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Principal Component Analysis for Exploring Sustainable Interior Design Implementation Challenges in Saudi Arabia's Building Industry

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Building industry; sustainability; interior design; architecture

Abstract: Sustainability is a growing priority in the built environment, yet its integration into interior architecture and design remains limited in many regions. This study focuses on identifying the barriers to Sustainable Interior Design (SID) implementation in Saudi Arabia's building industry, where rapid urbanization and Vision 2030 targets create both challenges and opportunities. A total of 187 responses were collected from industry professionals through a questionnaire listing 30 potential challenges. The data were analyzed using the Relative Importance Index (RII) and Exploratory Factor Analysis (EFA). Results show that the most significant barriers are a lack of knowledge and awareness, followed by issues related to government regulations, economic constraints, attitudes and market demand, and technology and training. These findings are specific to the Saudi context but may also offer insights for other rapidly developing economies. The study contributes by providing a comprehensive, prioritized list of SID implementation challenges in Saudi Arabia, thereby informing policymakers, practitioners, and academics seeking to promote sustainable interior practices.

1. Introduction

The building industry is one of the largest contributors to environmental challenges, accounting for about 40% of global energy consumption, 30% of CO_2 emissions, and nearly 40% of total waste generation [1]. In response, sustainable practices have become increasingly important, particularly in interior architecture and design, where human well-being and indoor environmental quality are directly influenced by design decisions [2]. Sustainable Interior Design (SID) integrates environmental responsibility with the creation of healthy, functional, and aesthetically pleasing indoor spaces. It goes beyond material selection, encompassing energy efficiency, water conservation, waste reduction, and the enhancement of occupants' mental and physical health [3]. Despite its recognized benefits, SID adoption remains limited in many regions due to technical, economic, regulatory, and awareness-related barriers [4]
In line with Saudi Arabia's Vision 2030, sustainability has become a national priority across all sectors, including the building industry. The Kingdom has already established and begun implementing standards

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and conditions for sustainable construction, aiming to align new developments with environmental goals and global best practices. This strategic framework reinforces the urgency of integrating Sustainable Interior Design (SID) principles into building projects, ensuring that design solutions meet both functional needs and the country's environmental commitments [5]. In Saudi Arabia, rapid urban growth and the nation's Vision 2030 sustainability targets present both an urgent need and a unique opportunity to embed SID principles in the building sector. However, there is a scarcity of empirical research on the specific challenges to SID implementation in the Saudi context. Existing global studies may not fully reflect the country's climate, market conditions, regulatory framework, and cultural preferences [6].

2. Adoption of Sustainable Interior Design Practices

Sustainable Interior Design (SID) is an increasingly complex and expanding discipline that requires a multidisciplinary and integrative approach. It encompasses the assessment of design impacts on both the environment and human health and well-being. Effective SID practice necessitates a thorough understanding of environmentally responsible materials, building systems, and energy-efficient technologies. The selection and application of recyclable, reusable, and low-impact resources such as bamboo, cork, reclaimed metals, and glass are central to minimizing environmental degradation [7]. The use of renewable materials not only reduces ecological footprints but also supports local communities and decreases greenhouse gas emissions associated with long-distance transportation. Integrating green lighting solutions, including LEDs, CFLs, and passive solar design, along with renewable heating, ventilation, and cooling systems, further reduces energy consumption and associated CO_2 emissions. Water conservation is equally critical, achievable through low-flow fixtures, rainwater harvesting, greywater recycling, and the incorporation of drought-tolerant plant species [8].

Designing for disassembly, reusing materials, and prioritizing biodegradable options can significantly decrease construction and demolition waste. SID thus serves as a strategic framework for reducing the environmental impact of interior spaces while enhancing occupant health, comfort, and productivity. To maintain relevance and effectiveness, designers must stay informed about advances in sustainable technologies and methods. Although SID holds substantial potential to mitigate environmental harm and improve human well-being, further empirical research is required to evaluate its long-term effects on ecological systems and residents' mental and physical health [9].

SID is a subclass of environmentally friendly architecture promoting indoor environmental quality (IEQ) with efficiency in energy use, site ecological responsibility, water usage reduction, and material choice. According to, material selection and IEQ are critical factors in environmentally friendly interior design because they immediately impact building occupants' emotional and physical health. Adopting and implementing SID becomes even more crucial when the typical individual spends 88% of their time indoors [10]. Despite the recent rise in interior design research, limited articles have examined the challenges related to SID in detail. Challenges are limitations that professionals have to bypass before completely integrating and using SID into their projects [11]. Given the scarcity of research in this area, Palm and Reindl's (2018) study is an applied, exploratory investigation into the barriers hindering energy-efficiency renovations in multifamily dwellings, offering valuable insights for sustainable interior design. By identifying social, economic, technical, and regulatory constraints, the research highlights critical gaps that limit the adoption of energy-efficient measures, thereby informing both design practice and policy. Its significance lies in advancing climate-responsive renovation strategies, guiding incentive programs, and fostering life cycle thinking that balances environmental performance with occupant comfort and aesthetic considerations, ultimately contributing to more sustainable, resilient, and livable residential environments [12]. They extended their study to embrace the building industry impediments to eco-friendly residence transformations. In the same spirit, articles, books, seminars, theses, and reports on the challenges linked with sustainability in the building industry were assessed to get a wide-ranging thoughtful of general subjects that may relate to this research topic. As a result, a list of 30 challenges to implementing sustainable interior design was formed and considered sufficient (see Table 1).

Table 1: Highlighted potential challenges in practicing SID

Code	Challenges	Reference
D1	Higher expenses due to eco-friendly construction techniques	[19]
D2	Investing in long-term project research and development	[33]
D3	Costs related to the maintenance of environmentally friendly technologies integrated into sustainable projects	[34]
D4	Sustainable developments require substantial ecological assessment ratings and registration costs	[33]
D5	Long-term return on investment for green initiatives	[35]
D6	The rising cost of sustainable resources	[36]
D7	Sustainable efforts need more time (more extended building period)	[36]
D8	Designers' unwillingness to adapt	[37]
D9	Lack of belief in sustainability and its beneficial benefits	[38]
D10	The nearby market does not have reliable, enduring materials and components	[39]
D11	The local market's limited supply of environmentally friendly materials and components	[40]
D12	Disagreement related to interests among construction parties	[41]
D13	Client indifference	[41]
D14	Developers lack the incentive to work appropriately and persuade clients to embrace sustainable techniques	[42]
D15	Limited knowledge and actual study of environmental materials and components	[42]
D16	The absence of developer experience and awareness	[42]
D17	Contractors and subcontractors lacked skills	[35]
D18	Client's lack of awareness	[43]
D19	The notion that sustainable design will compromise aesthetic values	[44]
D20	Clients do not grasp the commercial and ecological benefits of sustainable approaches	[43]
D21	The idea that sustainable measures do not increase the property's value	[45]
D22	Lack of sustainability assessment techniques that can be used for a wide range of project types	[46]
D23	Absence of rules, regulations, and a legal framework specialized to certain types of operations	[43]
D24	Lack of governmental assistance and incentives for sustainable conduct	[47]
D25	Lack of government encouragement of sustainable practices	[47]
D26	Lack of rigorous restrictions enforcing sustainable conduct	[43]
D27	Lack of physical practice for designers, including seminars and conferences provided by professional groups	[35]
D28	Lack of reliable and adequate technologies	[48]
D29	Lack of experience and technical understanding among designers	[42]
D30	Shortage of skilled labor	[49]

3. Methods and tools

This part highlights the methodology procedures of this study. After establishing a list of challenges to implement sustainable interior design, surveys were circulated to professionals with relevant expertise in the field. This was carried out concurrently with the study examination of these components to guarantee that the collection of hurdles facing sustainable interior design was comprehensive and accurate.

3.1. Data collection

The initial information on the relevance of the barriers influencing sustainable interior design must be gathered to achieve the research's targets [13]. Despite the many data-collecting techniques, surveys using questionnaires are a trendy, affordable tool to acquire data regarding conduct, opinions, and perspectives, and it is widely utilized by construction-related researchers [14]. The survey form is thus determined to be a suitable tool for this research.

3.2. Identification of challenges

Given the scarcity of empirical studies on the topic, the present bound literature and designers' perspectives are considered while developing a list of barriers influencing sustainable interior design. The study looked at possible hurdles and ambiguities faced along the quality/cost/time axis of interior design work, building firms' views concerning these obstacles, and the consequences of these hurdles on sustainable interior design achievement. Parameters from previous studies and perspectives on building sector expertise were gathered for that goal.

3.3. Design of questions

A questionnaire was developed and sent out to individuals working in both the private and public sectors of Saudi Arabia's building industry as part of the study from which the data was collected. The questionnaire is divided into three sections, each with a 5-point Likert scale question (1-extremely low to 5-extremely high), demographic questions, challenges to the implementation of sustainable interior design in the building sector (Table 1), and an open-ended question that enables respondents to express their thoughts.

3.4. Data analysis method

Cronbach's alpha is used to assess the reliability of questionnaire results. Cronbach's alpha is 0.902, indicating internal solid coherence [14]. This study utilized IBM SPSS version 26 to analyze the challenges of implementing sustainable interior design in the construction industry. The analysis employed the Relative Importance Index (RII) and Exploratory Factor Analysis (EFA) based on data collected from the building sector.

Relative importance index (RII)

To determine the importance level of the refined variables, the Relative Importance Index (RII) is used to reflect the relative significance of each variable as assessed by participants in the questionnaire survey [14]. This approach is one of the most used and has good accuracy value [15]. Equation 1 illustrates how the RII for variable k is determined.

$$\text{RII} = \frac{\sum Sk}{S \times N} \tag{1}$$

Where sk is the overall rating given to inconstant k by respondents (1–5), S is the most significant rating (5), and N is the total amount of individuals who participated (187). The RII's value increases with more influencing variables. In this research, the RII might range from 0 to 1 (0,2 for less important, 1 for most important). Table 2 shows the criteria used to evaluate RII scores [16].

Table 2: The scoring criterion for 5-point Likert scale questions [16]

Likert Score Interval (Mean)	RII Score	Description
1,00 – 1,79	0,200 – 0,358	Extremely low level
1,80 – 2.59	0,359 – 0,518	Below average level
2,60 – 3,39	0,519 – 0,678	Moderate level
3,40 – 4,19	0,679 – 0,838	Above average level
4,20 – 5,00	0,839 – 1,000	Extremely high level

Exploratory factor analysis (EFA)

EFA is a mathematical method that aggregates a variety of connected parameters into more straightforward, more fundamental components known as "factors" [17]. The main aim of this approach is to limit the number of variables evaluated to a smaller set of parameters, thereby enhancing interpretation and uncovering hidden insights [18]. Before factor extraction, two essential factor analysis criteria (FA) criteria should be tested: multivariate normality and sample adequacy [15]. The normal distribution of variables in multiple dimensions is measured using the test of sphericity by Bartlett. In contrast, the Kaiser-Meyer-Olkin (KMO) test determines whether the spreading of values is acceptable for performing FA. The data is statistically significant ($p < 0.05$) according to the Bartlett sphericity test, and the KMO value (0.876) confirms eligibility for FA (>0.5) [19]. The analysis of principal components is the extraction technique used in EFA, and Oblimin is the rotation method. Each factor's primary variables are established and utilized as contextual indicators to help determine the factor's significance. Four criteria are used to select these essential variables: (1) an eigenvalue of 1; (2) loading values for variables should be a minimum of 0.4; (3) each factor should include only one variable; and (4) a factor must consist of at least two variables [20].

3.5. Responses

The study's panel of participants includes 187 construction industry practitioners from Saudi Arabia. 37% of the participants are directors, 21% are project managers, 17% are site leaders, 15% are contractors, and 10% are office/site engineers. 43% of participants have more than 15 years of work experience, while 29% have 10-15 years, 16% have 1-4 years, 9% have 5-9 years, and 3% have less than a year.

4. Results

This part presents the findings from the analysis of the gathered data. It first reports the results of the Relative Importance Index (RII), followed by the outcomes of the Exploratory Factor Analysis (EFA).

4.1. RII results

The RII values for the barriers are revealed in Table 3 and illustrated in Figure 1. As noted in the table, the RII values for most obstacles are more than 0,519, suggesting respondents generally agree on the likelihood of these hurdles to adopting SID in the building sector, but with varying degrees of agreement. Six of the 30 challenges have been identified as extremely high levels ($0.679 \leq RII \leq 0.838$). These challenges contain (1) contractors and subcontractors lacking skills; (2) shortage of skilled labor; (3) client's lack of awareness; (4) clients do not grasp the commercial and ecological benefits of sustainable approaches; (5) limited knowledge and actual study on environmental materials and components, and (6) the absence of developer experience and awareness. At the same time, 21 variables are rated as moderate significant (lack of rigorous restrictions enforcing sustainable conduct; higher expenses due to eco-friendly construction techniques; the local market's limited supply of environmentally friendly materials and components; disagreement related to interests among construction parties; lack of belief in sustainability and its beneficial benefits; absence of practice and methodical thoughtful among designers; the nearby market does not have reliable, enduring materials and components; the idea that sustainable practices don't boost the property value; absence of rules, regulations, and a legal framework specialized to certain types of operations; lack of sustainability assessment techniques that can be used to a wide range of project types; investing in long-term project research and development; costs related to the maintenance of environmentally friendly technologies integrated into sustainable projects; sustainable efforts need more time (more extended building period); developers lack the incentive to work appropriately and persuade clients to embrace sustainable techniques; lack of governmental assistance and incentives for sustainable conduct; sustainable developments require substantial ecological assessment ratings and registration costs; the rising cost of sustainable resources; long-term return on investment for green initiatives; the notion that sustainable design will compromise aesthetic values; lack of physical activity for designers, including seminars and conferences provided by professional groups; lack of reliable and adequate technologies). The remaining three variables are rated low significant (client indifference, designers' unwillingness to adapt, and lack of government encouragement of sustainable practices).

Table 3: RII scores of challenges

No	Code	Challenge	RII
1	D17	Contractors and subcontractors lacked skills	0.707
2	D30	Shortage of skilled labor	0.706
3	D18	Client's lack of awareness	0.695
4	D20	Clients do not grasp the commercial and ecological benefits of sustainable approaches	0.693
5	D15	Limited knowledge and actual study of environmental materials and components	0.689
6	D16	The absence of developer experience and awareness	0.679
7	D26	Lack of rigorous restrictions enforcing sustainable conduct	0.648
8	D1	Higher expenses due to eco-friendly construction techniques	0.641
9	D11	The local market's limited supply of environmentally friendly materials and components	0.639
10	D12	Disagreement related to interests among construction parties	0.616
11	D9	Lack of belief in sustainability and its beneficial benefits	0.614
12	D29	Lack of experience and technical understanding among designers	0.606
13	D10	The nearby market does not have reliable, enduring materials and components	0.603
14	D21	The idea that sustainable measures do not increase the property's value	0.599
15	D23	Absence of rules, regulations, and a legal framework specialized to certain types of operations	0.589
16	D22	Lack of sustainability assessment techniques that can be used for a wide range of project types	0.586
17	D2	Investing in long-term project research and development	0.579
18	D3	Costs related to the maintenance of environmentally friendly technologies integrated into sustainable projects	0.576
19	D7	Sustainable efforts need more time (longer building period)	0.574
20	D14	Developers lack the incentive to work appropriately and persuade clients to embrace sustainable techniques	0.569
21	D24	Lack of governmental assistance and incentives for sustainable conduct	0.567
22	D4	Sustainable developments require substantial ecological assessment ratings and registration costs	0.559
23	D6	The rising cost of sustainable resources	0.548
24	D5	Long-term return on investment for green initiatives	0.542
25	D19	The notion that sustainable design will compromise aesthetic values	0.532
26	D27	Lack of physical practice for designers, including seminars and conferences provided by professional groups	0.529

No	Code	Challenge	RII
27	D28	Lack of reliable and adequate technologies	0.523
28	D13	Client indifference	0.516
29	D8	Designers' unwillingness to adapt	0.479
30	D25	Lack of government encouragement of sustainable practices	0.464

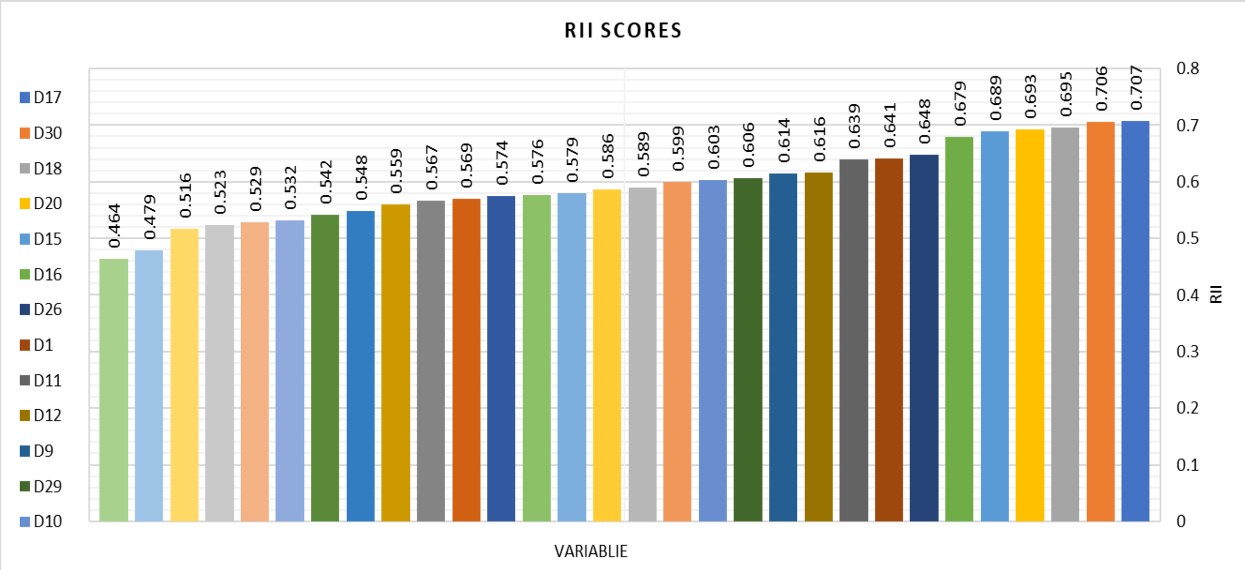

Figure 1: Graphical display of challenges' RII scores

4.2. EFA results

EFA yielded five components that explain 61.065% of the variation. Table 4 shows these parameters and their respective variations. Table 5 displays the factor order and weights for the primary factor extraction. Except for three variables, the loadings of the critical variables given for each extracted component are more than 0.5, indicating that each variable contributes considerably to the extraction factor. The extracted component is assigned to a suitable aggregate name to illustrate the relationship among all variables. Table 6 shows the extracted components and their corresponding variables. The variance proportion establishes the ranking of the relevant elements: (1) knowledge and awareness, (2) governmental rules and regulations, (3) economics, (4) attitude and market, and (5) technology and training. The first component, "knowledge and awareness", reflects the most significant total variance (%31.861). It consists of seven variables: clients do not grasp the commercial and ecological benefits of sustainable approaches, clients lack awareness, the idea that sustainable practices don't boost the property value, limited knowledge and actual study on ecological materials and components, the absence of developer experience and awareness, the notion that sustainable design will compromise aesthetic values, and contractors and subcontractors lacked skills.

The second component, "governmental rules and regulations", covers 13.780% of the total variance and consists of five challenges: lack of government encouragement of sustainable practices, lack of rigorous restrictions enforcing sustainable conduct, lack of sustainability assessment techniques that can be used to a wide range of project types, lack of governmental assistance and incentives for sustainable conduct. The lack of governmental assistance refers to the absence or insufficiency of institutional support mechanisms that could facilitate the adoption of sustainable interior design (SID) practices. Such assistance typically includes financial incentives such as tax rebates, subsidies, and low-interest loans targeted training programs, and the provision of standardized sustainability assessment tools applicable to a wide range of project types [1]. In Saudi Arabia, these measures remain limited or are not tailored to interior design, resulting in higher project costs, constrained access to specialized expertise, and reduced motivation among stakeholders to prioritize SID. Comparative experiences from Singapore and Malaysia illustrate the impact of well-structured governmental support: Singapore's Green Mark Scheme and Malaysia's Green Building Index have successfully boosted sustainable practices by combining mandatory requirements in public projects with tax benefits, certification advantages, and capacity-building programs. The absence of similar, comprehensive frameworks in the Saudi context means that industry players especially small and medium-sized firms lack the institutional backing necessary to offset the financial, technical, and operational barriers to implementing SID, thereby slowing its mainstream adoption [21].

In line with the Kingdom of Saudi Arabia's Vision 2030, sustainability has been identified as a strategic priority across all sectors, including the construction and interior design industries. Vision 2030 explicitly promotes environmentally responsible practices to reduce resource consumption, enhance energy efficiency, and protect the natural environment. To support these goals, national standards and conditions for sustainable construction such as the Saudi Building Code's sustainability provisions and the Mostadam rating system have been established and are progressively being implemented in both public and private sector projects [22]. However, despite these frameworks, gaps remain in their integration into sustainable interior design practices. Many existing policies focus primarily on structural and urban-scale sustainability, with limited direct application or enforcement mechanisms tailored to the interior design domain. Bridging this gap by aligning SID-specific guidelines with Vision 2030 objectives could accelerate the sector's contribution to national sustainability targets [1].

The third component, "economic", represents 5.800% variances. This group includes seven challenges: sustainable efforts need more time (more extended building period), costs related to the maintenance of environmentally friendly technologies integrated into sustainable projects, long-term return on investment for green initiatives, investing in long-term project research and development, higher expenses due to eco-friendly construction techniques, the rising cost of sustainable resources, and sustainable developments require substantial ecological assessment ratings and registration costs. The fourth component, "attitude and market," reveals 5.478% of the total variance and is composed of seven challenges: designers' unwillingness to adapt, lack of belief in sustainability and its beneficial benefits, the nearby market does not have reliable, enduring materials and components, the local market's limited supply of environmentally friendly materials and components, disagreement related to interests among construction parties, client indifference, and developers lack the incentive to work appropriately and persuade clients to embrace sustainable techniques. The fifth and last component, "technology and training," represents a minor total variance (4.674%). This factor has four challenges: lack of physical practice for designers, including seminars and conferences provided by professional groups, lack of reliable and adequate technologies, lack of experience and technical understanding among designers, and shortage of skilled labor.

Table 4: Components and explained variance

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	7.430	31.861	31.861	7.430	31.861	31.861	6.287
2	3.271	13.780	45.509	3.271	13.780	45.509	3.722
3	1.436	5.800	51.177	1.436	5.800	51.177	4.047
4	1.362	5.478	56.523	1.362	5.478	56.523	2.697
5	1.177	4.674	61.065	1.177	4.674	61.065	2.202

Table 5: Structure and loadings of the primary extraction

	Component				
	1	2	3	4	5
D20	**0.844**	0.257	0.578	0.086	0.199
D18	**0.826**	0.296	0.196	0.006	0.258
D21	**0.766**	0.259	-0.020	0.321	0.109
D15	**0.716**	0.083	0.112	0.143	0.066
D16	**0.680**	0.229	0.092	0.194	0.199
D19	**0.656**	0.311	0.221	0.320	0.055
D17	**0.640**	0.334	0.329	0.207	-0.087
D23	0.022	**0.756**	0.073	0.106	0.239
D25	0.197	**0.654**	0.134	-0.093	0.367
D26	0.187	**0.632**	0.310	-0.011	0.214
D22	0.056	**0.621**	0.080	0.296	0.065
D24	0.299	**0.620**	0.072	0.210	-0.010
D7	0.167	0.080	**0.795**	0.003	0.034
D3	0.133	0.160	**0.713**	0.032	0.062
D5	0.016	0.304	**0.647**	0.045	0.233
D2	-0.108	0.244	**0.606**	0.020	0.326
D1	0.126	0.210	**0.596**	-0.014	0.007
D6	0.293	0.293	**0.569**	0.306	0.184
D4	-0.030	0.005	**0.491**	0.302	0.171
D14	0.065	0.315	0.096	**0.769**	0.016
D9	-0.189	0.005	0.139	**0.747**	0.196
D13	0.286	0.059	0.008	**0.689**	0.045
D11	0.339	0.322	0.296	**0.653**	0.007
D10	0.020	0.244	0.326	**0.587**	0.055
D12	0.326	0.051	0.062	**0.498**	-0.014
D8	0.299	0.120	0.167	**0.484**	0.005
D30	0.051	0.067	0.302	0.096	**0.769**
D29	0.005	0.167	0.055	0.139	**0.745**
D28	0.302	0.096	0.005	0.016	**0.647**
D27	0.005	0.286	0.051	0.008	**0.513**

Table 6: Derived components and their associated challenges

Component	Challenge
Knowledge and awareness	Clients do not grasp the commercial and ecological benefits of sustainable approaches Client's lack of awareness The idea that sustainable practices don't boost the property value Limited knowledge and actual study of environmental materials and components The absence of developer experience and awareness The notion that sustainable design will compromise aesthetic values Contractors and subcontractors lacked skills
Governmental rules and regulations	Absence of rules, regulations, and a legal framework specialized in certain types of operations Lack of government encouragement of sustainable practices Lack of rigorous restrictions enforcing sustainable conduct Lack of sustainability assessment techniques that can be used for a wide range of project types Lack of governmental assistance and incentives for sustainable conduct
Economic	Sustainable efforts need more time (more extended building period)

Component	Challenge
	Costs related to the maintenance of environmentally friendly technologies integrated into sustainable projects
	Long-term return on investment for green initiatives
	Investing in long-term project research and development
	Higher expenses due to eco-friendly construction techniques
	The rising cost of sustainable resources
	Sustainable developments require substantial ecological assessment ratings and registration costs
Attitude and market	Designers' unwillingness to adapt
	Lack of belief in sustainability and its beneficial benefits
	The nearby market does not have reliable, enduring materials and components
	The local market's limited supply of environmentally friendly materials and components
	Disagreement related to interests among construction parties
	Client indifference
	Developers lack the incentive to work appropriately and persuade clients to embrace sustainable techniques
Technology and training	Lack of physical practice for designers, including seminars and conferences provided by professional groups
	Lack of reliable and adequate technologies
	Lack of experience and technical understanding among designers
	Shortage of skilled labor

5. Discussion

Writing Sustainable interior design is crucial in many developed nations' building industries but is almost non-existent in impoverished ones. Like many other rising countries, Saudi Arabia has encountered construction-related challenges and disputes. This emphasizes the need for sustainable interior design solutions to address these challenges. Upper management's decision to integrate SID as a key component of their projects would greatly help experts recognize sustainable practices and their core building activities. The proposed method emphasizes the challenges of implementing sustainable interior design. This approach has the potential to increase sustainability in residential buildings. As a result, organizations in the building sector may conserve time and cost without compromising project quality or utility by adopting SID [23]. The subsequent sections provide examples of groups developed from the challenges structures by subject matter experts.

5.1. Knowledge and awareness challenges

According to studies, significant challenges to employing SID involve a lack of physical activity, experience, and knowledge [24]. Several studies have linked delayed development and reluctance to participate in green efforts to a lack of awareness among clients and other stakeholders. According to, it might take time for architectural design professionals to find resources due to a lack of understanding about maintainable solutions. Clients believe that the economic advantages of a sustainable approach, as assessed by improvements in the price of properties, are inadequate. In a comparable direction, it was noticed that homeowners in Malaysia lacked awareness, emphasizing the significance of educating customers on the benefits of sustainability to stimulate their attention. Aydin, et al. stated, homeowners incredibly value style, making them the next greatest significant factor. This is particularly right for those who think ecologically sociable elements distract from the building's aesthetics [25]. Others, however, argue that more significant market rivalry is the cause of this issue is essential does not exist in the SID business nowadays; as a result, they claim builders have produced innovative, more visually appealing goods, resources, and appearances to fulfill customer preferences [1]. It is important to note that this viewpoint is formed in a developed nation; many evolving countries do not have access to the matching range, depth, and standard of market-provided commodities.

In the context of Saudi Arabia's hot and arid climate, passive design strategies such as maximizing natural ventilation, optimizing building orientation, and using shading devices play a crucial role in reducing energy loads while improving indoor thermal comfort [26]. Selecting locally available, climate-appropriate materials (e.g., high thermal mass stone, insulated wall systems, and reflective roofing finishes) can significantly enhance building performance while supporting SID principles. Raising awareness among practitioners about these strategies is essential for achieving environmentally responsive interiors in the Saudi context [27].

5.2. Governmental rules and regulations challenges

Comparative international experiences offer valuable lessons for enhancing governmental support for sustainable interior design in Saudi Arabia. For example, Singapore's Green Mark Scheme has combined strict regulatory requirements with strong incentives such as tax rebates, expedited approvals, and public recognition to encourage environmentally responsible projects. A notable case is the Parkroyal Collection Pickering, a luxury hotel designed by WOHA, (Figure 2)which integrates extensive "sky gardens," water features, solar cells, and rainwater harvesting systems [28]. This project demonstrates how clear government frameworks, certification benefits, and a supportive policy environment can foster ambitious sustainability outcomes in both architectural and interior design. Similarly, Malaysia's Green Building Index (GBI) has promoted sustainable practices through voluntary certification tied to financial incentives and awareness programs [29]. However, both countries faced early-stage challenges, including industry resistance due to perceived higher costs, the need for specialized training, and limited market availability of sustainable materials. These examples illustrate that while robust governmental frameworks and incentives can significantly advance sustainable design adoption, complementary measures such as capacity building, supply chain development, and public awareness are essential to overcoming initial market and professional barriers.

Figure 2 Parkroyal Collection Pickering, Singapore (formerly known as PARKROYAL on Pickering), is a luxury five-star hotel located in Singapore's Central Area.

The hotel was designed by WOHA, a Singapore-based architecture firm. It was designed as a hotel-as-garden. It includes green walls, water features, and 15,000 m2 of tiered "sky gardens". The building is claimed to be self-sustaining and designed to consume minimal energy with the use of solar cells, motion sensors, rainwater harvesting and reclaimed water [30].

The absence of governmental benefits that encourage industry players to adopt maintainable performance may result in a scarcity of ecological projects. Though investigations in wealthier nations have shown no issues, a deficiency of governmental motivations is recognized as the most significant challenge in growing countries. While adopting such encouragement is viewed as a good phase to a more environmentally friendly future, its true importance stems from their flexibility and adaptability for a wide range of developments and participants. Even though the Singaporean management has provided many inducements, stated that these incentives disproportionately benefit designers, builders, and proprietors, hindering other investors from benefiting from embracing maintainable performance. Another challenge to workable methods frequently noted in studies is the absence of development-specific guidelines, rules, and authorized frameworks. According to, a comprehensive legal system exists to oversee the creation of new structures well previously the building phase begins. Still, there is no comparable rigorous governing process for restoration projects. claimed that existing assessment systems, such as the GBI, are unsuitable since they remained not designed with refurbishment schemes in mind.

5.3. Economic challenges

Clients frequently desire immediate savings over future savings; the higher initial cost of sustainable initiatives and the further raised payback savings period, as opposed to traditional kinds, have been identified as some of the most significant barriers [31]. In the work of, the extra cost for eco-friendly architecture could be up to 21% more than typical constructions. Sustainable design requires more research time, which can contribute to lengthier design processes and more significant consultation expenses [32]. According to the World Green Building Smart Market Report published in 2018, while cost is perceived as the biggest impediment to sustainable structure, its impact differs meaningfully by country [33]. This disparity demands region-specific studies. mentioned, the possibility of employing SID on a specific development is proportional to its size [34]. The academic works regularly mention the greater cost of renewable resources and the expenditures associated with the certification of green development. Complex starting prices, expenses for upkeep, R&D costs, and risk associated with investments have remained recognized as substantial challenges in research focusing on the Malaysian environment [35].

5.4. Attitude and market challenges

Attitude-related barriers are considered the most important challenges to implementing green development in the USA, Canada, and Australia. Consultants should push their clients to develop ecologically friendly solutions [36]. However, studies indicate that not all experts are excited about this duty. As stated by designers and architectural professionals, they favor sticking to known procedures rather than going into innovative territory since it saves energy and time. The term "unfamiliar territory" may be more accurate in locations where SID is still underappreciated. Architects play a critical role in bridging the gap between sustainable design principles and client acceptance. By actively incorporating environmental solutions such as improved indoor air quality measures, daylighting strategies, and thermal comfort enhancements into their design proposals, architects can demonstrate tangible benefits to clients [37]. Moreover, effective marketing of sustainable designs, emphasizing both lifestyle improvements and long-term economic savings, can shift market attitudes and increase demand for SID-compliant projects.

Lee and Hallak found that practitioners' perceptions regarding the advantages of SID are highly connected to their positions on applying the practice [38]. This is similar to Mate results, which revealed that proactive SID professionals did not consider cost a significant obstacle to entrance, but reactive practitioners did. Similarly, the client's values influence how they function as market stakeholders. Some research has revealed that consumers are unsure of the concept of sustainability, with many wondering if it will help their health, comfort, or quality of life in any way [39]. According to Hwang and Tan, the client's lack of interest is a huge impediment, and applying sustainable building methods is impractical. However, the frequency of inequalities between stakeholders' interests and the unavailability of ecologically obtained structure constituents in the local market pose significant barriers to the broad application of environmentally friendly building practices [40].

5.5. Technology and training challenges

Advances in materials science and building technologies offer promising opportunities for SID implementation. For example, nano-sensors can be integrated into interior systems to monitor temperature, humidity, and air quality in real time, enabling adaptive environmental control. Smart materials such as thermochromic glass and phase-change wall panels can dynamically respond to environmental changes, enhancing occupant comfort while reducing energy consumption. Training designers to integrate these technologies into local practice could significantly advance Saudi Arabia’s sustainable interior design sector [41].

Tabassi, et al. underlined the importance of training since it could result in happier workers and boost sustainability-related ideas [42]. One of the major impediments in the economies of Malaysia, Singapore, and Thailand is a lack of exercise and practical knowledge among practitioners. As a result, the process of building and designing may take longer than anticipated, raising expenses and limiting the possibility of customers selecting environmentally friendly choices. According to Olanrewaju, et al., operators' lack of access to accurate and pertinent technologies in the local market impedes the broad application of sustainable building methods. Because most of the essential science and technology, elements, and materials are imported, this challenge is compounded by growing countries that are just beginning their journey to sustainable growth. According to the researchers, the mentioned items may cost more than initially estimated owing to the substantial exercise required for planning, implementation, and construction [43].

6. Conclusions

The building sector has recently shifted its attention to implementing environmental standards. Moreover, sustainability in the SID sector has been ignored for much longer than necessary. Since humans spend more time indoors, it is critical to incorporate SID themes in any indoor development. Due to the novelty of the concept, SID practitioners in Saudi Arabia face various challenges. Given this, this study intended to recognize and order the variables that impede the practice of SID in Saudi Arabian developments. This paper presents a detailed analysis of the hurdles to SID implementation in Saudi Arabia's construction sector. Challenges to SID implementation in the construction industry were identified using the RII and EFA. Interpreting the findings of the RII and EFA combined gives a novel insight, allowing an individual to identify the key hurdles. According to the study's findings, the top five hurdles to implementing SID in home projects are as follows: (1) knowledge and awareness hurdles; (2) governmental rules and regulations hurdles; (3) economic hurdles; (4) attitude and market hurdles; and (5) technology and training hurdles.

Given the above, there is an urgent need to improve SID-related training for interior architects and designers in Saudi Arabia, alongside targeted awareness campaigns for developers, clients, and the wider public. While these recommendations are tailored to Saudi Arabia's building industry, many of the identified challenges such as lack of awareness, limited regulatory frameworks, and inadequate training are also relevant to other developing countries, allowing for cross-regional learning and adaptation. Overall, monetary considerations are not considered substantial impediments, which goes against the traditional understanding of the surroundings. This doesn't mean that cost should be ignored when designing an interior; nonetheless, assuming the limited scope of SID in Saudi Arabia, it is understood that other factors should be prioritized. Given the above, there is an urgent need to wholly and dramatically improve interior architect and designer training. To raise understanding across developers, clients, and the community, lawmakers and legal bodies should take a more active role in promoting, supporting, and regulating the SID profession.

7. Limitations

While the study's objectives were achieved, it's important to acknowledge certain limitations to guide future research and enhance the interpretation of the results. First and foremost, keep in mind that the results are skewed in favor of Saudi Arabian professionals' perspectives. As a result, regardless of whether the researchers predict comparable findings in analogous circumstances, the current study's findings cannot be generalized due to the well-known drawback of using random sampling methodologies.
Nonetheless, subject matter experts need to conduct comparative studies in many countries and locales since challenges are significantly influenced by their specific contexts. Future research could explore the acceptance and obstacles of SID in both developed and emerging nations. Such studies would make it easy to construct an entire representation to investigate how impediments interact with other elements at play. For meaningful contributions to the SID field, further studies should target the core challenges (whether broad or specific) highlighted in this research, as well as assess efficient strategies, standards of learning, and regulations related to sustainable restoration. The absence of relevant literature on the topic related to the inquiry is also viewed as a severe limitation. As a result, the writers expanded their literature search to incorporate challenges to sustainable activities that are common in the construction industry. They then refined them further, following the context of the present research.

8. Implications

Considering previously stated, the current study proposes several practical and theoretical implications for academic and occupational. This study identified the most significant challenges to adopting SID in indoor building projects that have not yet been explored in existing literature. The results differ from earlier research, suggesting that financial limitations are not ranked as the most critical challenge. Instead, barriers to training, education, regulations, and legislation are high. Given the scarcity of such studies in Saudi Arabia, this work addresses a knowledge gap and creates a path for future research. This study provides an original quantitative approach for streamlining data collection and processing while ensuring high-quality results. Furthermore, to these advantages, the study's outcomes could help those in the construction industry identify the most significant difficulties in the SID field. The findings indicate a critical need for broad improvement, involving but not restricted to variations in learning ethics, regulation, and professional attitudes. The details of these modifications are as follows:

1- SID plan certification standards must incorporate ecological modules dealing with the triple bottom line.
2- Only qualified experts can collaborate on interior restoration projects; thus, interior architects/designers must pass a qualification test incorporating SID principles and tightly control their activity.
3- Official organizations, companies, and institutions should provide regular seminars and educational courses for working professionals.
4- Interior architects and designers are encouraged to embrace SID, enlighten, inspire, and persuade consumers, and implement the concept into developments without compromising aesthetics or affordability.

The foundation established will pave the way for more comprehensive future programs. Instructors, legal responsibilities, resident and national management, and legislators may all benefit from the findings, not only professionals' architects and designers. Consequently, this can stimulate local economies, increase demand for renewable resources in the area, and lower overall energy consumption.

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