buildings

MDPI

Article

Barriers to Undertaking Green Building Projects in Developing Countries: A Turkish Perspective

Emre Caner Akcay

Department of Civil Engineering, Atilim University, 06830 Ankara, Turkey; caner.akcay@atilim.edu.tr

Abstract: Green buildings (GBs) play an important role in achieving sustainable development goals. However, the implementation of green technologies in building projects has not reached the desired level in developing countries such as Turkey because of barriers stemming from country-related factors as well as factors related to design and construction. The objective of this study was to explore the barriers to undertaking GB projects in Turkey. A questionnaire survey was administered to 116 construction practitioners to analyze the criticality of barriers to GB design and construction in the Turkish construction industry. Both descriptive and inferential statistics were adopted to evaluate the data obtained from the questionnaire survey. The findings suggest that the major barriers that hinder the adoption of GBs in Turkey are higher construction cost, lack of knowledge about GBs, lack of an authorized GB rating system, unavailability of GB materials, and inadequate market demand, whereas longer design time is the least critical barrier. The results of factor analysis indicate that the barriers to undertaking GB projects can be grouped under five "factors", i.e., cost- and demand-related barriers, market-related barriers, people-related barriers, government-related barriers, and time-related barriers. In light of the results, policy makers and construction practitioners can devise strategies to promote GBs in Turkey, which can also be valid in other developing countries with similar socio-economic conditions.

Keywords: barrier; construction industry; factor analysis; green building; sustainability

Citation: Akcay, E.C. Barriers to Undertaking Green Building Projects in Developing Countries: A Turkish Perspective. *Buildings* **2023**, *13*, 841. https://doi.org/10.3390/buildings13040841

Academic Editor: Antonio Caggiano

Received: 14 February 2023
Revised: 15 March 2023
Accepted: 21 March 2023
Published: 23 March 2023

1. Introduction

Global warming is one of the major problems for humanity, causing a range of changes in the environment and weather systems [1]. The amount of greenhouse-gas emissions has a direct impact on global warming [2]. Compared with other industries, the construction industry is responsible for a significant share of greenhouse-gas emissions [3]. The construction industry in the European Union accounts for 40% of energy consumption and 36% of CO_2 emissions [4]. According to the International Energy Agency [5], with 35% of the total energy consumption and 38% of the total CO_2 emissions, the construction industry ranks first among other industries with respect to energy consumption and greenhouse-gas emissions. Furthermore, buildings account for 14% of potable water consumption, 30% of waste output, 40% of raw material use, and 72% of electricity consumption in the U.S. [6]. Moreover, only 75% of the building stock in the E.U. is energy inefficient [4]. To reduce the negative environmental impact of the construction industry and to achieve sustainable development, GBs have been designated by researchers as a panacea [7].

GB can be defined as an approach that provides healthier buildings that minimize negative environmental effects by performing a resource-efficient construction process [8]. Compared with conventional buildings, GBs involve several environmental benefits, such as saving energy, reducing CO_2 emissions, reducing waste, and reducing the consumption of potable water [9,10].

As energy efficiency is one of the most important criteria for the performance of buildings, there has been growing interest in the concept of nearly zero-emission buildings (nZEBs) and passive buildings (PBs). The concept of PB refers to a design standard for buildings that maintains thermal comfort with minimal heating and cooling [11]. On the other hand, an nZEB is defined as "a building that has a very high energy performance, while the nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby" [12]. According to Kang et al. [13], implementations to achieve nZEBs can be grouped into four categories, including passive design techniques; high-performance heating, ventilation, and air conditioning (HVAC) systems; high-efficiency lighting systems; and utilization of renewable energy sources. Both PBs and nZEBs aim to reduce adverse environmental impacts of buildings [11,14].

GBs not only provide environmental benefits, but they also promote economic solutions (e.g., reducing maintenance costs) and social benefits (e.g., improving indoor air quality and improving thermal comfort) [1]. Due to these benefits, many countries strive to undertake many GB projects to achieve sustainable development [15]. Turkey is a developing country that attaches great importance to GBs to reduce the negative impacts of conventional buildings. With a total number of 518 certified GBs, Turkey ranks sixth in the world, but it is still lagging far behind the government's sustainability goals [16]. Despite their social, economic, and environmental benefits, there are some barriers to undertaking GB projects. As indicated in previous research studies [17–19], exploring the barriers to undertaking GB projects is the key factor for the wider acceptance of GBs.

Turkey is a transcontinental country, located partly in Europe and partly in Asia. With a population of 84.1 million [20] and a gross domestic product (GDP) of USD 806.804 billion, Turkey is the twenty-third largest economy in the world [21] but is classified as a developing country. In terms of purchasing power parity (PPP), Turkey ranks as the eleventh largest country in the world [21]. The construction sector has vital importance in the development of the country's economy, contributing approximately 8–9% of the GDP [22]. Moreover, it contributes nearly 30% of the overall economy with its direct and indirect effects on associated sectors [23].

The main objective of this research study was to explore the barriers hindering the adoption and use of green practices in building design and construction in Turkey and in other developing countries with similar socio-economic conditions. This research was performed to answer the following questions:

(1) What are the key barriers to undertaking GB projects in Turkey?
(2) Are there any differences in the perceptions of representatives of public agencies and professionals employed by private owners relative to the criticality of the barriers to adopting green principles in building design and construction?

In light of this research, both practitioners and policy makers can devise strategies to overcome the barriers hindering the adoption of green objectives.

2. Literature Review

2.1. Previous Studies on GBs

Ali and Nsairat [24] described the main purpose of GB as "to create environmentally efficient buildings by using an integrated approach of design so that the negative impact of building on the environment and occupants is reduced". The concept of GB first emerged in the middle of the nineteenth century [25]. The indoor air temperatures in London's Crystal Palace and Milan's Galleria Vittorio Emanuele II were controlled using passive systems such as roof ventilators and underground air-cooling chambers [25]. Moreover, deep-set windows were used in skyscrapers in New York to block the sun in the early twentieth century [25]. As the first significant concern about energy sources appeared in the early 1970s with the increase in oil prices, there has been growing interest in solar technologies, energy efficiency, and retrofitting wall insulation for homes and commercial buildings [26]. This interest can be considered an important step of the GB movement. In 1987, the World Commission on Environment and Development published a report where they first described the "sustainable development" term [27]. According to this report, "sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [27]. The GB concept was first discussed at the Environment and Development Conference in Rio de Janeiro, Brazil, in 1992 [9]. From this year onwards, researchers' interest in GBs has gradually increased. Specifically, over the past two decades, GBs or high-performance buildings have been attracting the attention of both researchers and practitioners. It should be noted that the terms "green building", "sustainable construction", and "high performance building" have been used interchangeably in previous studies.

There have been various research studies on different aspects of GBs. Several studies have been performed to reveal the economic, social, and environmental benefits of GBs (e.g., [28–43]). For instance, Alsulaili et al. [28] used a case study in Kuwait to demonstrate the benefits of GBs. In this case study, a conventional building was converted into a GB. The findings revealed that by greening the building, the CO_2 emissions, energy waste, and water consumption dramatically decreased, whereas cost savings and indoor air quality increased. GB rating systems play an important role in the development of GBs, as these rating systems assist designers and construction professionals in making informed decisions about different green alternatives [44]. Consequently, there have been many research efforts to analyze and compare the different GB rating systems (e.g., [45–57]). The vast majority of these studies focused especially on the Leadership in Energy and Environmental Design (LEED) certification, because LEED is the most extensively used GB rating system in the world. For example, Pham et al. [55] evaluated the selections performed by the project teams of 222 projects that used LEED New Construction Version 4 (LEED-NC-V4). Since heating ventilation and air conditioning (HVAC) systems have the largest impact on the energy consumption of GBs [58], several research studies solely concentrated on applying different optimization techniques to HVAC systems to reduce the total energy usage of buildings (e.g., [59–65]). For instance, Bichiou and Krarti [59] presented a study that optimizes the HVAC system of residential buildings by adopting three different optimization algorithms, such as genetic algorithms, the particle swarm algorithm, and the sequential search algorithm.

2.2. Previous Studies on Barriers to Undertaking GB Projects

The proliferation of GBs has been hampered by many local and global barriers, especially in developing countries [66]. According to Chan et al. [67], the number of GBs cannot reach the desired level unless a thorough examination is performed of the barriers hindering the proliferation of GBs. One of those studies was conducted by Chan et al. [7], who investigated the barriers to undertaking GB projects by administering a questionnaire survey to respondents from Australia, Canada, and the U.S. and found that "resistance of stakeholders to change from the use of traditional technologies" and "the high cost of green technologies" were the most critical barriers. Agyekum et al. [68] concluded in their study that there are eight key barriers to undertaking GB projects in Ghana. These barriers include "lack of information on existing GBs", "lack of incentives", "conservative nature of Ghanaians", "lack of active government participation", "inadequate human resource", "lack of awareness of the benefits", "cost and financing", and "lack of legal backing". Mesthrige and Kwong [69] reported that crucial barriers preventing GB adoption in Hong Kong include "the green cost implications", "the structural unsuitability of the current stock of old buildings", and "the lack of financial incentives". According to Azeem [70], the top three barriers impeding the adoption of GBs in Pakistan are "lack of awareness", "lack of incentives", and "lack of regulations". Addy et al. [71] investigated the barriers to developing GBs in Sub-Saharan Africa. They summarized that the top three barriers are "lack of awareness", "lack of education", and "lack of fiscal incentives". Samari et al. [72] explored the impediments to implementing sustainable building in Malaysia. They highlighted that "lack of governmental financial incentives" and "lack of public awareness" are the most important barriers. Olowosile et al. [73] identified the top three barriers to the achievement of sustainable construction projects in Nigeria as "unawareness of client", "overall management action", "lack of fund", and "contractual procedures". Samari et al. [74] examined the barriers to GB development in Malaysia. "Lack of credit resources to cover up front cost", "risk of investment", "lack of demand", and "higher price" were found to be the top barriers. Tafazzoli et al. [75] divided barriers to sustainable construction in the U.S. into three categories, i.e., owner-related, contractor-related, and government-related barriers. The most important barrier was found to be "higher cost of GBs". Ohiomah et al. [76] investigated the barriers to sustainable construction in South Africa. They concluded that "higher cost", "lack of expertise", and "lack of training" are the major barriers that hinder the adoption of sustainable construction. According to Deng et al. [77], the top five barriers impeding the development of GBs in China include "inadequate incentive mechanism", "insufficient construction industrialization level", "lack of platform to publicize and demo new technologies", "lack of market recognition", and "lack of coordination among participants and between different stages of a GB project", whereas according to Arokiaprakash and Kumar [78], who focused on the barriers to the implementation of GBs in India, the most important barrier was found to be "financial risks in GBs". Nikyema and Blouin [66] identified five categories of barriers, i.e., government, human, knowledge and information, market, and cost and risk barriers, to GB adoption in Burkina Faso. Durdyev et al. [79] explored the barriers preventing sustainable construction adoption in Cambodia and found that "lack of awareness and knowledge", and "reluctance to adopt new sustainable technologies" were the two main barriers. Shen et al. [80] listed the top two barriers to GBs in Thailand as "lack of motivation from owners" and "high initial cost". Simion et al. [81] identified 14 barriers that prevent the implementation of GBs in Romania. The top three critical barriers include "higher price of GB materials", "technical and technological difficulties", and "operational risks involved in green procurement and GB materials".

The review of the literature shows that many studies, as summarized above, have investigated the barriers that impede the implementation of GBs across the globe. However, there has not been a study reported in the literature that particularly focused on the barriers to undertaking GB projects in Turkey or in developing countries with socio-economic conditions that are similar to Turkey's. As Durdyev et al. [19] stated, given the distinct social, economic, and political characteristics, every country deserves a special analysis of the barriers to the implementation of green practices in building design and construction. In addition, the review of the literature also reveals that only a few studies have quantified the interrelationships among the barriers and grouped them using statistical techniques. However, grouping barriers provides a clear understanding of the problem and allows practitioners to devise strategies to overcome these barriers. Therefore, this study aims to investigate the barriers hindering the adoption of green practices in building design and construction in the Turkish construction industry. The results of this study may benefit GB projects undertaken in other developing countries with similar socio-economic conditions.

3. Research Methodology

The methodology adopted in this research included four successive steps, that is, questionnaire design, data collection, data analysis, and presentation of results.

3.1. Questionnaire Design

According to Arantes and Ferreira [82], designing a questionnaire has great importance in ensuring survey success. The design of the questionnaire used in this research involved two steps, namely, a literature review and a pilot survey. This research began with an extensive literature review to elicit the barriers to undertaking GB projects. As a result of this review, a list of 17 GB barriers was developed. The potential barriers and the associated studies are listed in Table 1. This research adopted a quantitative approach, where close-ended questions were used for data collection. The questionnaire consisted of two parts: The first part sought to obtain demographic and general information from the respondents. In the second part, the respondents were asked to rate the degree of the severity of the 17 barriers presented to them using a 5-point Likert scale, where "1" represents never; "2", seldom; "3", sometimes; "4", often; and "5", always. In a pilot study, this survey was administered to six experts to assess the appropriateness and applicability of the questionnaire. As Malmqvist et al. [83] stated, pilot studies can be useful for ensuring the transparency of survey questions. The expert team consisted of two academics and four practitioners who had been involved in GB projects for more than ten years. The experts were asked for suggestions and recommendations relative to the barriers listed in the questionnaire. The responses were collected and analyzed. The questionnaire was finalized making the minor modifications suggested by the experts.

Table 1. Barriers to undertaking green building projects.

Barrier ID	Barrier	Sources
B1	Higher construction cost	[68–71,75,78,79,81]
B2	Higher design cost	[68,69,71,72]
B3	Higher operation cost	[68–72]
B4	Lack of training for professionals	[68,76,79]
B5	Scarcity of GB projects	[7,17,19,73]
B6	Unavailability of GB materials	[7,70,76]
B7	Inadequate green material suppliers	[19,76,81]
B8	Inadequate market demand	[68–70,81]
B9	Lack of knowledge about GBs	[17,70–72,76,77,81]
B10	Lack of expert professionals in GBs	[70,77,79]
B11	Inadequate environmental awareness	[70,72,75,77]
B12	Lack of government incentives	[71,77,79]
B13	Lack of government regulations related to GBs	[19,68,76]
B14	Lack of authorized GB rating system	[17,68,70]
B15	Longer construction time	[7,72,76]
B16	Longer design time	[71,72,76]
B17	Risks and uncertainties in the adoption of GB technologies	[17,68,70,76]

3.2. Data Collection

Sarvari et al. [84] asserted that data collection is a critical and complicated part of every survey. The success of data collection greatly depends on the proper selection of the target respondents. In this research, the target respondents were construction professionals working in both public and private organizations. A potential target list was created on the basis of information provided by the Turkish Contractors Association representing the private sector and by government agencies involved in public construction.

As this research was conducted under pandemic conditions, the questionnaires were sent to construction professionals with an email that contained a link to a web-based questionnaire. The questionnaire was sent to 500 randomly selected construction professionals working in both the public and private sectors. A total of 128 responses were received. Of these 128 responses, 12 were incomplete and were thus eliminated. In sum, 116 valid responses were received for further analysis. The rate of response of 23.20% is satisfactory.

3.3. Data Analysis

Statistical Package for Social Sciences (SPSS), Version 23, was used to analyze the collected data. As per Maree's [85] recommendation, as a first step, Cronbach's alpha coefficient was calculated to measure the internal consistency and reliability of the data on 17 barriers, whose criticality was assessed by the respondents using a five-point Likert scale. In this research, both descriptive and inferential statistics were used to evaluate the data obtained from the survey. In the second step, the criticality of the barriers was assessed by calculating the mean score and standard deviation of the responses. This method is a popular method and has been frequently used in similar studies [86]. In this method, the barriers were ranked according to their mean values. If more than one barrier had the same mean value, the barrier having a lower standard deviation was ranked higher, as recommended by Le et al. [87]. In the third step, the criticality of the barriers relative to different demographic characteristics (i.e., sector, profession, education, and experience) was evaluated. According to Pallant [88], the Kolmogorov–Smirnov test must be used to test the normality of the distribution of variables to decide whether a parametric or non-parametric test should be performed. The result of the Kolmogorov–Smirnov test revealed that the data on the GB barriers were not normally distributed. Therefore, the Mann–Whitney *U* test was used to determine the differences in the criticality of barriers relative to different groups of respondents. Lastly, in order to obtain fewer factors for the adoption of GBs, exploratory factor analysis was performed following Aslan et al.'s [89] recommendation. In this context, preliminary analysis was carried out by assessing the sample size and calculating the Kaiser–Meyer–Olkin (KMO) and Bartlett's test of sphericity. The rotated component matrix was obtained using principal component analysis as an extraction method and varimax with Kaiser normalization as a rotation method.

4. Results

4.1. Demographic Characteristics of Respondents

Table 2 summarizes the demographic characteristics of the respondents. According to Table 2, the majority of respondents, 79 out of 116 (68%), were employed by private organizations, and the remaining 37 were representative of the public sector. Of the 116 respondents, 65 were civil engineers and architects, and 51 were mechanical and electrical engineers. While 75% of the respondents were bachelor's degree holders, only 5% of the respondents had a doctorate. Only 15% of the respondents had less than five years of industry experience, and 85% had more than 5 years of experience.

Table 2. Demographics of respondents.

Category	Property	Frequency	Percentage (%)
Sector	Private companies	79	68
	Public agencies	37	32
Profession	Civil engineer	39	34
	Mechanical engineer	28	24
	Architect	26	22
	Electrical engineer	23	20
Education	Bachelor's degree	87	75
	Master's degree	23	20
	Doctoral degree	6	5
Experience	<5 years	17	15
	5–10 years	52	44
	10–15 years	25	22
	>15 years	22	19

4.2. Barriers to Undertaking GB Projects in Turkey

Table 3 shows the ranking of 17 barriers that have been impeding the spread of GBs according to all respondents, respondents employed by public agencies, and respondents employed by private companies. When all participants are considered, the mean scores of the barriers range from 2.29 to 4.32. The top five ranked barriers include higher construction cost, lack of knowledge about GBs, lack of an authorized GB rating system, unavailability of GB materials, and inadequate market demand. The three least critical barriers are higher design cost, higher operation cost, and longer design time. The results showed that participants perceived higher construction cost as a chief barrier that prevents the construction of a larger number of GBs in Turkey. This situation can be explained by two reasons. First, as stated in similar studies, the initial cost of GBs is higher than the cost of traditional buildings. Furthermore, because most green materials used in GBs are imported in Turkey, the construction cost of GBs mostly depends on the exchange rate. Due to unexpected, large, and frequent fluctuations in the exchange rate of the Turkish currency, GB projects commonly face significant cost overruns. Therefore, construction owners in Turkey are unwilling to undertake GB projects. Lack of knowledge about GBs was considered another important barrier that hinders the adoption of GBs in Turkey by survey participants. The GB industry in Turkey has only 10 years of history and is still in its infancy. Most stakeholders in the Turkish construction industry do not have enough knowledge and expertise in GBs. Therefore, it is not easy to convince them to adopt green technologies and methods.

Table 3. Ranking of the barriers.

Barrier	Overall			Public			Private		
	Mean	SD	Rank	Mean	SD	Rank	Mean	SD	Rank
B1	4.32	0.94	1	4.11	1.22	2	4.42	0.76	1
B9	4.16	1.15	2	4.14	1.18	1	4.18	1.14	2
B14	4.02	1.05	3	4.08	1.06	3	3.99	1.04	3
B6	3.91	1.10	4	3.78	1.13	4	3.96	1.08	4
B8	3.83	0.90	5	3.65	0.98	7	3.91	0.85	5
B5	3.82	1.12	6	3.76	1.19	5	3.85	1.10	6
B7	3.78	1.10	7	3.73	1.17	6	3.80	1.07	7
B17	3.64	1.20	8	3.62	1.21	8	3.65	1.21	8
B13	3.58	1.20	9	3.54	1.19	10	3.59	1.20	9
B10	3.57	1.13	10	3.57	1.09	9	3.57	1.15	10
B4	3.45	1.09	11	3.38	1.16	11	3.48	1.06	11
B11	3.00	1.18	12	2.84	0.93	14	3.08	1.28	12
B12	2.86	1.19	13	2.84	1.24	15	2.87	1.17	13
B15	2.84	1.17	14	2.86	1.16	13	2.84	1.18	14
B3	2.78	1.16	15	2.89	1.22	12	2.73	1.14	15
B2	2.52	1.12	16	2.51	1.26	16	2.52	1.06	16
B16	2.29	1.13	17	2.32	1.25	17	2.28	1.07	17

If a threshold mean value of 3.50 is set for the study, as was performed in a previous similar study by Olanrewaju et al. [86], 10 out of the 17 barriers qualify as significantly critical barriers in the Turkish construction industry. These barriers include higher construction cost, scarcity of GB projects, unavailability of GB materials, inadequate material suppliers for GB, inadequate market demand, lack of knowledge about GBs, lack of expert professionals in GBs, lack of government regulations related to GBs, lack of an authorized GB rating system, and risks and uncertainties in the adoption of GB technologies.

These findings are in agreement with previous GB studies conducted in different countries. Indeed, higher cost was found to be a major barrier to undertaking GB projects in the U.S., Canada, and Australia according to Chan et al. [7]; in Malaysia, according to Durdyev et al. [19]; in Romania, according to Simion et al. [81]; in Hong Kong, according to Mesthrige and Kwong [69]; and in Finland, according to Hakkinen and Belloni [90]. Similarly, lack of knowledge, risk and uncertainties in the adoption of GB technologies, and market demand were also mentioned by one or more of the above-cited researchers. Therefore, it is safe to assume that regardless of whether the country is developed or developing, high cost and limited knowledge are the big obstacles that prevent a larger number of GB projects from being undertaken.

In order to see the differences between the perceptions of public agency representatives and professionals employed by private companies related to the criticality of the barriers, which would help to highlight the critical barriers to GB adoption in different types of building projects, the Mann–Whitney *U* test was used to perform a non-parametric test. The results of the Mann–Whitney *U* test can be seen in Table 4, which shows that the asymptotic significance (two-tailed) values for all barriers are higher than the threshold level of 0.05. Therefore, there were no significant differences between the perception of public agency representatives and professionals employed by private companies.

Table 4. Differences in the criticality of barriers according to public agency representatives and professionals employed by private companies.

Barrier	Mean Rank, Public	Mean Rank, Private	Mann–Whitney U	Z	Asymp. Sig. (2-Tailed)
B1-Higher construction cost	54.92	60.18	1329.0	−0.874	0.382
B2-Higher design cost	57.49	58.97	1424.0	−0.232	0817
B3-Higher operation cost	61.54	57.08	1349.0	−0.690	0.490
B4-Lack of training for professionals	56.18	59.59	1375.5	−0.530	0.596
B5-Scarcity of GB projects	57.47	58.98	1423.5	−0.236	0.813
B6-Unavailability of GB materials	54.72	60.27	1321.5	−0.883	0.377
B7-Inadequate green material suppliers	58.04	58.72	1444.5	−0.105	0.916
B8-Inadequate market demand	52.50	61.31	1239.5	−1.425	0.154
B9-Lack of knowledge about GBs	57.62	58.91	1429.0	−0.211	0.833
B10-Lack of expert professionals in GBs	58.50	58.50	1461.5	0.000	1.000
B11-Inadequate environmental awareness	54.41	60.42	1310.0	−0.926	0.354
B12-Lack of government incentives	57.72	58.87	1432.5	−0.179	0.858
B13-Lack of government regulations related to GBs	57.50	58.97	1424.5	−0.226	0.821
B14-Lack of authorized GB rating system	60.97	57.34	1370.0	−0.575	0.566
B15-Longer construction time	59.82	57.88	1412.5	−0.304	0.761
B16-Longer design time	58.24	58.62	1452.0	−0.059	0.953
B17-Risks and uncertainties in the adoption of GB technologies	57.89	58.78	1439.0	−0.138	0.890

4.3. Findings of Exploratory Factor Analysis

The aim of factor analysis is to reduce the number of variables by grouping them into a few factors [91]. The initial step in factor analysis is to test the reliability and suitability of the collected data for further analysis. Our sample size was greater than the sample size of 100 recommended by Aslan et al. [89] and was suitable for factor analysis. Before carrying out factor analysis, the Kaiser–Meyer–Olkin (KMO) and Bartlett's test of sphericity were conducted to evaluate the appropriateness of the data for factor analysis. The results are presented in Table 5. According to the results, the KMO value is 0.705, which is greater than the suggested value of 0.60 [92], showing that the obtained data were suitable for factor analysis. In addition, the value of Bartlett's test of sphericity is 0.000, which is smaller than the value of 0.05 suggested by Mapanga et al. [93] and indicates that the correlation matrix of the variables in the dataset significantly diverged from the identity matrix, which meant that a data reduction technique such as factor analysis was suitable to use.

Table 5. Results of the Kaiser–Meyer–Olkin and Bartlett's test of sphericity.

KMO and Bartlett's Test		
Kaiser–Meyer–Olkin measure of sampling adequacy		0.705
Bartlett's test of sphericity	Approx. chi-squared	1080.761
	df	120
	Sig.	.000

Factor analysis was carried out on the 17 barriers to undertaking GB projects in the Turkish construction industry. Table 6 presents the summary of the rotated component matrix of the barriers. One out of the seventeen barriers (B17-Risks and uncertainties in the adoption of GB technologies) was removed, as its factor loading was not greater than the threshold value of 0.5 as recommended by Hair et al. [94]. According to Table 6, a total of five factors were extracted out of the 16 barriers. These five factors explained a cumulative 74.91% contribution to the variance, which is greater than the 60% threshold recommended by Hair et al. [94]. Table 7 shows the total variance of each factor. These five factors that impede GB adoption within the Turkish construction industry included cost- and demand-related barriers, market-related barriers, people-related barriers, government-related barriers, and time-related barriers.

Table 6. Summary of the rotated component matrix.

Barrier	Component				
	1	2	3	4	5
Cost- and demand-related barriers					
B1-Higher construction cost	0.521				
B2-Higher design cost	0.843				
B3-Higher operation cost	0.847				
B8-Inadequate market demand	0.598				
Market-related barriers					
B4-Lack of training for professionals		0.846			
B5-Scarcity of completed GB projects		0.927			
B6-Unavailability of GB materials		0.943			
B7-Inadequate green material suppliers		0.895			
People-related barriers					
B9-Lack of knowledge about GBs			0.832		
B10-Lack of expert professionals in GBs			0.931		
B11-Inadequate environmental awareness			0.861		
Government-related barriers					
B12-Lack of government incentives				0.844	
B13-Lack of government regulations related to GBs				0.909	
B14-Lack of authorized GB rating system				0.614	
Time-related barriers					
B15-Longer construction time					0.882
B16-Longer design time					0.889

Table 7. Summary of the rotation sums of squared loadings.

Component	Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1	3.637	22.73	22.73
2	2.478	15.49	38.22
3	2.232	13.95	52.17
4	2.01	12.56	64.73
5	1.628	10.18	74.91

5. Discussion

In this section, the findings are discussed in detail by comparing them to the findings of earlier studies published in the literature.

A vast amount of research (e.g., [7,18,19,69,74]) observed that cost is a major hindrance to the proliferation of GB projects. In line with these studies, with a variance of 22.73%, this factor (i.e., cost- and demand-related barriers) represented the largest contribution to the total variance. This factor included four variables, which are higher construction cost, higher design cost, higher operation cost, and inadequate market demand. The factor loadings of these items were 0.521, 0.843, 0.847, and 0.598, respectively. As expected, higher construction cost constituted the most important barrier not only in this category but also among all barriers. The World Green Building Council's [95] determination that GB implementation has increased the design and construction costs between 0.4 and 12.5% compared with conventional buildings supports this finding. According to Tam et al. [96], the increase in design and construction costs is caused by the green materials and energy efficient systems that are used in GBs. Although cost is a great barrier preventing the proliferation of GB projects [68], several actions can be taken to overcome this barrier. First, as argued by many researchers (e.g., [19,69,70,97]), the government can provide financial incentives to GB developers and purchasers. For instance, tax exemptions for GBs encourage developers and homeowners to turn towards GBs [70]. Second, owners, designers, and contractors need to be informed in more detail about the costs of GBs as well as their long-term benefits. While the surveys conducted by Hamad [98] revealed that the cost of GBs is not as high as perceived by many construction practitioners, Masia et al. [99] opined that the long-term savings of GBs are much higher than conventional buildings (by as much as 25–35%) with shorter payback periods). In addition, hiring experienced designers and contractors can be an effective way to lower costs [95]. Another important barrier in this category is "inadequate market demand". Indeed, Chan et al. [7] stated that GB technologies cannot be applied to buildings without developer and potential user demand or interest. In addition, according to Hwang and Tan [100], the demand for GBs can be increased by informing owners, building users, designers, and contractors about the benefits of GBs. They also recommended to arrange GB tours for developers and potential users to educate them about the importance and convenience of GBs [100].

Factor 2 (i.e., market-related barriers) consisted of four variables: "lack of training for professionals", "lack of GBs", "unavailability of GB materials", and "inadequate green material suppliers". The factor loadings of these items were 0.846, 0.927, 0.943, and 0.895, respectively. With a contribution to the total variance of 15.49%, this factor (i.e., market-related barriers) explained the second highest portion of the total variance. Aktas and Ozorhon [101] observed six completed GB projects in Turkey, and they concluded that the "unavailability of GB materials" is one of the major obstacles to the speedy completion of these projects. The "unavailability of green materials" and "inadequate green material suppliers" are major challenges not only in Turkey but also in other developing countries such as Romania [81] and Pakistan [70]. The reason behind the unavailability of GB materials in Turkey and other developing countries is that green materials and energy efficient systems are not manufactured locally but are imported from advanced countries [81]. Although some GB materials (such as limestone, granite, marble, and wood products) are currently manufactured in Turkey, to overcome this barrier, not only GB materials should be locally produced, but the production rate of these materials should also be accelerated to satisfy local demand. This would lead to easy access to GB materials and motivate the project stakeholders to adopt GB technologies in their construction project. Based on the information collected with the survey, the number of completed GB projects is limited in Turkey. The scarcity of completed GBs constitutes another critical barrier to the adoption of green technologies, as existing GBs demonstrate the advantages of green technologies over conventional buildings relative to indoor air quality, energy efficiency, etc. [19]. A large number of GBs have to be operational and serve as appealing examples to encourage the public to consider green technologies and to appreciate the advantages of GBs.

Factor 3 (i.e., people-related barriers) had three variables as follows: "lack of knowledge about GBs", "lack of expert professionals in GBs", and "inadequate environmental awareness". The loadings of these items were 0.832, 0.931, and 0.861, respectively. This factor explained the third highest portion of the total variance, with 13.95%. "The lack of knowledge about GBs", which is the second most important barrier among all barriers (see Table 3), was also part of this factor. This finding is consistent with those of several previously published studies (e.g., [19,81,90]). As the design and construction of GBs is a new field of study [102] and the number of GB certifications has gone up only recently [68], stakeholders in construction projects do not have adequate information about GBs nor about which buildings received green certifications. The results of the survey conducted by Abidin [103] revealed that the overall knowledge of construction developers about GBs was between low and moderate low. The finding also agrees with that of the previous study by Azeem et al. [70] showing the importance of knowledge about GBs in Pakistan. Particular knowledge that the construction professionals should acquire is that about green certification systems [104]. Therefore, it is important to educate professionals about the fundamentals and the certifications of GBs [68]. In addition, technology transfer (TT), which can be defined as the development of a system that helps to disseminate knowledge, innovations, and improvements to the public [105], can be an effective solution to increase the overall knowledge about GBs. By integrating the "triple helix" (universities–industries–governments), countries could predict how they could build a knowledge-based society [105].

Factor 4 (i.e., government-related barriers) included three variables: "lack of government incentives", "lack of government regulations related to GBs", and "lack of an authorized GB rating system". The factor loadings of these items were 0.844, 0.909, and

0.614, respectively. The government has a vital role in encouraging construction owners to undertake GB projects by setting up the necessary policies/regulations and incentives [69]. When mandatory regulations are created, all construction owners and practitioners are under pressure to either implement these regulations or suffer the consequences [68]. Since it is very difficult to change construction practices and move from constructing conventional buildings to GBs, this is only possible with substantial incentives provided by the government [70]. For instance, the Turkish government has guaranteed a higher price for renewable energy when the energy investment uses more than a certain amount of domestic goods [106]. After this declaration, the use of domestic goods in renewable energy power plants has reached the desired level [107]. Since the main purpose of the project developers is to make a hefty profit [68], such government incentives for GBs can motivate them to move forward in the adoption of GBs. Another critical barrier is the lack of an authorized GB rating system. It is estimated that there are more than 34 GB certification systems to evaluate the greenness of buildings [108]. The selection of the GB certification system is one of the major problems for project stakeholders who consider adopting GB technologies in their construction projects [51]. Although the U.S. Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) is the rating system that is most commonly used worldwide [109], project stakeholders face many problems when using LEED, since this rating system was not developed for Turkey. For instance, one of the problems encountered when using LEED in Turkey is that the LEED requirements are written in English [101]. Since not all members of the project team know English, the project team is often confused about technical terms and needs expert support to complete the project [101]. Hence, without an authorized GB rating system that all professionals in Turkey can understand, the extensive use of GB technologies is difficult to achieve.

Factor 5 (i.e., time-related barriers) consisted of two variables: "longer construction time" and "longer design time". The factor loadings of these items were 0.882 and 0.889, respectively. This factor explained the smallest portion of the total variance, 10.18%. It is indeed well known that due to their complicated nature, GBs need longer construction and design time than conventional buildings [95]. For example, Fischhoff [110] showed that the construction of GBs takes 11% longer than the construction of conventional buildings. As a result, the average internal rate of return for GB projects is 2.6% lower than that for conventional building projects [110]. The barriers in this category have a mean value that is smaller than the threshold value of 3.5, suggesting that the time-related barriers are not the most important barriers to undertaking GB projects in Turkey.

6. Conclusions

It has been widely discussed that the construction industry has a negative impact on the environment. GBs can play a vital role in the construction industry in achieving sustainable development goals. This research aimed to investigate the critical barriers to the development of GB practices in Turkey. The results reveal that 10 out of 17 barriers are significant, and the most critical barriers are "higher construction cost", "lack of knowledge about GBs", "lack of an authorized GB rating system", "unavailability of GB materials", and "inadequate market demand", whereas "higher design cost", "higher operation cost", and "longer design time" are the least important barriers. Additionally, the results show that there were no significant differences between the perceptions of representatives of public agencies and professionals employed by private construction companies regarding the criticality of the barriers. The 17 barriers were later reduced to five factors by carrying out exploratory factor analysis. These five factors include cost- and demand-related barriers, market-related barriers, people-related barriers, government-related barriers, and time-related barriers. It can be stated that the strategies that promote green consciousness and the reduction in construction cost can have a vital importance in increasing the proliferation of GB practices in Turkey. Although this study was performed in Turkey, the recommendations in this research may also be applicable to other developing countries with similar socio-economic conditions. First and foremost, the government should provide more financial incentives to encourage a more extensive use of green technologies in building design and construction. Second, developers and potential users should be better informed about the costs and the long-term benefits of GBs. Third, the production of locally manufactured GB materials should be increased to provide easy access to GB materials. Fourth, existing GBs should be used to demonstrate the benefits of GBs. Finally, an authorized GB rating system should be developed by taking into account the characteristics of the country.

The theoretical contributions of this research include (1) identifying the barriers to undertaking GB projects in Turkey, which may be similar to barriers in other developing countries with similar socio-economic conditions, and (2) developing a comprehensive approach that can be used for analyzing the barriers to and drivers of the adoption of GB technologies in different countries.

The practical contributions of this research include (1) exploring the barriers to undertaking GB projects in Turkey in depth and (2) bringing clarity to the perceptions of representatives of public agencies and professionals employed by private entities regarding the criticality of the barriers to undertaking GB projects. In light of the deeper understanding of these barriers, policy makers and construction practitioners can devise informed strategies to promote green practices in Turkey, which can also be valid for other developing countries with similar socio-economic conditions. In addition, the depth of the analysis of the barriers can also inform foreign investors who are willing to invest in GB projects in Turkey. Once they have deeper knowledge about the GB industry in Turkey, they can make more realistic investments.

The limitation of this study is the size of the sample. Although the number of participants was higher than the recommended value for proper factor analysis, a larger sample size could have given more realistic results. Future studies could focus on increasing the sample size and providing a more balanced distribution of the respondent demographic characteristics. This study only concentrated on the barriers to undertaking GB projects, but future research could also investigate the drivers along with the barriers in different countries.

Funding: This research received no external funding.

Data Availability Statement: Data are contained within the article.

Conflicts of Interest: The author declares no conflict of interest.

References

1. Zuo, J.; Zhao, Z.-Y. Green building research–current status and future agenda: A review. *Renew. Sustain. Energy Rev.* **2014**, *30*, 271–281. [CrossRef]
2. United States Environmental Protection Agency (USEPA). Overview of Greenhouse Gases. 2021. Available online: https://www.epa.gov/ghgemissions/overview-greenhouse-gases (accessed on 25 December 2021).
3. Labaran, Y.H.; Mathur, V.S.; Farouq, M.M. The carbon footprint of construction industry: A review of direct and indirect emission. *J. Sustain. Constr. Mater. Technol.* **2021**, *6*, 101–115. [CrossRef]
4. European Commission (EC). Energy Efficiency in Buildings. 2021. Available online: https://ec.europa.eu/info/news/focus-energy-efficiency-buildings-2020-feb-17_en (accessed on 17 November 2021).
5. International Energy Agency (IEA). Tracking Buildings. 2020. Available online: https://www.iea.org/reports/tracking-buildings-2020 (accessed on 15 December 2021).
6. Bergman, D. *Sustainable Design: A Critical Guide*; Princeton Architectural Press: Hudson, NY, USA, 2013.
7. Chan, A.P.C.; Darko, A.; Ameyaw, E.E.; Owusu-Manu, D. Barriers Affecting the Adoption of Green Building Technologies. *J. Manag. Eng.* **2017**, *33*, 04016057. [CrossRef]
8. Canada Green Building Council (CGBC). What Is Green Building? 2021. Available online: https://greenbuildingcanada.ca/green-building-guide/what-is-green-building/ (accessed on 15 December 2021).
9. Yas, Z.; Jaafer, K. Factors influencing the spread of green building projects in the UAE. *J. Build. Eng.* **2020**, *27*, 100894. [CrossRef]
10. Bond, S. Barriers and drivers to green buildings in Australia and New Zealand. *J. Prop. Invest. Finance* **2011**, *29*, 494–509. [CrossRef]
11. Bungau, C.C.; Bungau, T.; Prada, I.F.; Prada, M.F. Green Buildings as a Necessity for Sustainable Environment Development: Dilemmas and Challenges. *Sustainability* **2022**, *14*, 13121. [CrossRef]

12. European Commission. Nearly Zero-Energy Buildings. 2023. Available online: https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/nearly-zero-energy-buildings_en (accessed on 14 March 2023).
13. Kang, Y.; Wu, J.; Lu, S.; Yang, Y.; Yu, Z.; Zhou, H.; Xie, S.; Fu, Z.; Fan, M.; Xu, X. Comprehensive Carbon Emission and Economic Analysis on Nearly Zero-Energy Buildings in Different Regions of China. *Sustainability* **2022**, *14*, 9834. [CrossRef]
14. Guan, Z.; Xu, X.; Xue, Y.; Wang, C. Multi-Objective Optimization Design of Geometric Parameters of Atrium in nZEB Based on Energy Consumption, Carbon Emission and Cost. *Sustainability* **2023**, *15*, 147. [CrossRef]
15. Wuni, I.Y.; Shen, G.Q.; Osei-Kyei, R. Scientometric review of global research trends on green buildings in construction journals from 1992 to 2018. *Energy Build.* **2019**, *190*, 69–85. [CrossRef]
16. Turkish Green Building Council (TGBC). 2021. Available online: https://cedbik.org/en (accessed on 12 November 2021).
17. Darko, A.; Chan, A.P.C.; Yang, Y.; Shan, M.; He, B.-J.; Gou, Z. Influences of barriers, drivers, and promotion strategies on green building technologies adoption in developing countries: The Ghanaian case. *J. Clean. Prod.* **2018**, *200*, 687–703. [CrossRef]
18. Shen, L.; Zhang, Z.; Long, Z. Significant barriers to green procurement in real estate development. *Resour. Conserv. Recycl.* **2017**, *116*, 160–168. [CrossRef]
19. Durdyev, S.; Ismail, S.; Ihtiyar, A.; Abu Bakar, N.F.S.; Darko, A. A partial least squares structural equation modeling (PLS-SEM) of barriers to sustainable construction in Malaysia. *J. Clean. Prod.* **2018**, *204*, 564–572. [CrossRef]
20. World Bank. 2022. Available online: https://www.worldbank.org/en/country/turkey/overview#1 (accessed on 2 May 2022).
21. International Monetary Fund (IMF). 2022. Available online: https://www.imf.org/en/Publications/WEO/weo-database/2022/April/weo-report?c=186,&s=NGDPD,PPPGDP,NGDPDPC,PPPPC,&sy=2021&ey=2027&ssm=0&scsm=1&scc=0&ssd=1&ssc=0&sic=0&sort=country&ds=.&br=1 (accessed on 10 May 2022).
22. Bilgin, G.; Bilgin, P.; Dikmen, I.; Birgonul, M. Innovation Vision of the Turkish Construction Industry: A Comparative Qualitative Content Analysis of Strategic Roadmaps. In Proceedings of the International Conference on Innovation, Technology, Enterprise and Entrepreneurship (ICITEE), Bahrain, 24–25 November 2019.
23. European Construction Industry Federation (FIEC). 2019. Available online: https://fiec-statistical-report.eu/turkey (accessed on 3 May 2022).
24. Ali, H.H.; Nsairat, S.F.A. Developing a green building assessment tool for developing countries—Case of Jordan. *Build. Environ.* **2009**, *44*, 1053–1064. [CrossRef]
25. United States Environmental Protection Agency (EPA). Available online: https://archive.epa.gov/greenbu3/greenbuilding/web/pdf/bdcwhitepaperr2.pdf (accessed on 10 March 2023).
26. Kibert, C.J. Green Buildings: An Overview of Progress. *J. Land Use Environ. Law* **2004**, *19*, 491–502.
27. The Federal Council. Brundtland Report. 1987. Available online: https://www.are.admin.ch/are/en/home/media/publications/sustainable-development/brundtland-report.html (accessed on 10 March 2023).
28. Alsulaili, A.D.; Al-Matrouk, M.F.; Al-Baghli, R.A.; Al-Enezi, A.F. Environmental and economic benefits of applying green building concepts in Kuwait. *Environ. Dev. Sustain.* **2020**, *22*, 3371–3387. [CrossRef]
29. Chen, Z. Economic benefit analysis of green building based on fuzzy logic and bilateral game model. *J. Intell. Fuzzy Syst.* **2019**, *37*, 301–313. [CrossRef]
30. Cheng, M.-Y.; Chiu, K.-C.; Lien, L.-C.; Wu, Y.-W.; Lin, J.-J. Economic and energy consumption analysis of smart building—MEGA house. *Build. Environ.* **2016**, *100*, 215–226. [CrossRef]
31. Chernysheva, N.A.; Perskaya, V.; Petrov, A.; Bakulina, A.A. Green energy for belt and road initiative: Economic aspects today and in the future. *Int. J. Energy Econ. Policy* **2019**, *9*, 178–185. [CrossRef]
32. Franco, M.A.J.Q.; Pawar, P.; Wu, X. Green building policies in cities: A comparative assessment and analysis. *Energy Build.* **2021**, *231*, 110561. [CrossRef]
33. Kats, G.H. *Green Building Costs and Financial Benefits*; Massachusetts Technology Collaborative: Boston, MA, USA, 2003; pp. 1–10.
34. Liu, Y.; Guo, X.; Hu, F. Cost-benefit analysis on green building energy efficiency technology application: A case in China. *Energy Build.* **2014**, *82*, 37–46. [CrossRef]
35. Manso, M.; Teotónio, I.; Silva, C.M.; Cruz, C.O. Green roof and green wall benefits and costs: A review of the quantitative evidence. *Renew. Sustain. Energy Rev.* **2021**, *135*, 110111. [CrossRef]
36. Mehndi, S.M.; Chakraborty, I. Simulation for a Cost-Effective and Energy Efficient Retrofits of the Existing Building Stock in India using BIM. In Proceedings of the 2020 International Conference on Contemporary Computing and Applications (IC3A), Dr. A.P.J. Abdul Kalam Technical University, Lucknow, India, 5–7 February 2020.
37. Meron, N.; Meir, I.A. Building green schools in Israel. Costs, economic benefits and teacher satisfaction. *Energy Build.* **2017**, *154*, 12–18. [CrossRef]
38. Ngwakwe, C.C. Environmental and economic benefits of compliance to green building. *Int. J. Green Econ.* **2020**, *13*, 288–299. [CrossRef]
39. Rosasco, P. Economic Benefits and Costs of Vertical Greening Systems. *Nat. Based Strateg. Urban Build. Sustain.* **2018**, 291–306.
40. Rosasco, P.; Perini, K. Evaluating the economic sustainability of a vertical greening system: A Cost-Benefit Analysis of a pilot project in mediterranean area. *Build. Environ.* **2018**, *142*, 524–533. [CrossRef]
41. Sherwin, D. Reducing the Cost of Green. *J. Green Build.* **2006**, *1*, 46–54. [CrossRef]
42. Suh, M.J.; Zhang, Y.; Ahn, Y.H.; Ma, J.; Pearce, A.R. The Impact of LEED-Energy Star Certified Office Buildings on the Market Values of Neighboring Areas in New York City. *KICEM J. Constr. Eng. Proj. Manag.* **2019**, *9*, 25–51.

43. Wang, M.; Cheng, Z.; Li, Y.; Li, J.; Guan, K. Impact of market regulation on economic and environmental performance: A game model of endogenous green technological innovation. *J. Clean. Prod.* **2020**, *277*, 123969. [CrossRef]
44. Shan, M.; Hwang, B.-G. Green building rating systems: Global reviews of practices and research efforts. *Sustain. Cities Soc.* **2018**, *39*, 172–180. [CrossRef]
45. Alapati, P.L.K.S.; Kavuri, N.C. Analysis of Green Building Certification Attainment through LEED System for SDC Block at KLEF, India. In *IOP Conference Series: Materials Science and Engineering*; IOP Publishing: Bristol, UK, 2020; Volume 912.
46. Bondili, M.; Kavuri, N.C. Analysis of Green Building Certification Attainment through GRIHA System for R & D Block at KLEF, India. In *IOP Conference Series: Materials Science and Engineering*; IOP Publishing: Bristol, UK, 2020; Volume 912.
47. Brem, A.; Cusack, D.Ó.; Adrita, M.M.; O'Sullivan, D.T.J.; Bruton, K. How do companies certified to ISO 50001 and ISO 14001 perform in LEED and BREEAM assessments? *Energy Effic.* **2020**, *13*, 751–766. [CrossRef]
48. Castro-Lacouture, D.; Sefair, J.A.; Florez, L.; Medaglia, A.L. Optimization model for the selection of materials using a LEED-based green building rating system in Colombia. *Build. Environ.* **2009**, *44*, 1162–1170. [CrossRef]
49. Chi, B.; Lu, W.; Ye, M.; Bao, Z.; Zhang, X. Construction waste minimization in green building: A comparative analysis of LEED-NC 2009 certified projects in the US and China. *J. Clean. Prod.* **2020**, *256*, 120749. [CrossRef]
50. Da Silva, L.; Ruwanpura, J.Y. Review of the LEED points obtained by Canadian building projects. *J. Archit. Eng.* **2009**, *15*, 38–54. [CrossRef]
51. Dabash, M.; Kianmehr, P.; Doczy, R. Upgrading locally-regulated green buildings to LEED standards: A Dubai case study. In *IOP Conference Series: Earth and Environmental Science*; IOP Publishing: Bristol, UK, 2020; Volume 588.
52. Elkhapery, B.; Kianmehr, P.; Doczy, R. Benefits of retrofitting school buildings in accordance to LEED v4. *J. Build. Eng.* **2020**, *33*, 101798. [CrossRef]
53. Goijberg, N.; Madrid, H. Sustainable Building Certification in Chile. In *IOP Conference Series: Earth and Environmental Science*; IOP Publishing: Bristol, UK, 2020; Volume 503.
54. Gui, X.; Gou, Z. Association between green building certification level and post-occupancy performance: Database analysis of the National Australian Built Environment Rating System. *Build. Environ.* **2020**, *179*, 106971. [CrossRef]
55. Pham, D.H.; Kim, B.; Lee, J.; Ahn, Y. An Investigation of the Selection of LEED Version 4 Credits for Sustainable Building Projects. *Appl. Sci.* **2020**, *10*, 7081. [CrossRef]
56. Tang, K.H.D.; Foo, C.Y.H.; Tan, I.S. A review of the green building rating systems. In *IOP Conference Series: Materials Science and Engineering*; IOP Publishing: Bristol, UK, 2020; Volume 943.
57. Tleuken, A.; Tokazhanov, G.; Guney, M.; Turkyilmaz, A.; Karaca, F. Readiness Assessment of Green Building Certification Systems for Residential Buildings during Pandemics. *Sustainability* **2021**, *13*, 460. [CrossRef]
58. Jana, R.L.; Dey, S.; Dasgupta, P. A Hierarchical HVAC Control Scheme for Energy-aware Smart Building Automation. *ACM Trans. Des. Autom. Electron. Syst.* **2020**, *25*, 1–33. [CrossRef]
59. Bichiou, Y.; Krarti, M. Optimization of envelope and HVAC systems selection for residential buildings. *Energy Build.* **2011**, *43*, 3373–3382. [CrossRef]
60. Chegari, B.; Simeu, E.; Tabaa, M.; Medromi, H.; Moutaouakkil, F. Energy savings and thermal comfort benefits of shading devices: Case study of a typical Moroccan building. In Proceedings of the Fourth International Conference on Smart City Applications, Casablanca, Morocco, 2–4 October 2019.
61. Chiba, Y.; Marif, Y.; Boukaoud, A.; Meredef, L.; Kaidi, Y. Impact of green buildings on HVAC system located in Algeria. In Proceedings of the 2018 International Conference on Applied Smart Systems ICASS, Médéa, Algeria, 24–25 November 2018.
62. Congradac, V.; Kulic, F. HVAC system optimization with CO_2 concentration control using genetic algorithms. *Energy Build.* **2009**, *41*, 571–577. [CrossRef]
63. Fong, K.; Hanby, V.; Chow, T. HVAC system optimization for energy management by evolutionary programming. *Energy Build.* **2006**, *38*, 220–231. [CrossRef]
64. Ibrahim, M.; Rachid, E.; Awera, Y.; Beheiry, S. Green Building Retrofitting in the UAE. In *Collaboration and Integration in Construction, Engineering, Management and Technology: Proceedings of the 11th International Conference on Construction in the 21st Century, London 2019*; Springer International Publishing: Berlin/Heidelberg, Germany, 2021; pp. 637–642.
65. Somasundaram, S.; Raj Thangavelu, S.; Chong, A. Improving building efficiency using low-e coating based retrofit double glazing with solar films. *Appl. Therm. Eng.* **2020**, *171*, 115064. [CrossRef]
66. Nikyema, G.A.; Blouin, V.Y. Barriers to the adoption of green building materials and technologies in developing countries: The case of Burkina Faso. In *IOP Conference Series: Earth and Environmental Science*; IOP Publishing: Bristol, UK, 2020; Volume 410.
67. Chan, E.H.W.; Qian, Q.K.; I Lam, P.T. The market for green building in developed Asian cities—The perspectives of building designers. *Energy Policy* **2009**, *37*, 3061–3070. [CrossRef]
68. Agyekum, K.; Adinyira, E.; Baiden, B.; Ampratwum, G.; Duah, D. Barriers to the adoption of green certification of buildings: A thematic analysis of verbatim comments from built environment professionals. *J. Eng. Des. Technol.* **2019**, *17*, 1035–1055. [CrossRef]
69. Mesthrige, J.W.; Kwong, H.Y. Criteria and barriers for the application of green building features in Hong Kong. *Smart Sustain. Built Environ.* **2018**, *7*, 251–276. [CrossRef]
70. Azeem, S.; Naeem, M.A.; Waheed, A.; Thaheem, M.J. Examining barriers and measures to promote the adoption of green building practices in Pakistan. *Smart Sustain. Built Environ.* **2017**, *6*, 86–100. [CrossRef]

71. Addy, M.; Adinyira, E.; Danku, J.C.; Dadzoe, F. Impediments to the development of the green building market in sub-Saharan Africa: The case of Ghana. *Smart Sustain. Built Environ.* **2021**, *10*, 193–207. [CrossRef]
72. Samari, M.; Mirhosseini, S.M.; Esmaeilifar, R.; Shafiei, M.W.M. Market Barriers to Implementing Sustainable Building in Malaysia. *Adv. Environ. Biol.* **2015**, *9*, 135–138.
73. Olowosile, S.; Oke, A.; Aigbavboa, C. Barriers to the Achievement of Sustainable Construction Project in Nigeria. In Proceedings of the International Conference on Industrial Engineering and Operations Management, Toronto, ON, Canada, 23–25 October 2019.
74. Samari, M.; Ghodrati, N.; Esmaeilifar, R.; Olfat, P.; Shafiei, M.W.M. The investigation of the barriers in developing green building in Malaysia. *Mod. Appl. Sci.* **2013**, *7*, 1–10. [CrossRef]
75. Tafazzoli, M.; Kermanshachi, S.; Shrestha, K.; Kisi, K. Investigating the Relative Importance Barriers to Sustainable Construction Related to Owners, Contractors, and Government. In Proceedings of the ASCE Construction Research Congress (CRC), Tempe, AZ, USA, 8–10 March 2020.
76. Ohiomah, I.; Aigbavboa, C.; Thwala, W.D. An assessment on the drivers and obstacles of sustainable project management in South Africa: A case study of Johannesburg. In *IOP Conference Series: Materials Science and Engineering*; IOP Publishing: Bristol, UK, 2019; Volume 640.
77. Deng, W.; Yang, T.; Tang, L.; Tang, Y.-T. Barriers and policy recommendations for developing green buildings from local government perspective: A case study of Ningbo China. *Intell. Build. Int.* **2018**, *10*, 61–77. [CrossRef]
78. Arokiaprakash, A.; Kumar, A.H. Study on the Implementation Barriers of Green Building Design in Indian Construction Industry. *Int. J. Civ. Eng. Technol. IJCIET* **2018**, *9*, 640–647.
79. Durdyev, S.; Zavadskas, E.K.; Thurnell, D.; Banaitis, A.; Ihtiyar, A. Sustainable Construction Industry in Cambodia: Awareness, Drivers and Barriers. *Sustainability* **2018**, *10*, 392. [CrossRef]
80. Shen, W.; Tang, W.; Siripanan, A.; Lei, Z.; Duffield, C.F.; Hui, F.K.P. Understanding the Green Technical Capabilities and Barriers to Green Buildings in Developing Countries: A Case Study of Thailand. *Sustainability* **2018**, *10*, 3585. [CrossRef]
81. Simion, C.-P.; Nicolescu, C.; Vrîncuț, M. Green Procurement in Romanian Construction Projects. A Cluster Analysis of the Barriers and Enablers to Green Procurement in Construction Projects from the Bucharest-Ilfov Region of Romania. *Sustainability* **2019**, *11*, 6231. [CrossRef]
82. Arantes, A.; Ferreira, L.M.D.F. Underlying causes and mitigation measures of delays in construction projects: An empirical study. *J. Financ. Manag. Prop. Constr.* **2020**, *25*, 165–181. [CrossRef]
83. Malmqvist, J.; Hellberg, K.; Möllas, G.; Rose, R.; Shevlin, M. Conducting the Pilot Study: A Neglected Part of the Research Process? Methodological Findings Supporting the Importance of Piloting in Qualitative Research Studies: Methodological findings supporting the importance of piloting in qualitative research studies. *Int. J. Qual. Methods* **2019**, *18*, 1–11.
84. Sarvari, H.; Valipour, A.; Yahya, N.; MD Noor, N.; Beer, M.; Banaitiene, N. Approaches to Risk Identification in Public–Private Partnership Projects: Malaysian Private Partners' Overview. *Adm. Sci.* **2019**, *9*, 17. [CrossRef]
85. Maree, K. Planning A Research Proposal. In *First Steps in Research*, 2nd ed.; Maree, K., Ed.; Paarl Media: Paarl, South Africa, 2016; pp. 25–47.
86. Olanrewaju, O.I.; Chileshe, N.; Babarinde, S.A.; Sandanayake, M. Investigating the barriers to building information modeling (BIM) implementation within the Nigerian construction industry. *Eng. Constr. Arch. Manag.* **2020**, *27*, 2931–2958. [CrossRef]
87. Le, P.T.; Chileshe, N.; Kirytopoulos, K.; Rameezdeen, R. Investigating the significance of risks in BOT transportation projects in Vietnam. *Eng. Constr. Arch. Manag.* **2020**, *27*, 1401–1425. [CrossRef]
88. Pallant, J. *A Step by Step Guide to Data Analysis Using SPSS for Windows, SPSS Survival Manual*; Open University Press: New York, NY, USA, 2007.
89. Aslan, S.; Arditi, D.; Tantekin-Çelik, G. Factors That Affect the Level of Success of the Transaction between Home Buyers and Developers in Sell-Build Residential Projects. *Buildings* **2021**, *11*, 127. [CrossRef]
90. Hakkinen, T.; Belloni, K. Barriers and drivers for sustainable building. *Build. Res. Inf.* **2011**, *39*, 239–255. [CrossRef]
91. Yong, A.G.; Pearce, S. A Beginner's Guide to Factor Analysis: Focusing on Exploratory Factor Analysis. *Tutorials Quant. Methods Psychol.* **2013**, *9*, 79–94. [CrossRef]
92. Kaiser, H.F. An index of factorial simplicity. *Psychometrika* **1974**, *39*, 31–36. [CrossRef]
93. Mapanga, A.; Miruka, C.O.; Mavetera, N. Barriers to effective value chain management in developing countries: New insights from the cotton industrial value chain. *Probl. Perspect. Manag.* **2018**, *16*, 22–35. [CrossRef]
94. Hair, J.F.; Black, W.C.; Babin, B.J.; Anderson, R.E. *Multivariate Data Analysis: A Global Perspective*, 7th ed.; Pearson Education: Upper Saddle River, NJ, USA, 2010.
95. World Green Building Council. The Business Case for Green Building. 2013. Available online: https://www.worldgbc.org/sites/default/files/Business_Case_For_Green_Building_Report_WEB_2013-04-11-2.pdf (accessed on 5 January 2022).
96. Tam, V.W.Y.; Hao, J.L.; Zeng, S.X. What affects implementation of green buildings? an empirical study in Hong Kong. *Int. J. Strat. Prop. Manag.* **2012**, *16*, 115–125. [CrossRef]
97. Masrom, A.N.; Rahim, M.H.I.A.; Ann, S.C.; Mohamed, S.; Goh, K.C. A Preliminary Exploration of the Barriers of Sustainable Refurbishment for Commercial Building Projects in Malaysia. *Procedia Eng.* **2017**, *180*, 1363–1371. [CrossRef]
98. Hamad, S. Is It Affordable to Build Green? 2020. Available online: https://thesustainabilist.ae/is-it-affordable-to-build-green/ (accessed on 15 January 2022).

99. Masia, T.; Kajimo-Shakantu, K.; Opawole, A. A case study on the implementation of green building construction in Gauteng province, South Africa. *Manag. Environ. Qual. Int. J.* **2020**, *31*, 602–623. [CrossRef]
100. Hwang, B.G.; Tan, J.S. Green building project management: Obstacles and solutions for sustainable development. *Sustain. Dev.* **2012**, *20*, 335–349. [CrossRef]
101. Aktas, B.; Ozorhon, B. Green Building Certification Process of Existing Buildings in Developing Countries: Cases from Turkey. *J. Manag. Eng.* **2015**, *31*, 05015002. [CrossRef]
102. Sourani, A.; Sohail, M. Barriers to addressing sustainable construction in public procurement strategies. *Proc. ICE Eng. Sustain.* **2011**, *164*, 229–237. [CrossRef]
103. Abidin, N.Z. Sustainable Construction in Malaysia–Developers' Awareness. *World Acad. Sci. Eng. Technol.* **2009**, *53*, 807–814. Available online: http://eprints.usm.my/20303/1/sustainable.pdf (accessed on 10 February 2022).
104. Le Jeune, K.; Nurick, S.D.; Roux, J.P. The business case for building green: Motivate for energy saving design. In Proceedings of the Research Conference: Green Vision 20/20, Cape Town, South Africa, 20–21 June 2013.
105. Craiut, L.; Bungau, C.; Bungau, T.; Grava, C.; Otrisal, P.; Radu, A.-F. Technology Transfer, Sustainability, and Development, Worldwide and in Romania. *Sustainability* **2022**, *14*, 15728. [CrossRef]
106. The Official Gazette of the Republic of Turkey. 2017. Available online: https://www.resmigazete.gov.tr/eskiler/2017/06/20170609-4.htm (accessed on 10 October 2021).
107. Anadolu Agency. 2019. Available online: https://www.aa.com.tr/tr/ekonomi/elektrik-uretiminde-yerli-ve-yenilenebilir-kaynak-hedefine-ulasildi/1635833 (accessed on 2 November 2021).
108. Fowler, K.M.; Rauch, E.M. *Sustainable Building Rating Systems Summary*; Technical Report no. PNNL-15858; Pacific Northwest National Laboratory: Richland, WA, USA, 2006.
109. Akcay, E.C.; Arditi, D. Desired points at minimum cost in the "Optimize Energy Performance" credit of leed certification. *J. Civ. Eng. Manag.* **2017**, *23*, 796–805. [CrossRef]
110. Fischhoff, M. Green Building Has a Strong Business Case. 2020. Available online: https://www.nbs.net/articles/green-building-has-a-strong-business-case (accessed on 10 December 2021).