propel the sector towards a more robust and environmentally aware future.

This literature review has explored the concept of sustainable leadership practices in construction and how they can help to build a resilient society in the face of environmental, social, and economic challenges. It has also examined the end-of-life decision phase of complex structures, which requires carefully assessing the options for disposal or reuse of the built asset (Cheung et al., 2023; Maqbool et al., 2023). The review has shown the need for more empirical research on sustainable leadership practices in the construction industry, especially in Pakistan, where the industry faces many issues, such as low productivity, poor quality, corruption, and environmental degradation. The review has also identified some of the benefits, barriers, drivers, and practices of sustainable leadership in the construction industry and some of the tools and methods that can be used to measure and improve its performance and sustainability outcomes (Maqbool et al., 2023; Waqar et al., 2023).

A complex knowledge of sustainable leadership practises in the construction industry was uncovered by the literature study, which highlighted the interdependence of several aspects. Important factors impacting sustainable leadership include green building design, certification requirements, life cycle assessment, integration of renewable energy, resilient infrastructure, social equality, and waste management. To create a construction sector that is both resilient and environmentally conscientious, previous research has shown that leadership strategies should be in line with social and environmental concerns. It is important to better comprehend the impact of sustainable leadership on the future of the construction industry thanks to the review's results, which guided the development of our conceptual framework.

3. Methodology

This study involved four essential sections, shown in Fig. 3; the first section involved conceptual study, which involves research framework development from the literature; the second stage is the questionnaire phase which includes designing the questionnaire; and the third stage is the S.E.M. analysis which consists of testing of hypothesis lastly the final stage is conclusion phase which is discussing the success of the study in terms of its designed concept. The connection between these methodologies is vital in attaining a full comprehension of sustainable

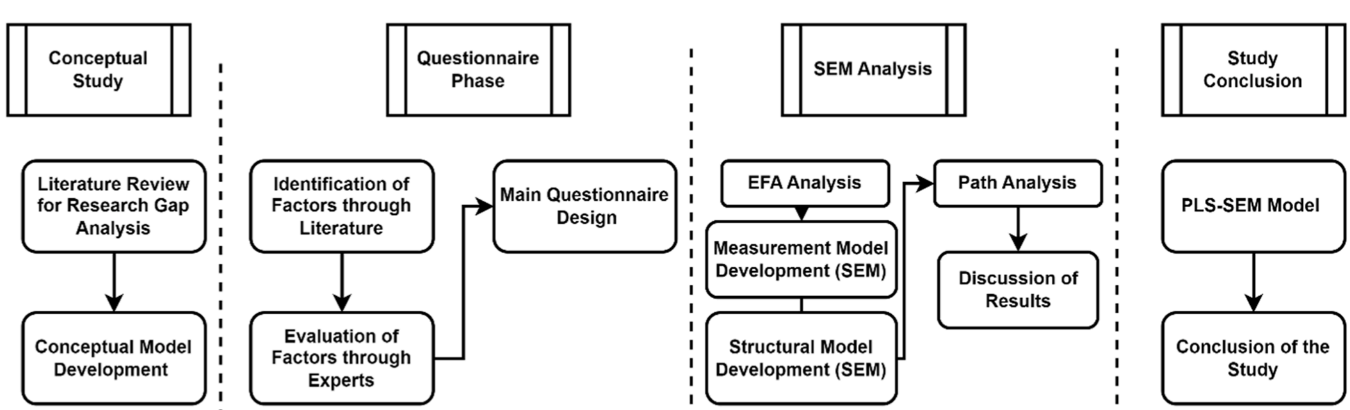

Fig. 3. Flow chart of the study.

leadership practices within the building industry. The expert analysis was undertaken in order to provide a qualitative viewpoint and verify the findings of the questionnaire. The incorporation of both quantitative and qualitative data enables a comprehensive examination of sustainable leadership practices within the particular context of Pakistan. In conducting the literature review, the method adhered to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement guidelines.

- **Identification:** We searched Scopus, PubMed, Web of Science, and Google Scholar. The search approach included "sustainable leadership," "construction industry," "green building," "Pakistan," and related topics. The first search yielded 1250 items.
- **Screening:** Titles and abstracts were reviewed to exclude extraneous research, reducing the pool to 600 articles. At this level, publications not about sustainable leadership or building were excluded.
- **Eligibility:** The remaining articles were full-text reviewed for relevance and quality. Studies on sustainable building and leadership were included. Excluded studies lacked empirical evidence or concentrated beyond Pakistan. This reduced the choices to 300 items.
- **Inclusion and data extraction:** We included 150 suitable articles that satisfied all our criteria and gave considerable subject insights. These research' major results, methodology, geographic emphasis, and theoretical frameworks were summarised during data extraction.
- **Synthesis:** The last step was synthesising these 150 publications' data. This synthesis presented a complete knowledge of sustainable leadership in construction, notably in Pakistan, and identified research gaps and possibilities.

Moving further, SEM is a sophisticated statistical methodology that enables the modelling and analysis of complex interactions (Hashim et al., 2022; Egwunatum et al., 2022). The examination of causal relationships and interactions among various factors aids in the exploration of the intricate connections between green building design, certification standards, life cycle assessment, renewable energy integration, resilient infrastructure, social equity and inclusion, and waste management in the context of sustainable leadership practices. The integration of various research methodologies and analytical tools offers a holistic perspective on sustainable leadership in the construction industry of Pakistan. This approach facilitated the integration of theoretical frameworks, as shown by the literature study, with empirical data obtained via questionnaires and expert analysis (Mohamed and Eltohamy, 2022; Maqbool et al., 2023). The selection of this method was based on its effectiveness in comprehensively addressing the many dimensions of sustainable leadership within the construction sector. Moreover, it aims to provide significant contributions by shedding light on the ways in which sustainable leadership may facilitate the adoption of environmentally aware practises and enhance the industry's ability to withstand challenges and changes.

3.1. Identification of factors through literature

The method used in this part consisted of a rigorous process that systematically identified and extracted essential elements related to sustainable leadership practices in the construction sector. This method thoroughly examines the relevant literature to build a framework for future analyses and debates (Lee and Ashuri, 2023; Kuzucuoğlu et al., 2023). The goal of this method is to develop a comprehensive foundation. The selection of systematic literature review strategy was based on its systematic and rigorous approach to the collection and examination of pertinent scholarly articles. The process of conducting a systematic literature review entails the use of predetermined search criteria, a meticulously designed search strategy, and a rigorous selection procedure aimed at including only those studies that satisfy certain criteria.

During the implementation of our systematic literature review, we used prominent databases such as Scopus, Web of Science, and Google Scholar. Search string involved, Search String: "sustainable leadership practices in construction" AND "Pakistan" AND "green building design" OR "certification standards" OR "life cycle assessment" OR "renewable energy integration" OR "resilient infrastructure" OR "social equity and inclusion" OR "waste management". The investigation was carried out via a meticulously chosen collection of keywords and a search string customised to meet the specific criteria of the research. Our search included the relevant literature over the last decade. The selection criterion prioritised peer-reviewed research publications and conference proceedings, with a strong focus on studies pertaining to sustainable leadership practises in the construction industry, particularly within the specific context of Pakistan. A thematic analysis was undertaken in order to classify and integrate the material that was discovered. The following is an outline of the methodology:

In the first step of the process, a methodical approach to the literature search is used to access a wide variety of scholarly materials (Lee and Ashuri, 2023; Chen et al., 2023). These resources may include recognized databases, academic journals, conference proceedings, and authoritative reports. This approach uses many search terms, including restricted vocabulary, Boolean operators, and carefully selected keywords, to guarantee that relevant research is retrieved.

Afterward, the selection criteria are applied to these acquired materials, focusing on peer-reviewed publications, case studies, reviews, and reports centered on sustainable leadership methods within the construction industry (Chen et al., 2023; Turnbull et al., 2023). The chosen studies give new insights into the elements that influence sustainable leadership. These factors include social inclusion, ethical decision-making, environmental responsibility, and economic viability.

To begin the data extraction and synthesis process, relevant information from the selected research must first be extracted methodically (Waqar et al., 2023a). We have selected critical aspects connected to environmentally responsible leadership practices and arranged them in an organized (Lee and Ashuri, 2023; Chen et al., 2023). The next step is to utilize thematic analysis to classify and arrange these aspects into consistent themes, making it easier to recognize overarching patterns and trends that may be found throughout the text (Latiffi and Zulkiffli, 2022).

A expert review process is implemented into the research design to strengthen the validity and dependability of the discovered elements and themes. The input and recommendations of specialists in sustainable leadership, construction management, and sustainable development are requested and considered (Chen et al., 2023; Turnbull et al., 2023). The iterative approach to developing the factors improves the entire framework's resilience.

The framework that is ultimately produced as a consequence of this methodical process of identifying relevant prior research will be used as the foundation for future analyses and debates included within the paper. This method paves the way for more empirical investigation and model validation since it places these aspects within the broader landscape of sustainable leadership practices in the construction sector (Górecki et al., 2022; Turnbull et al., 2023).

3.2. Evaluation of factors through expert analysis

A meticulous expert study was carried out to strengthen the credibility and completeness of the synthesis framework that outlines sustainable leadership practices within the construction sector. This was done to strengthen the credibility of the framework. This evaluation is being carried out with the participation of sixteen highly experienced industry professionals, each of whom has worked in the building and construction industry for over 15 years. Because most of these specialists have held management and other leadership responsibilities in the past, they have a wide variety of valuable insights that result from their significant experience (Waqar et al., 2023h, 2023i). This is of the utmost importance.

The professional evaluation was carried out in the following methodical order:

- The chosen professionals were singled out for their outstanding skill and thorough acquaintance with the building world. Because of their leadership positions and management responsibilities within the sector, they were excellently suited to deliver insightful opinions on effective, environmentally responsible leadership methods.
- The myriad of aspects derived from the research was painstakingly compiled into an orderly structure before being presented to the specialists (Mergos, 2023; Tran et al., 2023). This presentation included explanations of the elements, thematic groupings of those characteristics, and the implications those explanations have for fostering sustainable leadership in the construction industry (Banmairuroy et al., 2022; Hu and Shu, 2023).
- The experts participated in intentional discussions by exchanging the thoughts gained from their extensive professional experiences. These dialogues took the form of interviews or questionnaires. Because of their significant practical experience, their contributions covered a wide range, ranging from validation and refinement to even prospective augmentations (Banmairuroy et al., 2022; Lühr et al., 2023). This was made possible by their excellent hands-on expertise.
- The insights obtained from the expert cohort were subjected to a careful synthesis, and then an in-depth analysis was performed on them. During this process, common threads, convergences, and variances across their points of view were identified, which led to the crystallization of visible patterns (Hashim et al., 2022; Egwunatum et al., 2022).
- The assessment started on an iterative path, with repeated rounds of expert comment and revision invited (Jiang et al., 2022; Elkhapery et al., 2023). This iterative approach enabled a complete and multifaceted review of the discovered elements, bringing together contrasting points of view in the process.
- The findings that emerged from the expert analysis were meticulously compared and contrasted with those obtained during the preliminary phase of literature extraction (López Paredes et al., 2023; Elkhapery et al., 2023). Using this triangulation method, we confirmed a resonance between the variables, academic viewpoints, and practical industrial knowledge.
- Invigorated by the contributions and insights of the expert panel, the improved framework emerged as an excellent resource for additional analyses, debates, and empirical studies included within the paper (López Paredes et al., 2023; Zhang and Dong, 2023).

3.3. Questionnaire plan

The questionnaire has been designed to identify factors through literature review and expert analysis. The research approach that was used for this stage consisted of doing a quantitative analysis of the results of a questionnaire that had been painstakingly constructed. The questionnaire inquired about sustainable leadership practices in the building and construction business. The questionnaire was distributed across the research region of Rawalpindi, located in Pakistan (Latiffi and Zulkiffli, 2022; Zenteno et al., 2023). The following is an overview of the methods that may be used going forward:

To investigate the topic of sustainable leadership practices within the construction sector in a comprehensive manner, a quantitative method was used. The questionnaire was essential for collecting quantitative data, which were then analyzed statistically to provide empirical insights. These findings inform future research and policy decisions (Banmairuroy et al., 2022; Egwunatum et al., 2022). Fig. 4 is presenting the hypothesis of the study on which the questionnaire was constructed for data collection. Hypothesis are as follows.

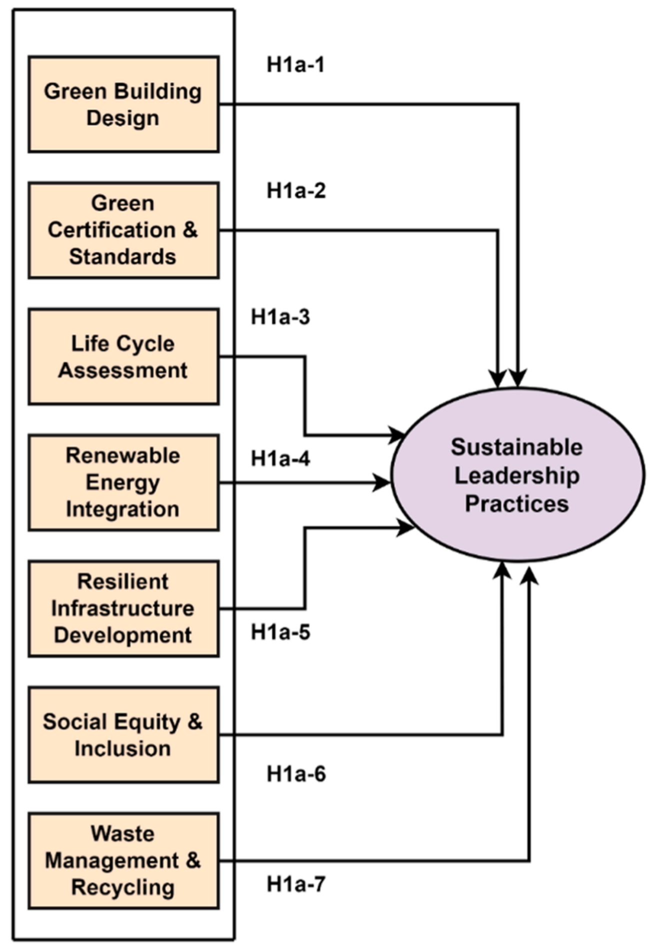

Fig. 4. Hypothesis of the study.

- H1: Green building design positively affects sustainable leadership practice.
- H2: Green certification and standards positively affects sustainable leadership practice.
- H3: Lifecycle assessment positively affects sustainable leadership practice.
- H4: Renewable energy integration positively affects sustainable leadership practice.
- H5: Resilient infrastructure development positively affects sustainable leadership practice.
- H6: Social equity and inclusion positively affects sustainable leadership practice.
- H7: Waste management and recycling positively affects sustainable leadership practice.

The study sample consisted of experts and stakeholders operating within the construction industry in Pakistan. In order to gather participants for our study, we used a purposive sample method, specifically focusing on persons who had knowledge and experience in the areas of sustainable leadership and building practices. The study procedure was conducted with a strong emphasis on ethical concerns, and strict adherence to ethical regulations and norms regulating research involving human participants was maintained in order to uphold the highest standards of research conduct. To safeguard the credibility and ethical validity of our study, informed consent was also taken. The questionnaire was meticulously prepared, and it used a Likert scale with five points to examine respondents' viewpoints on various environmentally responsible leadership methods (López Paredes et al., 2023; Elkhapery et al., 2023). The questionnaire, which was constructed using proven concepts found in the existing body of research, included a variety of topics such as environmental stewardship, ethical decision-making, social inclusion, and economic viability, among others. The design of the structured questionnaire ensured that replies would be consistent and similar.

To participate in the poll, 296 individuals were contacted and asked to participate. A respectable response rate of 69 % was achieved due to the questionnaire's successful collection of 206 valid replies. The questionnaire was disseminated via many email channels, making participation convenient and easy for many people. In addition, to guarantee that a varied pool of responses was collected, the questionnaire was also personally distributed to local experts who lived within the research region (Hashim et al., 2022; Banmairuroy et al., 2022; López Paredes et al., 2023).

Careful thought was made to guaranteeing the data obtained was representative and relevant while choosing the participant sample for this research. The sample includes 206 individuals who are now working as professionals in Pakistan's construction business. The rationale for this decision is that studying sustainable leadership practises in a local setting requires experts with first-hand knowledge and experience (Egwunatum et al., 2022; Górecki et al., 2022). Architects, engineers, project managers, and sustainability experts were among the carefully chosen participants from the building industry. The goal in embracing diversity is to have a well-rounded understanding of sustainable leadership in all its aspects. Further adding to the study's generalizability is the geographical distribution of its participants, who hail from all throughout Pakistan (Banmairuroy et al., 2022; Mohamed and Eltohamy, 2022).

The research was carried out in Rawalpindi, Pakistan, which is recognized as an essential metropolitan hub in the building and construction sector (Tran et al., 2023; Hu and Shu, 2023). The study region was chosen so that the researchers could contribute to the more extensive debate on sustainable building practices while also gaining insights into sustainable leadership methods applicable within the local area's unique context.

The method combines quantitative analysis with a thorough questionnaire design, and it is rooted in the city of Rawalpindi, which is located in Pakistan. The adopted Likert-scale questionnaire adequately evaluated respondents' impressions of sustainable leadership practices, allowing for statistically valid results and meaningful comparisons. In the context of the construction industry's sustainable leadership environment, the substantiated sample size and the results from earlier research lend credence to the validity of the study's conclusions (Waqar et al., 2023h; Hu and Shu, 2023).

3.4. Structural Equation Modeling (S.E.M.) analysis

Exploratory Factor Analysis (E.F.A.) and Partial Least Squares Structural Equation Modeling (PLS-SEM) are two of the most critical analytical procedures used in the research approach. Each method uses its own set of criteria and software tools.

- **Exploratory Factor Analysis (E.F.A.):** In this study, we used E.F.A. to unearth latent variables that reflect sustainable leadership approaches. The extraction method, Principal Component Axis, was used for the E.F.A. It looked at factors whose Eigenvalues were more significant than 1.0 (Górecki et al., 2022; Jiang et al., 2022). The factors were rotated using the Varimax method to improve their interpretability; nonetheless, only the items with loadings of more than 0.6 were kept for each factor (Dubljević et al., 2023; Khahro et al., 2023).
- **P.L.S. measurement modeling:** The SmartPLS 4 program was used for the PLS-SEM study. The robustness of the measurement model was evaluated based on convergent validity, discriminant validity, and other aspects of validity. Convergent validity was shown by item loadings higher than 0.7 and average variance extracted (AVE) values higher than 0.5 (Phinias, 2023; Waqar and Othman, 2023). When the square root of the AVE for each construct was more significant than its correlations with other constructs, this indicated that the discriminant validity of the model was intact. Path coefficients, t-values, and p-values were used to analyze the structural model's performance (Latiffi and Zulkiffli, 2022). This test determines the extent to which the correlations between constructs compare to those between indicators included inside a construct. The cutoff point, in terms of discriminant validity, is established at 0.85 (Mohamed and Eltohamy, 2022; Madson et al., 2022). This test confirms that the constructions have a stronger relationship to the indicators of their construct than to the indicators of other constructs. Within this criteria, a comparison is made between the square root of the AVE for each construct and its connections with other constructs. When the average variance extracted (AVE) of each concept is shown to be higher than its correlation with the other constructs; discriminant validity has been established (Quyen et al., 2023; Samuelsson et al., 2023). Cross-loadings are computed during PLS-SEM, and their purpose is to measure the strength of correlations between indicators and their target constructs in comparison to relationships between indicators and other constructs. The discriminant validity is adequate when the cross-loadings are more significant on the targeted concept than on others.
- **Analysis of the structural model and path analysis**: 5000 bootstrap samples were used to analyze the structural model created using the bootstrapping method. This approach made the computation of path coefficients, standard errors, t-statistics, and p-values easier (Ma et al., 2023; Ramis et al., 2023). When the path coefficients were significant (p 0.05), and the t-values of the hypotheses surpassed 1.96 (at a 95 % confidence level), the researchers considered the hypotheses to be supported.
- **A test of the predictive relevance (Q2):** Using SmartPLS 4, the predictive relevance test analyzed the Q2 values connected with the endogenous latent constructs. A positive score for Q2 revealed that the model had predictive relevance and proved the constructs' capacity to anticipate the changes in their respective indicators. Additionally, the model's ability to forecast these variations was proven.

4. Results and analysis

4.1. Identified factors through literature and expert analysis

Table 1 provides a detailed summary of the discovered criteria, developed from the literature research and then evaluated by domain experts. The outcomes of the study are shown in this table. These aspects of sustainable leadership practices within the construction sector are broken down into thematic groupings, with each group shedding light on important facets of these practices.

Green Building Design: This collection of considerations highlights the significance of incorporating environmentally responsible policies and procedures into the building design process. Actions such as reducing resource use, selecting environmentally friendly materials, and implementing energy-efficient technologies help reduce an organization's environmental imprint and reflect an organization's commitment to sustainability. The use of cutting-edge technology better aligns enterprises with the shifting landscape of their respective industries, therefore placing them as agents of constructive change (Quyen et al., 2023; Samuelsson et al., 2023).

Waste Management and Recycling: The components that make up this category shed light on the critical need for implementing waste management and recycling plans. These methods help reduce waste produced by building projects, reduce the burden placed on landfills, and lessen the negative effect of trash disposal on the environment. Adopting these methods not only complies with the principles of sustainable leadership but also encourages the appropriate management of

Table 1
Identified factors from the literature review and verified by experts.

Group	Code	S.L.P. Implementation Factors	Refs.
Green Building Design	GBD1	Reduces both resource consumption and refuse production.	Gbedemah (2023), Madson et al. (2022)
	GBD2	Selects eco-friendly and locally sourced materials to reduce environmental impact.	Banmairuroy et al. (2022), Tran et al. (2023)
	GBD3	Focuses on energy-efficient insulation, lighting, and HVAC systems to reduce energy consumption.	Interview
	GBD4	Seek out innovative technologies and methods for sustainable design.	Hashim et al. (2022), Lühr et al. (2023)
	GBD5	Informs stakeholders regarding the environmental benefits of ecological design.	Ghorbani (2023), Othman and Elwazer (2023)
Waste Management & Recycling	WMR1	Reduces construction waste through refuse management efficiency.	Indrayana and Pribadi (2023), Nguyen and Nguyen (2023)
	WMR2	Encourages recycling and material reuse to reduce landfill waste.	Foldy and Ospina (2023), D'Ambrosio and Longobardi, (2023)
	WMR3	Implements refuse separation and management strategies on construction sites.	Gordeev (2023), Anon (2023)
	WMR4	Adopts practices that reduce the impact of waste disposal on the environment.	Interview
	WMR5	Manifests a dedication to minimizing resource depletion and environmental damage.	Interview
Resilient Infrastructure Development	RID1	It is developing and constructing resilient infrastructure to natural disasters and climate change.	Interview
	RID2	Utilizes durable materials and engineering methods for longevity.	Nguyen and Nguyen (2023), Othman and Elwazer (2023)
	RID3	Enhances community safety and reduces disruptions during calamities.	Hashim et al. (2022), Lühr et al. (2023)
	RID4	Reduces long-term maintenance expenses by constructing durable structures.	Waqar et al. (2023h), Mergos (2023)
	RID5	Manifests a commitment to the long-term health of the community and environment.	Górecki et al. (2022), Hu and Shu (2023)
Renewable Energy Integration	REI1	Incorporates renewable energy sources such as solar, wind, and geothermal into building initiatives.	Interview
	REI2	Reduces reliance on fossil fuels and carbon dioxide emissions.	Interview
	REI3	Supports the transition to more environmentally friendly and sustainable energy sources.	Interview
	REI4	Contributes to long-term energy cost savings and conservation of natural resources.	López Paredes et al. (2023), Elkhapery et al. (2023)
	REI5	Promotes sustainable energy solutions and demonstrates a commitment to reducing the carbon footprint.	Egwunatum et al. (2022), Jiang et al. (2022)
Life Cycle Assessment	LCA1	Assesses the environmental impacts of an undertaking from start to finish.	Interview
	LCA2	Considers resource utilization, emissions, and energy consumption throughout the life cycle of the undertaking.	Interview
	LCA3	Guides judicious decisions to reduce the global environmental footprint.	Indrayana and Pribadi (2023), Ghorbani (2023)
	LCA4	Promotes ethical decision-making by highlighting areas for development.	Interview
	LCA5	Manifests a commitment to comprehensive sustainability and informed decision-making.	Interview
Green Certification & Standards	GCS1	Pursues certifications such as LEED to demonstrate adherence to environmentally responsible building practices.	Interview
	GCS2	Adheres to established ecological building guidelines and standards.	Interview
	GCS3	Environmentally responsible design, construction, and operation are validated.	Das et al. (2023), Othman and Elwazer (2023)
	GCS4	Encourages the adoption of sustainable practices and benchmarks across the industry.	Waqar et al. (2023a), Zaman et al. (2023)
	GCS5	Demonstrates dedication to meeting stringent sustainability criteria and fostering environmental improvement.	Interview
Social Equity & Inclusion	SEI1	Prioritizes the inclusion and well-being of diverse communities.	Interview
	SEI2	Provides affordable housing and meets the requirements of local residents.	Interview
	SEI3	Creates employment opportunities for disadvantaged populations and the local labor force.	Ma et al. (2023), Maqbool et al. (2023)
	SEI4	Encourages community participation and collaboration in building initiatives.	Tran et al. (2023), Lühr et al. (2023)
	SEI5	Demonstrates dedication to equitable and inclusive development that benefits the entire society.	López Paredes et al. (2023), Elkhapery et al. (2023)

resources and care of the surrounding environment.

Resilient infrastructure development: The elements included in this category highlight how important it is to build infrastructure resistant to natural disasters and climate change. Demonstrating a commitment to sustainable practices that can resist the difficulties given by a changing climate and environmental uncertainties is accomplished by giving durability, safety, and the community's long-term well-being a high priority.

Renewable Energy Integration: Incorporating various renewable energy sources is crucial and suggests a trend toward more sustainable energy practices. Companies not only lessen their carbon footprints but also significantly contribute to the more significant movement toward adopting renewable energy sources such as solar, wind, and geothermal power when implementing these technologies (Waqar et al., 2023f; Yun, 2023).

Life cycle assessment: The factors that fall under this category highlight the significance of taking a holistic approach to addressing sustainability issues by conducting life cycle assessments. Organizations can make educated choices that reduce their overall global environmental footprint and promote ethical and environmentally responsible business practices if they do environmental impact assessments throughout the lifecycle of a project.

Green Certification & Standards: The considerations included in this category show the relevance of acquiring environmental certifications and complying with standards that have been set. Not only does this legitimize a commitment to sustainability, but it also pushes industry-wide adoption of responsible practices and norms, ultimately elevating the construction industry's overall environmental performance (Samuelsson et al., 2023; Waqar et al., 2023e).

Social Equity & Inclusion: The considerations included under this category highlight the importance of fostering inclusive and equitable growth. A commitment to society's overall well-being may be shown by prioritizing issues such as social fairness, affordable housing, job possibilities for underserved populations, and community participation (Waqar et al., 2023f; Yun, 2023). This approach is in line with the ideals of sustainable leadership.

In conclusion, the findings in Table 1 represent an extensive spectrum of sustainable leadership criteria within the construction sector. Both academic research and the views of industry professionals have confirmed these factors. The construction industry is working toward the goal of creating a built environment that is resilient, inclusive, and ecologically responsible, and each category of variables highlights a different aspect of sustainable development (Li et al., 2023; Ramis et al., 2023). Together, these groups of characteristics contribute to this goal. These results highlight the significance of making educated decisions and strategically implementing sustainable leadership methods to meet modern issues and benefit society and the environment.

4.2. Demographic details of questionnaire respondents

The data shown in Table 2 offers insights into the participation of the participants, including information on gender distribution, professional experience, and occupational positions. The gender makeup of the industry may be inferred from the fact that male participants made up 86 % of the total population of the sample. A wide range of experience levels are present, with 36 % having 11 to 15 years of experience and 26 % having 6 to 10 years of experience. Regarding occupational positions, 42 % are civil engineers, 33 % are project managers, and 20 % are safety managers. The unique viewpoints and more profound comprehension of sustainable leadership methods in the construction sector result from a varied group of people participating in the research.

Table 2
Respondent involvement in the study.

Characteristics	Description	Values	Percentage
Gender	Male	188	86 %
	Female	18	8 %
Experience	0 to 5 Years	24	11 %
	6 to 10 Years	56	26 %
	11 to 15 Years	78	36 %
	16 to 20 Years	30	14 %
	Over 20 Years	18	8 %
Profession	Project Manager	72	33 %
	Civil Engineer	91	42 %
	Safety Manager	43	20 %

4.3. Structural Equation Modeling (S.E.M.) analysis

4.3.1. EFA analysis

Table 3 offers a detailed summary of the findings of the Exploratory Factor Analysis (E.F.A.). It does this by disclosing the extracted components, variable loadings, and Cronbach's alpha values for each found factor within sustainable leadership practices. The Exploratory Factor Analysis (E.F.A.) intended to discover underlying latent constructs represented by the observed variables, using Cronbach's alpha to validate the internal consistency of each component (Hashim et al., 2022; Banmairuroy et al., 2022). The findings illustrate the connections between the variables that can be seen and the latent factors, which enables us to understand the factors and evaluate the degree to which they may be relied upon.

For example, variable loadings ranging from 0.708 to 0.857 within the "Green Building Design" factor (G.B.D.) suggest high connections with the underlying latent construct. Similarly, the "Waste Management & Recycling" (W.M.R.) component has varying loadings ranging from 0.682 to 0.841, which indicates continuous correlations (Egwunatum et al., 2022; Elkhapery et al., 2023). The "Resilient Infrastructure Development" (R.I.D.) factor presents loadings ranging from 0.604 to 0.811, each representing a different variable associated with this construct. A similar trend may be seen across a variety of different considerations, including "Renewable Energy Integration" (R.E.I.), "Life Cycle Assessment" (L.C.A.), "Green Certification & Standards" (G.C.S.), and "Social Equity & Inclusion" (S.E.I.).

Principal Component Analysis was used as the extraction method, and Varimax rotation with Kaiser normalization was used to improve the components' interpretability. Both of these procedures were carried out

Table 3
Exploratory Factor Analysis (E.F.A.).

Variables	Component						
	1	2	3	4	5	6	7
GBD1	.857						
GBD2	.810						
GBD3	.760						
GBD4	.708						
WMR1		.820					
WMR2		.782					
WMR3		.731					
WMR4		.682					
RID1			.811				
RID2			.765				
RID3			.721				
RID4			.643				
RID5			.604				
REI1				.791			
REI3				.707			
REI4				.664			
REI5				.609			
LCA1					.781		
LCA2					.720		
LCA3					.673		
LCA4					.644		
GCS1						.751	
GCS2						.712	
GCS3						.641	
GCS4						.602	
SEI1							.713
SEI4							.654
SEI5							.601

"Extraction method: Principal Component Analysis."
"Rotation method: Varimax with Kaiser Normalization."
"Variable GBD5, WMR5, REI2, LCA5, GCS5, SEI2, SEI3 excluded because of loading less than 0.6."

before the data was analyzed. Variables such as GBD5, WMR5, REI2, LCA5, GCS5, SEI2, and SEI3 had loadings that were lower than 0.6; thus, they were omitted from the study since their connections with the corresponding latent constructs were not as strong as those of other variables.

In essence, Table 3 gives a thorough overview of the findings of the E.F.A. by emphasizing the variable loadings, Cronbach's alpha values, and the internal consistency of the discovered factors. This research examines the linkages between observable variables and latent constructs, thus enhancing the credibility and dependability of the sustainable leadership practices framework within the construction sector (Hashim et al., 2022; Tran et al., 2023). Specifically, this analysis focuses on the correlations between seen variables and hidden constructs.

4.3.2. PLS measurement modeling

Table 4 evaluates convergent validity using Cronbach's alpha (C.A.), composite reliability (C.R.), and average variance extracted (AVE) for each sustainable leadership practices group. The table shows item loadings, Variance Inflation Factor (V.I.F.), and C.A., C.R., and V.I.F. values. This assessment is essential to verify the measurement model and its components' dependability and consistency.

Cronbach's alpha, composite reliability and average variance extracted are used to evaluate cohesive validity, which measures how well items in a construct measure the same concept.

GBD1 has a loading of 0.820 for the "Green Building Design" group (G.B.D.), showing a high relationship with the latent construct. GBD2 was removed owing to its poor link. Both GBD3 and GBD4 have significant loadings of 0.819 and 0.952. The Variance Inflation Factor (V.I.F.) over 2.0 suggests multicollinearity (Banmairuroy et al., 2022; Lühr et al., 2023).

The dependability of each group is assessed using Cronbach's alpha (C.A.) values. Internal consistency is high with higher C.A. values. The composite reliability (C.R.) measures how well group components measure the underlying concept. The average variance extracted (AVE) shows the construct's variation relative to measurement error (Tran et al., 2023; Hu and Shu, 2023).

Table 4
Convergent validity considering Cronbach alpha, composite reliability and average variance extracted.

Group	Code	Loadings	VIF	CA	CR	V.I.F.
Green Building Design	GBD1	0.820	1.770	0.836	0.899	0.75
	GBD2	Deleted	2.252			
	GBD3	0.819	2.055			
	GBD4	0.952	2.075			
Waste Management & Recycling	WMR1	0.891	1.152	0.813	0.889	0.727
	WMR2	0.839	1.603			
	WMR3	0.827	2.629			
	WMR4	Deleted	1.555			
Resilient Infrastructure Development	RID1	Deleted	2.162	0.792	0.858	0.603
	RID2	0.812	1.736			
	RID3	0.768	1.795			
	RID4	0.723	1.443			
	RID5	0.801	2.898			
Renewable Energy Integration	REI1	0.879	2.488	0.816	0.879	0.647
	REI3	0.809	1.347			
	REI4	0.806	1.799			
	REI5	0.714	2.336			
Life Cycle Assessment	LCA1	0.920	1.860	0.815	0.891	0.732
	LCA2	0.798	1.987			
	LCA3	0.844	1.786			
	LCA4	Deleted	1.675			
Green Certification & Standards	GCS1	0.677	1.251	0.745	0.821	0.535
	GCS2	0.717	1.057			
	GCS3	0.766	1.075			
	GCS4	0.762	2.111			
Social Equity & Inclusion	SEI1	0.828	2.102	0.88	0.927	0.808
	SEI4	0.942	1.112			
	SEI5	0.922	1.242			

Convergent validity was validated for most components with significant C.A. and C.R. values. However, elements with low factor loadings were eliminated to refine the measurement model. V.I.F. values should be below 5 to reduce multicollinearity (Hashim et al., 2022; López Paredes et al., 2023).

Table 4 shows the comprehensive examination of convergent validity for each sustainable leadership practices group. The table shows each group's strength and dependability using loadings, C.A., C.R., and V.I.F. values, validating the measurement model's consistency and accuracy. This research strengthens the study and confirms the construction industry's sustainable leadership practices components (Tran et al., 2023; Hu and Shu, 2023).

Table 5 shows the findings of the commonly utilized Heterotrait-Monotrait Ratio of Correlations (HTMT) study to test construct discriminant validity. The table shows the HTMT values for each pair of constructs in the sustainable leadership practices framework, revealing their uniqueness. Each column in the table shows the HTMT value between two constructions (Lühr et al., 2023; Jiang et al., 2022). The HTMT values determine if item correlations within a concept are higher than between constructs (Waqar et al., 2023i; Waqar and Khan, 2023). Discriminant validity shows that the constructs are separate and not overly associated if the HTMT value is below a particular level (usually 0.85).

In the row "Green Building Design=GBD," the matrix diagonal is always 1 (showing perfect correlation); hence the value is left unfilled. The cell at the intersection of "Green Certification & Standards=GCS" and "Green Building Design=GBD" has a value of 0.316, below the 0.85 threshold, indicating discriminant validity. Similarly, the other cells show HTMT values between build pairings. If the value is below 0.85, the constructions are distinct and discriminant.

Table 6 shows the Fornell-Larcker criteria findings for assessing concept discriminant validity in the sustainable leadership practices framework. This criterion compares construct correlations to the square root of each construct's average variance extracted (AVE). Each table column shows the association between two constructs (Hashim et al., 2022; Egwunatum et al., 2022). The values are compared to create AVE values. If the correlation value is smaller than the AVE value for both variables, discriminant validity indicates that they are different and not strongly connected.

- In the cell "Green Building Design=GBD," the value is 0.866, more significant than the AVE of G.B.D. (0.75). G.B.D. and itself correlate more significantly than its AVE value, indicating a lack of discriminant validity.
- The cell at the intersection of "Green Certification & Standards=GCS" and "Green Building Design=GBD" has a value of 0.291, which is smaller than the AVE values of G.C.S. (0.535) and G.B.D. (0.75), demonstrating discriminant validity.
- Other cell values are compared to AVE values to evaluate discriminant validity between construct pairings.

Table 6 summarizes the Fornell-Larcker criteria findings, testing discriminant validity between pairs of items in the sustainable leadership practices framework. The findings confirm the distinctness of these constructs, boosting confidence in the measuring model's capacity to capture different sustainable leadership approaches in the construction sector effectively.

Table 7 shows the Cross Loading Criterion analysis findings for sustainable leadership practices framework variables' discriminant validity. In addition, the fact that the corresponding p-values are consistently lower than 0.005 demonstrates the statistical importance of these relationships. The cross-loading numbers show how much each variable loads onto its target construct relative to other constructs (Tran et al., 2023; Lühr et al., 2023). The variable properly measures a construct with a more excellent cross-loading value. Variables should have greater cross-loading values on their target construct and lower

Table 5
HTMT analysis for discriminant validity.

Constructs	GBD	GCS	LCA	REI	RID	SEI	WMR
Green Building Design=GBD							
Green Certification & Standards=GCS	0.316						
Life Cycle Assessment=LCA	0.16	0.266					
Renewable Energy Integration=REI	0.283	0.746	0.246				
Resilient Infrastructure Development=RID	0.189	0.322	0.197	0.444			
Social Equity & Inclusion=SEI	0.313	0.761	0.309	0.176	0.407		
Waste Management and Recycling=WMR	0.312	0.724	0.265	0.285	0.403	0.151	

Table 6
Fornell-Lacker criterion for discriminant validity.

Constructs	GBD	GCS	LCA	REI	RID	SEI	WMR
Green Building Design=GBD	0.866						
Green Certification & Standards=GCS	0.291	0.732					
Life Cycle Assessment=LCA	0.139	0.234	0.855				
Renewable Energy Integration=REI	0.265	0.208	0.207	0.804			
Resilient Infrastructure Development=RID	0.089	0.304	0.17	0.393	0.777		
Social Equity & Inclusion=SEI	0.297	0.462	0.262	0.422	0.378	0.899	
Waste Management and Recycling=WMR	0.29	0.291	0.218	0.576	0.366	0.402	0.853

Table 7
Cross-loading criterion for discriminant validity.

Variables	GBD	GCS	LCA	REI	RID	SEI	WMR
GBD1	**0.82**	0.233	0.165	0.14	0.159	0.183	0.18
GBD3	**0.819**	0.115	0.049	0.13	-0.035	0.156	0.149
GBD4	**0.952**	0.34	0.131	0.344	0.079	0.364	0.354
GCS1	0.155	**0.677**	0.119	0.264	0.096	0.241	0.257
GCS2	0.221	**0.717**	0.165	0.286	0.119	0.292	0.277
GCS3	0.247	**0.766**	0.234	0.223	0.338	0.222	0.316
GCS4	0.201	**0.762**	0.112	0.389	0.212	0.399	0.361
LCA1	0.145	0.242	**0.92**	0.192	0.186	0.263	0.188
LCA2	0.067	0.185	**0.798**	0.191	0.105	0.218	0.204
LCA3	0.142	0.166	**0.844**	0.145	0.139	0.185	0.166
REI1	0.322	0.204	0.214	**0.879**	0.344	0.242	0.392
REI3	0.217	0.525	0.198	**0.809**	0.302	0.67	0.221
REI4	0.187	0.519	0.139	**0.806**	0.287	0.265	0.332
REI5	0.091	0.504	0.098	**0.714**	0.335	0.149	0.543
RID2	-0.05	0.203	0.05	0.229	**0.812**	0.215	0.198
RID3	0.021	0.195	0.043	0.171	**0.768**	0.149	0.134
RID4	0.141	0.219	0.227	0.267	**0.723**	0.268	0.259
RID5	0.132	0.289	0.157	0.444	**0.801**	0.431	0.429
SEI1	0.227	0.576	0.264	0.282	0.34	**0.828**	0.219
SEI4	0.322	0.204	0.214	0.179	0.344	**0.942**	0.192
SEI5	0.247	0.366	0.234	0.223	0.338	**0.922**	0.219
WMR1	0.322	0.504	0.214	0.279	0.344	0.242	**0.891**
WMR2	0.187	0.519	0.139	0.306	0.287	0.365	**0.839**
WMR3	0.217	0.525	0.198	0.409	0.302	0.367	**0.827**

values on other constructs for discriminant validity.

- VBD1, GBD3, and GBD4 have significant cross-loading ratings on "Green Building Design," suggesting they correctly measure it.
- GCS1, GCS2, GCS3, and GCS4 also have substantial cross-loading values on the "Green Certification & Standards" construct, verifying their alignment.
- LCA1, LCA2, and LCA3 have the most significant cross-loading values on the "Life Cycle Assessment" construct, confirming its correct assessment.
- Other constructions, including "Renewable Energy Integration" (R.E.I.), "Resilient Infrastructure Development" (R.I.D.), "Social Equity & Inclusion" (S.E.I.), and "Waste Management and Recycling" (W.M.R.), show similar tendencies.

Table 7 precise cross-loading values support the variables' discriminant validity within their target constructs. These values demonstrate the measuring model's capacity to distinguish sustainable leadership approaches in the construction sector (López Paredes et al., 2023; Egwunatum et al., 2022).

4.3.3. *Structural model and path analysis*

Fig. 5 is a graphical representation of the PLS-SEM model, which shows the links between observable variables and latent constructs in the framework for sustainable leadership practices. The arrows represent route loadings, which indicate the influence of connections and the direction they take (Banmairuroy et al., 2022; Lühr et al., 2023). In addition, the fact that the corresponding p-values are consistently lower than 0.005 demonstrates the statistical importance of these relationships (Waqar et al., 2023e, k). This demonstrates that the model can accurately express the linkages and significance of those ties within the context of sustainable leadership practices in the construction sector (Hashim et al., 2022; Egwunatum et al., 2022).

The results of the study's hypothesis testing are summarized in Table 8. The table presents each hypothesis, its directional relationship, initial (O) values, mean (M) values, standard deviation (S.D.), T-statistic, p-values, and the resulting conclusions.

- H1: The connection between "Green Building Design" (G.B.D.) and sustainable leadership practices (S.L.P.) was examined. The T-statistic of 6.291 and the p-value of 0 indicate the hypothesis is accepted, implying a statistically significant and positive relationship between G.B.D. and S.L.P.
- H2: The relationship between "Green Certification & Standards" (G.C.S.) and S.L.P. was investigated. The T-statistic of 37.407 and the p-value of 0 indicate that the null hypothesis is accepted, indicating a significant and positive relationship between G.C.S. and S.L.P.
- H3: The research examined the relationship between "Life Cycle Assessment" (L.C.A.) and S.L.P. The hypothesis is accepted with a T-statistic of 4.68 and a p-value of 0, indicating that L.C.A. and S.L.P. have a meaningful and positive relationship.
- H4: The connection between "Renewable Energy Integration" (R.E.I.) and S.L.P. has been evaluated. A T-statistic of 40,223 and a p-value of 0 confirm a significant and positive relationship between R.E.I. and S.L.P.
- H5: Analysis of the hypothesis concerning the impact of "Resilient Infrastructure Development" (R.I.D.) on S.L.P. A T-statistic of 11.113 and a p-value of 0 indicate that the hypothesis is accepted, validating the existence of a substantial and positive relationship between R.I.D. and S.L.P.

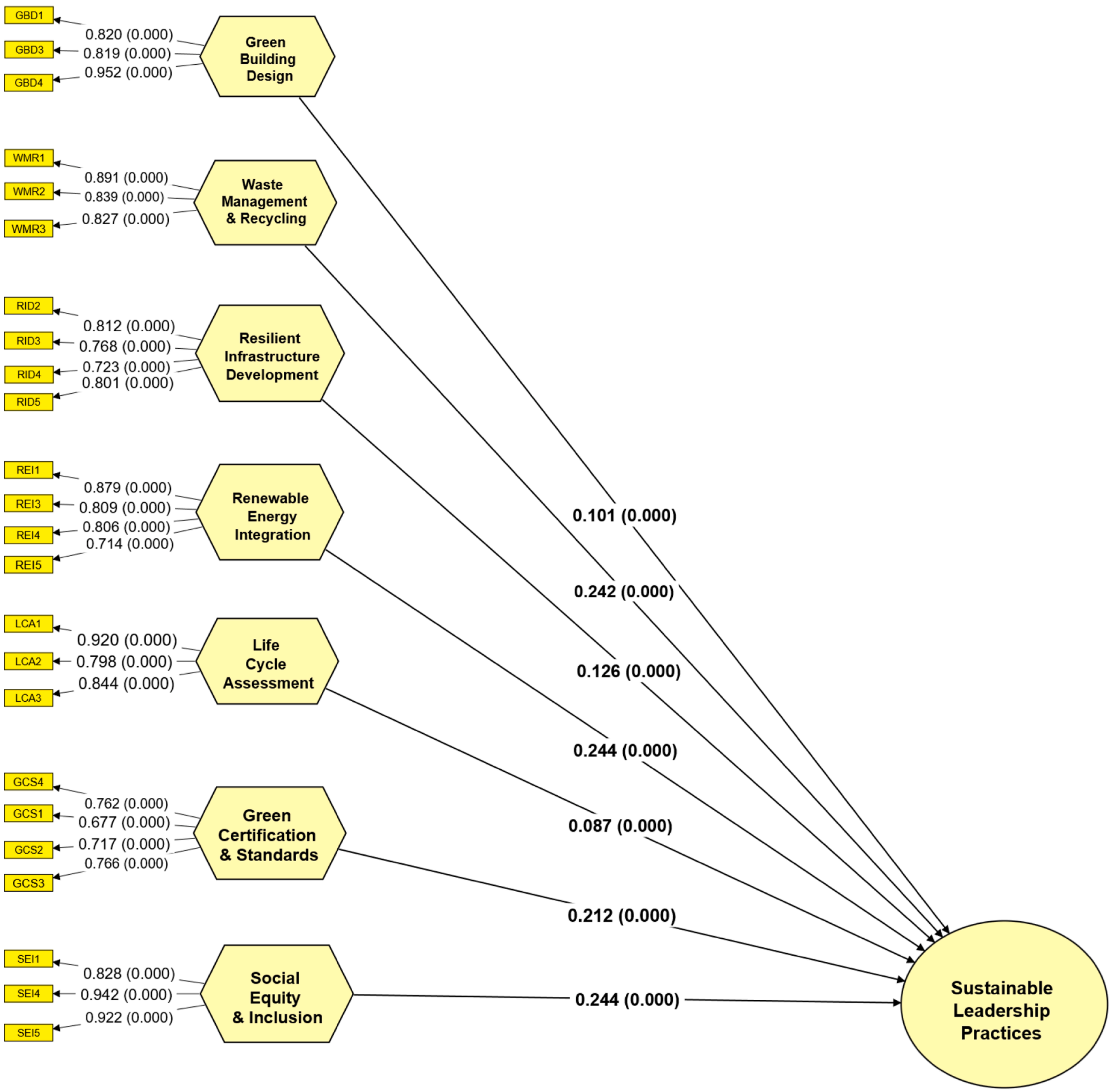

Fig. 5. PLS SEM Model indicating path loadings with P-values.

Table 8
Hypothesis testing output of the study.

Hypothesis	Relation	(O)	(M)	SD	T stat	P values	Results
H1	GBD -> SLP	0.101	0.101	0.016	6.291	0	Accepted
H2	GCS -> SLP	0.212	0.212	0.006	37.407	0	Accepted
H3	LCA -> SLP	0.087	0.087	0.019	4.685	0	Accepted
H4	REI -> SLP	0.244	0.242	0.006	40.223	0	Accepted
H5	RID -> SLP	0.126	0.127	0.011	11.113	0	Accepted
H6	SEI -> SLP	0.244	0.242	0.006	40.13	0	Accepted
H7	WMR -> SLP	0.242	0.24	0.006	40.829	0	Accepted

(O)= Original sample; (M)= Sample mean; SD= Standard deviation= Green Building Design; GCS= Green Certification & Standards; LCA= Life Cycle Assessment; REI= Renewable Energy Integration; RID= Resilient Infrastructure Development; SEI= Social Equity & Inclusion; WMR= Waste Management and Recycling; SLP=Sustainable Leadership Practices.

- H6: The study investigated the connection between "Social Equity & Inclusion" (S.E.I.) and S.L.P. A T-statistic of 40.13 with a p-value of 0 confirms the significance and positive relationship between S.E.I. and S.L.P
- H7 examined the relationship between "Waste Management & Recycling" (W.M.R.) and S.L.P. The hypothesis is accepted with a T-statistic of 40.829 and a p-value of 0, indicating that W.M.R. and S.L.P. have a meaningful and positive relationship.

Table 8 summarizes the results of hypothesis testing, confirming that all hypotheses were accepted due to highly significant p-values and robust T-statistic values. This indicates that substantial evidence supports the positive relationships between the various dimensions of sustainable practices and overall sustainable leadership practices in the construction industry (Hashim et al., 2022; Banmairuroy et al., 2022).

- SSO (Sum of Squares for Original): This value represents the total variance in the observed variables that the latent constructs of the model can explain. It quantifies how well the model explains the variability of the dependent variables (Egwunatum et al., 2022; Elkhapery et al., 2023).
- S.S.E. (Sum of Squares for Error): This value represents the variance or residual error in the observed variables that the model's latent constructs cannot explain.
- Q2 (Coefficient of Determination): This metric evaluates the predictive applicability of the model. It is determined by subtracting one from the ratio of S.S.E. to SSO. A higher Q2 value indicates the model's predictive ability is more substantial (Latiffi and Zulkiffli, 2022; Zhang and Dong, 2023).
- The "Sustainable Leadership Practices" construct has an SSO value of 14,980,00 and an S.S.E. value of 13,170.988.
- The calculated Q2 value is 0.121, indicating that the model's constructs can predict about 12.1 % of the observed variables' variance.

The predictive relevance analysis of Table 9 evaluates the model's ability to predict the variance of observed variables based on latent constructs. The Q2 value of 0.121 indicates a moderate level of predictive relevance, suggesting that the sustainable leadership practices model can explain and predict variations in the observed variables within the construction industry context (Hashim et al., 2022; Jiang et al., 2022).

5. Discussion

This research examined sustainable leadership practices in the context of the construction industry. With growing concerns about environmental preservation and societal welfare, sustainable practices have attracted considerable interest. The purpose of this study was to contribute to this critical discussion by examining the relationships between various sustainable practices and overall sustainable leadership in construction. Utilizing a comprehensive methodology, the research incorporated a literature review, expert opinions, and rigorous statistical analyses to shed light on the dynamics of sustainable leadership in the construction industry.

The first hypothesis investigated the relationship between Green Building Design and Sustainable Leadership Practices. The analysis demonstrated a statistically significant (T-statistic = 6.291) and practically significant positive path coefficient of 0.101. This result demonstrates that incorporating environmentally conscientious design principles influences sustainable leadership practices positively. Thus, Hypothesis 1 was accepted, indicating the significance of incorporating green building practices into leadership strategies to improve overall sustainability (Egwunatum et al., 2022; Jiang et al., 2022).

Table 9
Predictive relevance of the study.

Constructs	SSO	SSE	Q^2 (=1-SSE/SSO)
Sustainable Leadership Practices	14,980.000	13,170.988	0.121

The second hypothesis investigated the connection between Green Certification and Standards and Sustainable Leadership Practices. The findings revealed a significant and positive path coefficient of 0.212 and a remarkably high T-statistic of 37.407. This indicates that organizations adhering to established ecological standards demonstrate more sustainable leadership practices. Therefore, Hypothesis 2 was unequivocally supported, highlighting the importance of certifications in promoting sustainable leadership.

Life Cycle Assessment and Sustainable Leadership Practices were the focus of the third hypothesis. The analysis produced a path coefficient of 0.087 and a T-statistic of 4.685. These results indicate that contemplating a project's entire life cycle significantly impacts sustainable leadership practices (Hashim et al., 2022; Lühr et al., 2023). In conclusion, Hypothesis 3 was supported, emphasizing the importance of life cycle assessment in fostering sustainable leadership.

The fourth hypothesis examined the impact of Renewable Energy Integration on Sustainable Leadership Practices. The results revealed a significant path coefficient of 0.244 and a remarkable T-statistic of 40,223. Thus, incorporating renewable energy sources significantly improves sustainable leadership practices (Egwunatum et al., 2022; Elkhapery et al., 2023). Consequently, Hypothesis 4 was unequivocally supported, emphasizing the central role of renewable energy in fostering sustainable leadership.

The fifth hypothesis assessed the relationship between Resilient Infrastructure Development and Sustainable Leadership Practices. The analysis revealed a noteworthy path coefficient of 0.126 and a significant T-statistic of 11.113. These results highlight the contribution of resilient infrastructure development to sustainable leadership practices (Jiang et al., 2022; Elkhapery et al., 2023). Therefore, Hypothesis 5 was strongly supported, emphasizing the importance of constructing robust and flexible infrastructure for sustainable leadership (Waqar and Ahmed, 2023; Waqar et al., 2023l).

The sixth hypothesis investigated the connection between Social Equity and Inclusion and Sustainable Leadership Practices. The results demonstrated a substantial path coefficient of 0.244 and a robust T-statistic of 40.13. This suggests that practices promoting social equity and inclusion play a crucial role in forming sustainable leadership (López Paredes et al., 2023; Latiffi and Zulkiffli, 2022). Therefore, Hypothesis 6 was accepted confidently, highlighting the inherent relationship between social responsibility and effective leadership for sustainability.

The seventh hypothesis evaluated the influence of Waste Management and Recycling on Sustainable Leadership Practices. The analysis produced a significant path coefficient of 0.242 and a remarkable T-statistic of 40.829. These results highlight the significance of effective waste management and recycling in promoting sustainable leadership practices (Tran et al., 2023; Lühr et al., 2023). As a result, Hypothesis 7 was adopted unequivocally, emphasizing the importance of waste reduction and responsible disposal strategies in sustainable leadership (Egwunatum et al., 2022).

This study contributes considerably to understanding sustainable leadership practices in the construction industry. The study establishes a solid foundation for guiding decision-making and strategic planning within the industry by confirming the positive and significant relationships between various sustainable practices and overall sustainable leadership. This study provides a valuable road map for cultivating effective leadership that contributes to environmental preservation, societal well-being, and long-term organizational success as organizations increasingly recognize the need for sustainable practices (Mohamed and Eltohamy, 2022; Waqar et al., 2023g).

The study endeavours to broaden theoretical views on sustainable leadership by adopting a multi-dimensional approach to sustainability. This approach emphasises the need for leaders to concurrently address several facets of sustainability, beyond conventional limits.

The study provides valuable insights for key stakeholders in the construction industry, including industry leaders, policymakers, and practitioners. It highlights the significance of sustainable leadership in promoting environmentally sensitive and resilient practices. The results of this study may function as a guide for the reformation of industries, promoting the use of sustainable construction methods, efficient utilization of resources, and steps to ensure social fairness. The study findings may be used by policymakers to enhance the formulation of legislation and standards that facilitate the adoption of sustainable leadership practices within the construction industry.

Gaining a comprehensive understanding of the interconnections between green building design, certification standards, life cycle assessment, renewable energy integration, resilient infrastructure, social equity, and waste management, in relation to sustainable leadership practices, can empower managers to make well-informed decisions regarding the adoption of these practices. Managers has the potential to strategically incorporate these many facets of sustainability inside their own organizations. This entails not just prioritizing resource efficiency, but also advancing social equality and resilience in their initiatives and operations. In light of the considerable importance of certification standards, managers may contemplate the acquisition of relevant certificates and the assurance of adherence to sustainability standards (Hashim et al., 2022; Jiang et al., 2022). This has the potential to augment the credibility and market competitiveness of their organization.

The research identifies sustainable leadership concepts that may be applied to building industries in different areas. Nevertheless, the effective execution of a plan may need adjustments to accommodate the distinct attributes, legal structures, and socio-economic circumstances specific to each particular situation. The study findings may provide a solid basis for conducting comparative studies and can be used as a point of reference for industry executives and policymakers who are seeking to advance sustainability within their respective construction sectors, whether it be in diverse nations or areas.

6. Conclusion

The construction industry has reached a critical juncture in which the need for sustainable practices is unavoidable. This manuscript explored sustainable leadership practices in this industry, casting light on the intricate relationships that undergird a resilient and environmentally conscious approach to development. This study has advanced our understanding of the nuances and significance of sustainable leadership through a comprehensive literature review, expert opinions, and rigorous statistical analysis. The findings of this research highlight the importance of various sustainable practices in influencing the leadership landscape within the construction industry. The established positive relationships between Sustainable Leadership Practices and Green Building Design, Green Certification & Standards, Life Cycle Assessment, Renewable Energy Integration, Resilient Infrastructure Development, Social Equity & Inclusion, and Waste Management & Recycling attest to the interconnected nature of these dimensions. As organizations adopt these practices, their leadership initiatives acquire a new emphasis on environmental responsibility, social equity, and economic viability. This study's empirical evidence is consistent with previous research and expands our understanding of the construction industry's unique dynamics. The high path coefficients and T-statistic values highlight the robustness and statistical significance of these relationships. In addition, the predictive relevance analysis strengthens the model's credibility by demonstrating its capacity to predict and direct sustainable leadership initiatives in construction. As organizations navigate the complexities of the contemporary world, this study's findings provide actionable insights. By incorporating sustainable practices into leadership strategies, organizations can have a positive effect on their bottom lines, the environment, and society as a whole. These practices, ranging from green building principles to inclusive approaches and responsible refuse management, culminate in a comprehensive framework for sustainable leadership.

The sample size of the research was moderately sized, which may restrict the extent to which the results may be applied to a larger population. A more expansive and heterogeneous sample size has the potential to provide a more thorough and nuanced comprehension of sustainable leadership practices within the construction industry. The study used a cross-sectional design, which offers a momentary depiction of the associations at a particular juncture. A longitudinal research has the potential to provide valuable insights into the evolving dynamics and transformations of sustainable leadership practices throughout an extended period of time. The research primarily examined the construction industry in Pakistan; nevertheless, it is important to note that the results may not be readily applicable to other locations due to the presence of unique legal, cultural, and economic factors. The application of the identified sustainable leadership practices may be influenced by local variables. The research was dependent on data that was self-reported by participants, a method that has the potential to create response bias and may not consistently reflect the true practices used by construction organizations.

This manuscript concludes by capturing the substance of sustainable leadership practices in the construction industry. The findings highlight the importance of incorporating sustainable practices into leadership strategies, fostering a balance between economic development, environmental stewardship, and social equity. This research contributes to the evolving discourse on sustainable leadership by providing practitioners, policymakers, and academics with a firm foundation for effecting positive change in the construction industry. The way forward lies in putting these insights into practice, nurturing a future where construction leadership is a beacon of sustainable development, resilience, and progress.

CRediT authorship contribution statement

Ahsan Waqar: Writing – review & editing, Writing – original draft, Software, Data curation, Conceptualization. **Moustafa Houda:** Resources, Project administration, Methodology. **Abdul Mateen Khan:** Validation, Software, Investigation, Formal analysis. **Abdul Hannan Qureshi:** Writing – review & editing, Writing – original draft, Supervision, Investigation, Funding acquisition, Formal analysis. **Gremina Elmazi:** Visualization, Validation, Supervision, Resources.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

References

Anon, 2023. In: Proceedings of the 1st International Conference and Symposium on Construction Industry Development: Value Added Construction, 2599. American Institute of Physics Inc.

Banmairuroy, W., Kritjaroen, T., Homsombat, W., 2022. The effect of knowledge-oriented leadership and human resource development on sustainable competitive advantage through organizational innovation's component factors: evidence from Thailand 's new S- curve industries. Asia Pac. Manag. Rev. https://doi.org/10.1016/j.apmrv.2021.09.001.

Bouhmoud, H., Loudyi, D., Giordano, A., Azhar, S., Farah, M., 2023. Exploratory study of the gender equity in the North African AEC industry and academia: ratios, causes and remedial actions. In: Proceedings of the 2023 International Interdisciplinary PhD Workshop IIPhDW 2023. Mohammedia, Morocco. Institute of Electrical and

Electronics Engineers Inc.: University Hassan Ii of Casablanca, Faculty of Sciences and Technics of Mohammedia (FSTM).
Chen, J., Walker, A.D., Riley, P., 2023. Reconceptualizing principal well-being: state, measurement and consequences. J. Educ. Adm. 61, 495–513. https://doi.org/10.1108/JEA-12-2022-0224.
Cheung, C., Chih, Y.Y., Bowen, P., Liao, P.C., 2023. Leadership and employee well-being in the architecture, engineering, and construction (AEC) industry. J. Manag. Eng. 39 https://doi.org/10.1061/JMENEA.MEENG-5491.
D'Ambrosio, R., Longobardi, A., 2023. Adapting drainage networks to the urban development: an assessment of different integrated approach alternatives for a sustainable flood risk mitigation in northern Italy. Sustain. Cities Soc. 98 https://doi.org/10.1016/j.scs.2023.104856.
Das, P., Perera, S., Senaratne, S., Osei-Kyei, R., 2023. A smart modern construction enterprise maturity model for business scenarios leading to industry 4.0. Smart Sustain. Built Environ. https://doi.org/10.1108/SASBE-09-2022-0205.
Deng, H., Wu, M., Yang, Z., He, Y., Zhu, L., Zhao, Q., Dai, H., Wu, J., Liao, X., Zhang, Y., 2023. Construction of an innovative model of chronic disease management in compact county medical alliance with treatment-prevention integration. Chin. Gen. Pract. 26, 2720–2725. https://doi.org/10.12114/j.issn.1007-9572.2023.0150.
Dubljević, S., Tepavčević, B., Markoski, B., Anđelković, A.S., 2023. Computational BIM tool for automated LEED certification process. Energy Build. 292 https://doi.org/10.1016/j.enbuild.2023.113168.
Egwunatum, S.I., Anumudu, A.C., Eze, E.C., Awodele, I.A., 2022. Total quality management (TQM) implementation in the Nigerian construction industry. Eng. Constr. Archit. Manag. https://doi.org/10.1108/ECAM-08-2020-0639.
Elkhapery, B., Kianmehr, P., Doczy, R., 2023. Tradeoff between well-being of students and cost of greening schools in arid regions. Manag. Environ. Qual. Int. J. 34, 794–819. https://doi.org/10.1108/MEQ-09-2022-0249.
Foldy, E.G., Ospina, S.M., 2023. Contestation, negotiation, and resolution': the relationship between power and collective leadership. Int. J. Manag. Rev. 25, 546–563. https://doi.org/10.1111/ijmr.12319.
Górecki, J., Núñez-cacho, P., Rutkowska, M., 2022. Study on circular economy implementation propensity of construction companies in context of prevailing management styles. Appl. Sci. 12 https://doi.org/10.3390/app12083991.
Gbedemah, S.F., 2023. Eruditing from indigenous adaptation strategies for resilient and sustainable coastal erosion management in Southeastern Ghana. Discov. Sustain. 4 https://doi.org/10.1007/s43621-023-00123-z.
Ghorbani, A., 2023. A review of successful construction project managers' competencies and leadership profile. J. Rehabil. Civ. Eng. 11, 76–95. https://doi.org/10.22075/JRCE.2022.24638.1560.
Gordeev, P.N., 2023. I stayed in the hardest time and suffered everything: o. D. Kameneva's prison years. Bulletin of perm university. History 61, 128–136.
Hashim, R., Cooper, S., Salleh, N.A., Nawi, M.N.M., 2022. The influence of regulatory pressure in shaping construction firms' decision to adopt green innovation. J. Adv. Res. Appl. Sci. Eng. Technol. https://doi.org/10.37934/araset.28.2.301310.
Hu, Y., Shu, H., 2023. Synergetic mechanism of agricultural logistics ecosphere –the case study based on Jiangxi Taoxin. Nankai Bus. Rev. Int. 14, 272–294. https://doi.org/10.1108/NBRI-10-2021-0071.
Indrayana, D.V., Pribadi, K.S, 2023. A proposed framework of measuring maturity of safety leadership in construction. In: Proceedings of the AIP Conference, 2599. American Institute of Physics Inc.: Institut Teknologi Bandung, Bandung, 40132, Indonesia. B., H., null, M., E., H., B., A., B.O., A., M.F., A., A.M., Q., EdsVol.
Jiang, S., Wei, X., Jia, J., Ma, G., 2022. Toward sustaining the development of green residential buildings in China: a tripartite evolutionary game analysis. Build. Environ. 223 https://doi.org/10.1016/j.buildenv.2022.109466.
Karayel, G.K., Javani, N., Dincer, I., 2023. Hydropower for green hydrogen production in Turkey. Int. J. Hydrog. Energy 48, 22806–22817. https://doi.org/10.1016/j.ijhydene.2022.04.084.
Khahro, S.H., Shaikh, H.H., Zainun, N.Y., Sultan, B., Khahro, Q.H., 2023. Delay in decision-making affecting construction projects: a sustainable decision-making model for mega projects. Sustainability 15. https://doi.org/10.3390/su15075872.
Khan, M., Shafiq, N., Waqar, A., Radu, D., Cismaș, C., Imran, M., Almujibah, H., Benjeddou, O., 2023. Effects of jute fiber on fresh and hardened characteristics of concrete with environmental assessment. Buildings 13, 1691. https://doi.org/10.3390/buildings13071691.
Kuzucuoğlu, D., Koc, K., Kazar, G., Tokdemir, O.B., 2023. Prioritization of risk mitigation strategies for contact with sharp object accidents using hybrid bow-tie approach. Saf. Sci. 166 https://doi.org/10.1016/j.ssci.2023.106248.
López Paredes, H.A., Borja Borja, F.M., Gamboa Ortiz, J.D., 2023. Training and gender, career advancement advisors for leadership. Rev. Venez. Gerenc. 28, 1158–1173. https://doi.org/10.52080/rvgluz.28.103.15.
Lühr, G.J., Wagner, R.F., Radujković, M., 2023. The influence of leadership on the projectification of the public construction sector in Germany. Buildings 13. https://doi.org/10.3390/buildings13061506.
Larsen, E., Brandenburg, R., 2023. Navigating the neo-academy: experiences of liminality and identity construction among early career researchers at one Australian regional university. Aust. Educ. Res. 50, 1069–1087. https://doi.org/10.1007/s13384-022-00544-1.
Latiffi, A.A., Zulkiffli, N.A., 2022. Understanding the relationship of leadership skills in the pre-construction phase with the success of sustainable construction projects. ASEAN Eng. J. 12, 185–193. https://doi.org/10.11113/aej.V12.17310.
Lee, J.H., Ashuri, B., 2023. Project chief engineer: an industry review of a new position on design-build teams for major transportation projects. J. Leg. Aff. Disput. Resolut. Eng. Constr. 15 https://doi.org/10.1061/JLADAH.LADR-954.
Li, M., Wu, Y., Lv, F., 2023. Influencing factors of ideological and political construction work based on VSBPC model. Appl. Math. Nonlinear Sci. https://doi.org/10.2478/amns.2023.1.00321.
Ma, S., Huang, H., Tian, F., Duan, Z., Gong, J., Zhang, J., 2023. Investigation of dynamic characteristics and cumulative plastic strain prediction model of clay-fouled round gravel under cyclic subway loading. Soil Dyn. Earthq. Eng. 174 https://doi.org/10.1016/j.soildyn.2023.108173.
Madson, K., Franz, B., Leicht, R., Nelson, J., 2022. Evaluating the sustainability of new construction projects over time by examining the evolution of the LEED rating system. Sustainability 14. https://doi.org/10.3390/su142215422.
Maqbool, R., Thompson, C., Ashfaq, S., 2023. LEED and BREEAM green building certification systems as possible game changers in attaining low-cost energy-efficient urban housing projects. J. Urban Plan. Dev. 149 https://doi.org/10.1061/JUPDDM.UPENG-4292.
Mergos, P.E., 2023. Sustainable and resilient seismic design of reinforced concrete frames with rocking isolation on spread footings. Eng. Struct. 292 https://doi.org/10.1016/j.engstruct.2023.116605.
Mohamed, H.A.E., Eltohamy, A.I., 2022. Critical success factors for competitiveness of Egyptian construction companies. Sustainability 14. https://doi.org/10.3390/su141710460.
Nguyen, M.V., Nguyen, T.T, 2023. A fuzzy synthetic evaluation approach for climate for innovation measurement in construction firms. Eng. Constr. Archit. Manag. https://doi.org/10.1108/ECAM-02-2023-0130.
Othman, A.A.E., Elwazer, M.N., 2023. A talent management based framework for developing sustainable quality of work life in architectural design firms in Egypt. Int. J. Archit. Res. Archnet IJAR 17, 243–266. https://doi.org/10.1108/ARCH-12-2021-0365.
Oyewobi, L.O., Jimoh, R.A., 2022. Barriers to adoption of sustainable procurement in the Nigerian public construction sector. Sustainability. https://doi.org/10.3390/su142214832.
Phinias, R.N., 2023. Benefits and challenges relating to the implementation of health and safety leading indicators in the construction industry: a systematic review. Saf. Sci. 163 https://doi.org/10.1016/j.ssci.2023.106131.
Quyen, B.T., Huong, N.T.M., Han, D.T., Tung, P.H., Thu, N.T.X., Dung, T.P., 2023. Factors affecting Gen Z trend of 'standard working' in Vietnam. Rev. Gest. Soc. e Ambient. 17 https://doi.org/10.24857/rgsa.v17n5-024.
Ramis, M.S., Langoni, A.M., Pozzobon, F.B., Risuenho, F.M., Rego, F.C., Vitiello, R.P., 2023. Integrity management: a basic pilar of efficiency improvement program for offshore production unit. In: Proceedings of the Annual Offshore Technology Conference; Offshore Technology Conference: PETROBRAS. Vol. 2023-May.
Samuelsson, A.U., Larsman, P., Grill, M., 2023. For the sake of safety: a time-lagged study investigating the relationships between perceived leadership behaviors and employee safety behaviors. Saf. Sci. 166 https://doi.org/10.1016/j.ssci.2023.106245.
Tran, K.D.P., Thuy Vo, T.N., Tram Thai, N.B., 2023. The effect of innovation on competitive advantage and SMEs performance in vietnam: the moderating role of customer orientation. Int. J. Innov. Sci. https://doi.org/10.1108/IJIS-08-2022-0161.
Turnbull, B., Gordon, S.F., Fuentes-Balderrama, J., Ojeda-García, A., Cruz del Castillo, C., 2023. Resilience is not free: the undeserved failure of the urban poor in Mexico. Advers. Resil. Sci. 4, 319–333. https://doi.org/10.1007/s42844-023-00099-9.
Waqar, A., Ahmed, W., 2023. Reimagining construction safety: unveiling the impact of building information modeling (BIM) implementation. Saf. Extreme Environ. https://doi.org/10.1007/s42797-023-00086-4.
Waqar, A., Khan, M., 2023. Assessment of challenges to the adoption of IOT for the safety management of small construction projects in Malaysia: structural equation modeling approach. Appl. Sci. 13 https://doi.org/10.3390/app13053340.
Waqar, A.; Othman, I. Challenges to the implementation of BIM for the risk management of oil and gas construction projects : structural equation modeling approach sustainability challenges to the implementation of BIM for the risk management of oil and gas construction project. 2023, 10.3390/su15108019.
Waqar, A.; Othman, I.; Shafiq, N.; Altan, H. Modeling the effect of overcoming the barriers to passive design implementation on project sustainability building success : a structural equation modeling perspective sustainability modeling the effect of overcoming the barriers to passive design impleme. 2023.
Waqar, A., Othman, I., Radu, D., Ali, Z., Almujibah, H., Hadzima-Nyarko, M., Khan, M.B., 2023. Modeling the relation between building information modeling and the success of construction projects: a structural-equation-modeling approach. Appl. Sci. 13 https://doi.org/10.3390/app13159018, 9018.
Waqar, A., Othman, I., Shafiq, N., Mansoor, M.S., 2023a. Applications of AI in oil and gas projects towards sustainable development: a systematic literature review. Artif. Intell. Rev. 56, 12771–12798. https://doi.org/10.1007/s10462-023-10467-7.
Waqar, A., Khan, M.B., Shafiq, N., Skrzypkowski, K., Zagórski, K., Zagórska, A., 2023b. Assessment of challenges to the adoption of IOT for the safety management of small construction projects in malaysia: structural equation modeling approach. Appl. Sci. 13, 3340. https://doi.org/10.3390/app13053340.
Waqar, A., Qureshi, A.H., Alaloul, W.S., 2023c. Barriers to building information modeling (BIM) deployment in small construction projects: Malaysian Construction Industry. Sustainability 15, 2477. https://doi.org/10.3390/su15032477.
Waqar, A., Hannan Qureshi, A., Othman, I., Saad, N., Azab, M., 2023d. Exploration of challenges to deployment of blockchain in small construction projects. Ain Shams Eng. J., 102362 https://doi.org/10.1016/j.asej.2023.102362.
Waqar, A., Othman, I., Almujibah, H., Khan, M.B., Alotaibi, S., Elhassan, A.A.M., 2023e. Factors influencing adoption of digital twin advanced technologies for smart city development: evidence from Malaysia. Buildings 13, 775. https://doi.org/10.3390/buildings13030775.

Waqar, A., Othman, I., Pomares, J.C., 2023f. Impact of 3D printing on the overall project success of residential construction projects using structural equation modelling. Int. J. Environ. Res. Public Health. https://doi.org/10.3390/ijerph20053800.

Waqar, A., Othman, I., Shafiq, N., Altan, H., Ozarisoy, B., 2023h. Modeling the effect of overcoming the barriers to passive design implementation on project sustainability building success: a structural equation modeling perspective. Sustainability 15, 8954. https://doi.org/10.3390/su15118954.

Waqar, A., Skrzypkowski, K., Almujibah, H., Zagórski, K., Khan, M.B., Zagórska, A., Benjeddou, O., 2023i. Success of implementing cloud computing for smart development in small construction projects. Appl. Sci. 13, 5713. https://doi.org/10.3390/app13095713.

Waqar, A., Othman, I., Hayat, S., Radu, D., Khan, M.B., Galatanu, T.F., Almujibah, H.R., Hadzima-Nyarko, M., Benjeddou, O., 2023j. Building information modeling–empowering construction projects with end-to-end life cycle management. Buildings 13.

Waqar, A., Othman, I., Pomares, J., 2023k. Impact of 3D printing on the overall project success of residential construction projects using structural equation modelling. Int. J. Environ. Res. Public Health 20, 3800. https://doi.org/10.3390/ijerph20053800.

Yun, M., 2023. Instrumental leadership and creativity: cognitive mechanisms via problem-solving rumination and knowledge sharing with coworkers. Leadersh. Organ. Dev. J. 44, 543–563. https://doi.org/10.1108/LODJ-08-2022-0357.

Zaman, U., Florez-Perez, L., Anjam, M., Ghani Khwaja, M., Ul-Huda, N., 2023. At the end of the world, turn left: examining toxic leadership, team silence and success in mega construction projects. Eng. Constr. Archit. Manag. 30, 2436–2462. https://doi.org/10.1108/ECAM-08-2021-0755.

Zenteno, E., Sepúlveda, K., Johnson, K., Díaz, J.I., 2023. Women settlers in the reemergence and consolidation of the squatter land plots in Viña del Mar, Chile. Eure 49. https://doi.org/10.7764/eure.49.147.01.

Zhang, D., Dong, H., 2023. Understanding arable land change patterns and driving forces in major grain-producing areas: a case study of Sichuan province using the PLUS model. Land 12. https://doi.org/10.3390/land12071443.