International Journal of Sustainable Society

ISSN online: 1756-2546 - ISSN print: 1756-2538
https://www.inderscience.com/ijssoc

Assessment of the construction industry market: a study of the barriers and drivers of sustainability practices

Julia Carvalho Fernandes de Oliveira, Fagner José Coutinho de Melo, Djalma Silva Guimaraes Junior, Eryka Fernanda Miranda Sobral

DOI: 10.1504/IJSSOC.2023.10051484

Article History:

Received:	15 April 2022
Accepted:	14 September 2022
Published online:	26 June 2023

Assessment of the construction industry market: a study of the barriers and drivers of sustainability practices

Julia Carvalho Fernandes de Oliveira, Fagner José Coutinho de Melo* and Djalma Silva Guimaraes Junior

Mestrado em Gestão do Desenvolvimento Local Sustentável,
Departamento de Administração,
Universidade de Pernambuco,
Av. Gov. Agamenon Magalhães, Santo Amaro,
Recife – PE, 50100-010, Brazil
Email: juliacfo@outlook.com
Email: fagnercoutinhomelo@gmail.com
Email: dsgjunior@gmail.com
*Corresponding author

Eryka Fernanda Miranda Sobral

Departamento de Administração,
Universidade de Pernambuco,
Av. Gov. Agamenon Magalhães, Santo Amaro,
Recife – PE, 50100-010, Brazil
Email: eryka.sobral@upe.br

Abstract: This paper aims to analyse the perception of the city of Recife's local market regarding the main barriers that inhibit the adoption of sustainable practices and the main drivers that influence the decision to use sustainable design and construction practices. The survey research was conducted using two questionnaires: one applied to 66 professionals in the fields of architecture, engineering, and construction, and another applied to 55 residents. The results to professionals showed that the lack of knowledge and awareness on how to design a sustainable project is the most critical barrier identified. In relation to the public, it was noticed that despite the insecurity regarding the concept of sustainable construction, there is a market demand for sustainable projects in Recife – PE. This paper, therefore, contributes to expanding the knowledge about the factors that either foster or hinder the implementation of large-scale sustainable practices in the construction industry.

Keywords: construction industry; sustainability; barriers; drivers; sustainable projects.

Reference to this paper should be made as follows: de Oliveira, J.C.F., de Melo, F.J.C., Guimaraes Jr., D.S. and Sobral, E.F.M. (2023) 'Assessment of the construction industry market: a study of the barriers and drivers of sustainability practices', *Int. J. Sustainable Society*, Vol. 15, No. 2, pp.139–166.

Biographical notes: Julia Carvalho Fernandes de Oliveira earned her Master in Sustainable Local Development Management at the Universidade de Pernambuco (UPE). She graduated in Architecture and Urbanism at the Universidade Federal de Pernambuco (UFPE). ORCID: https://orcid.org/0000-0002-6149-6420.

Fagner José Coutinho de Melo earned his PhD in Production Engineering from the Universidade Federal de Pernambuco (UFPE). He obtained his Master's degree in Production Engineering from the Universidade Federal de Pernambuco (UFPE). He graduated in Administration from the Universidade Federal de Pernambuco. He is an Assistant Professor at the Universidade de Pernambuco (UPE). ORCID: https://orcid.org/0000-0002-0550-5177.

Djalma Silva Guimaraes Junior earned his PhD in Production Engineering from the Universidade Federal de Pernambuco (UFPE). He obtained his Master's degree in Production Engineering from the Universidade Federal de Pernambuco (UFPE). He graduated in Economics at Universidade Federal de Campina Grande (UFCG). He is a Professor at the Universidade de Pernambuco (UPE). ORCID: https://orcid.org/0000-0002-4539-8492.

Eryka Fernanda Miranda Sobral earned her PhD in Economics from the Universidade Federal da Paraiba (UFPB). She obtained her Master's in Economics from the Universidade Federal da Paraiba (UFPB) and graduated in Economics at Universidade Federal de Pernambuco (UFPE). She is an Assistant Professor at the Universidade de Pernambuco (UPE). ORCID: https://orcid.org/0000-0003-0288-9037.

1 Introduction

The construction industry has a significant impact on the environment, economy, and society (Darko et al., 2017). On a global scale, this sector consumes approximately 40% of total energy production, 32% of non-renewable and renewable resources, 12–16% of all available water, 40% of all raw materials, 25% of all wood, emits 35–40% of CO2 and produces 30–40% of all solid waste (GBCA, 2006; Son et al., 2011; Berardi, 2013). Given the impact exerted by the construction industry on the environment, the adoption and implementation of sustainable construction practices are considered key strategies for minimising the negative impacts of such activities (USGBC, 2003; Zhang et al., 2011).

When applied to the construction industry, 'sustainability' can be defined as the practice of developing and using more resource-efficient construction models, including the aspects of construction, renovation, operation, maintenance, and demolition (Qian et al., 2016). Hence, sustainable construction practices include approaches that allow the reduction of impacts, such as minimising water and energy consumption and the production of waste (Qian et al., 2016; Darko et al., 2017; Li et al., 2021). Consequently, that minimises their impact on the environment (Darko et al., 2018; Yas and Jaafer, 2020; Marsh et al., 2020) and enhances the user's quality of life (Olanipekun et al., 2017; He et al., 2018; Fan and Wu, 2020).

Several studies have been conducted to understand which drivers have the ability to stimulate sustainable construction and which barriers inhibit the adoption of sustainable practices in the sector (Darko et al., 2017). However, these studies are based on

sustainable approaches implemented in various locations around the world, which have different social, economic, and environmental realities than those found in the city of Recife – PE, located in the Northeast of Brazil.

The challenge faced by sustainability in Recife is attributable to the combination of its characteristics of environmental and geographical vulnerability, with a social and economic reality that is marked by high inequality (Diário de Pernambuco, 2016). As a coastal city, it is located at sea level and is also surrounded by bodies of water such as rivers and wetlands, which tend to put the city at constant risk of flooding due to rising sea level and strong storms (Bai et al., 2019). This situation is like those of cities such as Venice in Italy, New York in the USA, and Shanghai in China (OECD, 2007).

In addition to the geographic characteristics that exacerbate the city's vulnerability, Recife has undergone an accelerated, disorderly urbanisation process and has a high occupation rate in risk areas – such as slopes with more than 70 degrees of declivity which is extremely inadequate and dangerous situation that can also be found in other Brazilian cities such as Rio de Janeiro, São Paulo, Salvador, and Belo Horizonte (Ribeiro, 2008; PBMC, 2016).

Considering this, the following question arises: which sustainability barriers and drivers would be more in agreement with the particularities of Recife – Pernambuco and, therefore, would be more likely to be successfully applied on a large scale in the city? Thus, conducting a study focused on Recife is particularly important, timely and essential to enrich knowledge about sustainable construction approaches and ensure their agreement with the local market.

This is a worthwhile effort, since in recent times the implementation of sustainable construction practices has been incorporated as a part of international strategic agendas (WORLDGBC, n.d.). Considering that there are several issues surrounding the implementation of sustainable practices in the construction sector, it is valid and extremely necessary to carry out a comprehensive investigation into their applicability and acceptance by the local market.

Hence, this paper aims to analyse the perception of Recife's local market in relation to the main barriers that inhibit the adoption of sustainable practices and the main drivers that influence the decision to use sustainable design and construction practices. To understand these issues and their real applicability and acceptance in the city, two questionnaires were applied to stakeholders in the AEC sector (architecture, engineering and civil construction) in Recife – PE. One questionnaire applied to professionals in the fields of architecture, engineering, and construction (AEC) and another applied to residents of Recife – PE, who represented the city's general public.

This paper's relevance and applicability to the capital city of Pernambuco also derives from the fact that it occupies the 16th position in the ranking of the most vulnerable cities in the world and has constantly felt the impacts of climate change (ICLEI, n.d.). Recife's geographical setting makes it prone to frequent occurrences of floods, landslides, communicable diseases, strong heat waves, meteorological droughts, and rising sea levels, all of which result from the effects of climate change (Patz et al., 2004).

From this perspective, the findings of this paper not only contribute significantly to the existing knowledge about sustainability applied to the construction industry, but also manage to merge and implement such knowledge to the reality of the city of Recife. In this way, it is also possible to replicate this study in cities with geographic and socioeconomic characteristics like Recife and, potentially, minimise the vulnerability of these cities to climate change. Thus, this paper makes a significant and in-depth

contribution on the main factors that may influence the adoption of large-scale sustainability practices in Recife – PE, which can encourage decision makers to effectively implement sustainability in the AEC sector.

To promote and make informed and assertive decisions about implementing sustainability practices efficiently and effectively, stakeholders can focus and act on results with high-ranking factors, or values, and therefore of high importance, significance and relevance. Furthermore, this paper provides an opportunity for local organisations and professionals trying to enter the sustainable construction market to gain international and local insights into the sustainability market.

2 Theoretical basis

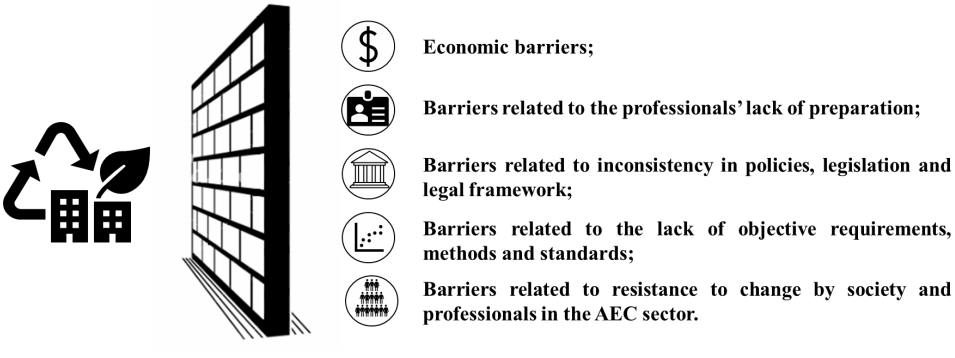
This section sought to identify, through the international literature, the most relevant barriers, and drivers to sustainable construction worldwide.

2.1 Barriers to sustainable building

Sustainable buildings are considered as one of the solutions to reduce the negative impacts of construction, becoming a growing trend in recent years (Fan and Hui, 2020). Despite the several benefits offered by sustainable buildings, some barriers to their adoption can be perceived as factors that hinder or even prevent the implementation of sustainable building practices altogether (Fan and Wu, 2020).

Understanding what the real obstacles are (named 'barriers' in this paper) that prevent the sustainable construction market from growing and expanding is crucial to help find effective ways to overcome them. Several researchers and professionals are constantly investigating the barriers that hinder the use of sustainability in construction, as shown in Figure 1.

Figure 1 Barriers to sustainable building



Source: Adapted from Oliveira and Melo (2021)

The economic barriers, which range from a lack of financing to the issue of high initial costs and long payback period (Zhao et al., 2016; Wang et al., 2018; Yas and Jaafer, 2020). It has also been observed that the Barriers related to education and a lack of preparation of professionals are extremely relevant and detrimental to a greater

acceptance of sustainability in the construction industry (Durdyev et al., 2018; Tokbolat et al., 2019; Marsh et al., 2020). The situation is even worse when considering the Barriers related to the inconsistency of policies, legislation, and legal framework (Deng et al., 2018; Sharma, 2018; Cohen et al., 2019).

These, in turn, are related to another group of barriers, the critical Absence of objective requirements, methods and standards related to the topic (Darko et al., 2018; Shan et al., 2017; Isa et al., 2018). Consequently, all these barriers cause a Great resistance to change, both on the part of society and professionals in the AEC sector (Murtagh et al., 2016; Yin et al., 2018; Darko et al., 2018).

While the merits of sustainable practices applied to construction greatly benefit human health and environmentally and economically sustainable development, sustainability still faces many challenges and barriers in its market penetration, as there are diverse concerns and reluctance regarding its implementation and full understanding, as seen above. In this way, it was necessary to better understand the barriers to the implementation of sustainable practices to find ways and means to overcome them. Next, it is possible to observe how some of the barriers mentioned above are overcome through drivers and, also, how other drivers appear in the literature, to promote sustainable construction.

2.2 Drivers to sustainable construction

Another important point to be considered in this paper pertains to the drivers capable of fostering the sustainable construction market. Drivers can also serve as incentives to correct external costs, provide information, reduce investment risk, and accelerate the pace of sustainability adoption (Qian et al., 2016). To function as drivers, incentives must be attractive to firms and administratively easy to handle for the government to implement. Figure 2 presents the main drivers to sustainable construction.

Figure 2 Drivers to sustainable construction

Source: Adapted from Oliveira and Melo (2021)

It has been found that to stimulate the sustainable construction market there are the:

1 Project-level drivers, which are those related to the consequential benefits of adopting sustainability in a project (Teng et al., 2016; Zhao et al., 2019; Fan and Wu, 2020).

2 Through the literature it is also possible to identify the group of government regulations, which argue that government commitment to the sustainable cause is one of the most efficient ways to promote sustainability (He et al., 2018; Darko and Chan, 2017; Ofek et al., 2018).

3 Another large group that is easily identifiable is the corporate drivers, which are strongly linked to a company's good image and reputation, ensuring competitive advantage, and demonstrating its commitment to society and the planet. In the view of corporate strategies, sustainability can be transformed into high profits due to its strong corporate marketing potential.

4 In contrast to one of the major barriers reported in 2.1, there are the economic and financial drivers, which serve to compensate companies for the extra costs tied to implementing sustainable practices (Olanipekun et al., 2017; Kuo et al., 2017; Zaini, 2017).

5 The drivers linked to education and the lack of environmental awareness are considered a key piece in the acceptance and implementation of sustainability (Rajaee et al., 2019; Tunji-Olayeni et al., 2020; Agyeum et al., 2020).

6 Standards are also extremely important and act as a driver for sustainable construction as they can guide and assess project's sustainability. The availability of standards can serve as a practical solution to the widespread lack of knowledge about sustainable building practices and their benefits (Darko et al., 2018; Zaini, 2017; Darko and Chan, 2017).

7 Personal drivers also function as driving factors and relate to people's moral values, which can influence them in their decision to adhere to sustainability (Olanipekum et al., 2017; Darko et al., 2018; Joachim et al., 2017; Li et al., 2021).

3 Methodology

Scientific research can be classified from several perspectives. According to Miguel (2018), these classifications are carried out according to their nature, objective, approach and method. In this way, this paper is classified in terms of nature as applied, due to its practical character. As for the objective, the paper is exploratory and descriptive, as it is intended to describe a phenomenon without manipulating it. In terms of approach, the paper is classified as quantitative, where the method used for data collection was the survey type, with the application of two online questionnaires, through the Google Forms platform.

Specifically in the literature on sustainable construction, questionnaire surveys have been conducted to examine what factors influence the adoption of sustainability in construction (Lam et al., 2009; Andelin et al., 2015; Forza, 2002). Hence, respondents received an online questionnaire and were asked to express their responses using a five-point Likert scale, ranging from '1' (strongly disagree) to '5' (strongly agree). The

Likert scale is used in research related to the AEC sector to rank the significance of factors based on expert opinion (Zhang et al., 2011; Qin et al., 2016).

For this paper, two questionnaires were applied:

1 one to the AEC sector professionals working in Recife – PE, representing the supply side of the local market

2 one to the general public residing in Recife – PE, representing consumers and local market demand.

Questions were based on the barriers and drivers, hereinafter referred to as 'factors', of sustainable construction, identified through the literature analysis conducted in this research.

Each of the factors was transformed into questions, so that it was possible to have a global assessment of them. A questionnaire equivalent to the factors was applied to professionals in the AEC sector (Appendix, Table A1); while to consumers, another questionnaire was applied with questions based on factors, with the aim of, mostly, evaluating the relevance of sustainability for Recife residents and their level of knowledge on the subject (Appendix, Table A2).

The questionnaire applied to the professionals from the AEC sector contained two parts. The first part assessed the general profile of the respondents, such as their profession, how much time they had been in the market and whether they have had any experience with sustainable projects. The second part assessed the respondents' opinions regarding the factors. The respondents were asked to express their opinions about each factor using a five-point Likert scale going from '1' (strongly disagree) to '5' (strongly agree).

Before the questionnaire was applied, a pre-test was conducted to test its understanding and relevance. The pre-test involved two architects, two engineers, and one administrator. The questionnaire was adjusted based on the feedback from the pre-test. The questionnaire was distributed by e-mail and Whatsapp to local professionals from Recife – PE, from the AEC sector, and collected by convenience. The questionnaire was sent via a Google Forms link to allow online and anonymous responses. Sixty-six responses were collected from professionals working in Recife – PE, which were submitted to classification and agreement analyses using the SPSS 17.0 statistical software.

The questionnaire applied to the public contained 2 parts. The first part evaluated the general profile of the respondents, such as their gender, age, level of education and salary information. The second part sought to assess the relevance of sustainability for Recife residents and their level of knowledge on the subject through factor-based questions. Respondents were asked to express their opinions through a 5-point Likert scale going from "1" (strongly disagree) to "5" (strongly agree).

Before the questionnaire was applied, a pre-test was conducted to test its understanding and relevance. The pre-test involved five people. The questionnaire was adjusted based on the feedbacks from the pre-test. The questionnaire was distributed via e-mail and Whatsapp to the public residing in Recife – PE. It was sent via a Google Forms link to allow online and anonymous responses. The questionnaire collected 55 responses from the local public, which in this research represents the consumer market (demand). These data were subjected to a descriptive statistical analysis.

4 Results

4.1 Analysis of the professionals from the AEC sector

The questionnaire applied to professionals in the AEC sector working in Recife – PE indicated that 35 (53%) respondents were architects, 28 (42%) were engineers and 3 (5%) were builders. Of the total of 66 professionals, 34 (51.1%) graduated less than 5 years ago, 6 (9.1%) graduated between 5 and 10 years ago, and 26 (39.4%) graduated more than 10 years ago. A total of 24 (36.4%) respondents work with projects/construction for more than 10 years, 21 (31.8%) work in projects/construction between 5 and 10 years and 21 (31.8%) work in projects/construction for less than 5 years.

In terms of knowledge about sustainability, of the 66 professionals, 8 (12.1%) consider their knowledge on the subject 'poor', 18 (27.3%) consider it 'reasonable', 17 (25.8%) say they have 'average' knowledge and 23 (34.8%) say they have 'good' knowledge. None of the respondents said they had 'excellent' knowledge regarding sustainability. Of the respondents, 37 (56.1%) said they had already worked on a project that implemented sustainable practices and 29 (43.9%) said they had never worked with sustainable projects. Table 1 presents a compendium of the profile of professionals in the AEC sector.

To measure the internal consistency between the various factors to assess the reliability of the five-point scales, Cronbach's alpha coefficient was used, as it can measure the correlation between responses to a questionnaire through the analysis of these responses, presenting an average match between the questions.

Table 1 Profile of the professionals from the AEC sector

Variable	*Level*	*Frequency*	*Total*	*Percentage*
Profession	Engineer	28	66	42%
	Architect	35		53%
	Builder	3		5%
Graduation time	Less than 5 years	34	66	51.5%
	From 5 to 10 years	6		9.1%
	More than 10 years	26		39.4%
Working time with projects/construction	Less than 5 years	21	66	31.8%
	From 5 to 10 years	21		31.8%
	More than 10 years	24		36.4%
Knowledge about sustainable buildings	Poor	8	66	12.1%
	Reasonable	18		27.3%
	Average	17		25.8%
	Good	23		34.8%

The Cronbach's alpha value of this study was 0.881, indicating that the values using the five-point scale are highly reliable, as pointed out by Freitas and Rodrigues (2005). Once the high reliability of the items in this study had been determined through Cronbach's alpha, the classification and agreement analyses were performed. For this, the data for each factor are presented as mean (X) and standard deviation (SD) of the mean in Table 2. These values were submitted to the t-test for statistical significance, considered when $p < 0.05$ (p-value).

Table 2 Ranking of the factors studied

Ranking	*Question (factor)*	*Frequency of the answer*					*Mean (x)*	*Standard deviation (sd)*	*Significance*
		1	*2*	*3*	*4*	*5*			
1	31	0	0	1	8	57	4.85	0.402	0.000
2	21	0	1	0	10	55	4.8	0.503	0.000
3	4	0	0	0	13	53	4.8	0.401	0.000
4	26	0	0	0	14	52	4.79	0.412	0.000
5	30	0	0	0	13	53	4.8	0.401	0.000
6	32	0	1	3	9	53	4.73	0.621	0.000
7	10	0	2	0	15	49	4.68	0.636	0.000
8	24	0	0	1	18	47	4.7	0.495	0.000
9	28	0	0	3	15	48	4.68	0.559	0.000
10	18	0	0	2	17	47	4.68	0.531	0.000
11	17	0	0	3	15	48	4.68	0.559	0.000
12	6	0	1	4	15	46	4.61	0.677	0.000
13	8	0	1	5	13	47	4.61	0.699	0.000
14	1	0	2	1	19	44	4.59	0.679	0.000
15	13	0	2	0	21	43	4.59	0.656	0.000
16	7	1	0	3	19	43	4.56	0.726	0.000
17	2	0	0	2	22	42	4.61	0.551	0.000
18	14	0	1	3	21	41	4.55	0.661	0.000
19	5	0	2	5	17	42	4.5	0.77	0.000
20	15	1	3	2	18	42	4.47	0.881	0.000
21	19	0	1	5	22	38	4.47	0.706	0.000
22	33	0	1	9	17	39	4.42	0.786	0.000
23	3	0	3	6	19	38	4.39	0.839	0.000
24	11	0	1	11	14	40	4.41	0.822	0.000
25	22	0	0	14	20	32	4.27	0.795	0.000
26	12	1	7	2	23	33	4.21	1.031	0.000
27	16	1	1	9	24	31	4.26	0.865	0.000
28	9	2	8	3	20	33	4.12	1.144	0.000
29	20	0	11	4	21	30	4.06	1.094	0.000
30	25	0	6	5	31	24	4.11	0.897	0.000
31	27	2	10	3	32	19	3.85	1.099	0.000
32	23	2	11	5	30	18	3.77	1.12	0.000
33	29	1	15	2	31	17	3.73	1.131	0.000
N							66		
Kendall's W**							0.161		
Chi-Square							340.847		
df							32		
Significance level							0.000		

Notes: *T-test.
** *Kendall's test of concordance.

The mean score classification technique has been widely used in studies aiming to rank and determine which factors are the most relevant among a range of factors (Manoliadis et al., 2006; Darko et al., 2018). It is considered a suitable method for testing the significance and importance among factors (Chan et al., 2003). In this research, the mean score method was used to analyse the driving factors and barriers to sustainability in the construction industry, to rank and prioritise the most relevant ones according to the perception of professionals from the AEC sector of Recife.

Once the mean score (X) method was applied, the SD was also calculated for each of the questions. Given that the answers were set up on a five-point Likert scale ranging from '1' (strongly disagree) to '5' (strongly agree), a high average (closer to 5) means that the respondents agreed with the question. In turn, the SD means that the degree of consensus between the answers to a question. In other words, the closer to 0 (zero) the result of the SD, the lower the degree of divergence between opinions, meaning that most professionals responded in a similar way, agreeing with each other.

After the observation of the mean and SD, the t-test was calculated to statistically verify whether the mean and SD values are significant or not. For this study a $p < 0.05$ was adopted; the closer the result is to 0 (zero), the greater is the significance of the factor, i.e., the is greater the significance of the driver or barrier to sustainability (Ferreira and Patino, 2015).

The nonparametric test known as Kendall's coefficient of concordance was used to analyse agreement by factors (Chan et al., 2009). In this way, the study tested whether the respondent's agreement among the factors is due to chance or not. Kendall's W value ranges from 0 (zero) to 1 (one), where a value of 0 (zero) indicates the absence of agreement between the factors, that is, the agreement is that which would be expected by chance and 1 (one) indicates perfect agreement between the factors (Howell, 2012). The hypotheses tested for the 33 factors studied are presented below:

H0 The rater agreement is due to chance.

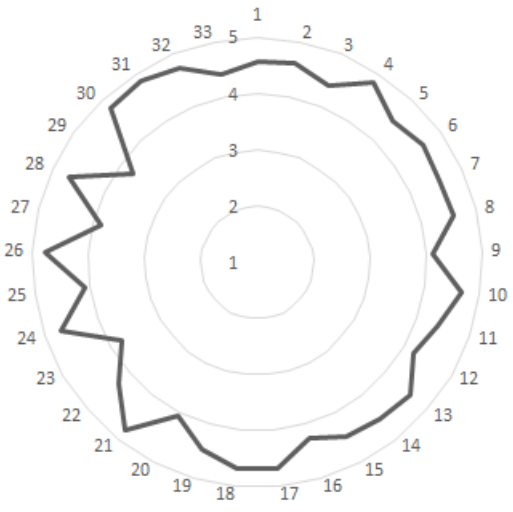
H1 The rater agreement is not due to chance.

From Table 2, it was possible to verify that the null hypothesis must be rejected since the p-value for the 33 factors was lower than $\alpha = 0.05$, i.e., the agreement of the raters is not due to chance, so one concludes that the respondent's ratings are associated with each other with a known pattern. Kendall's W = 0.161 suggests a slight agreement between the professionals.

It is recommended that since the number of factors ranked was 33 (N > 33) with a large sample size (> 66), the observed Kendall's W significance should be determined by reference to the distribution of the chi-square (x^2) approximation with N – 1 degrees of freedom (Siegel, 1956). The chi-square test $x^2 = 340.847$ with df = 32 indicated that there is a consensus among the professionals in expressing their opinions with respect to the ratings of the drivers and barriers to implementing sustainability practices.

An analysis of Table 2 reveals that the average of the factors is mostly close to 5, which means that most respondents agree with that factor, that is, they agree with the driver or with the barrier presented. Regarding the SD, Table 2 shows that for most factors there was a consensus among respondents, with only 6 factors showing a higher degree of disagreement among respondents.

Figure 3 Radar chart of the mean of the factors



Therefore, according to the mean and SD, the factors that deserve highlighting for being the first ones in the ranking are factors number 31, 21, 4, 26, and 30. On the other hand, the factors that ranked last also deserve some highlighting, since the lack of agreement and consensus among respondents can also bring helpful findings. These were factors number 29, 23, 27, 25, and 20.

It is also possible to observe this through Figure 3, which graphically demonstrates that most of the answers are in the same range, between scale point 5 and scale point 4. Therefore, in general terms, it has been observed that most of the respondents agreed with each of the factors and have formed a consensus.

4.2 Discussion of the results obtained from AEC-related professionals

The t-test of the means indicates that all 33 factors are of high significance. Thus, all of them are considered critical or valid by the respondents. The first factor in Table 2, according to the respondents' ranking, is: 'I believe that opportunities for innovation and the development of new technologies in the field of sustainability can promote the adoption of sustainable buildings' (mean = 4.85). This is, therefore, considered the most critical factor in Recife – PE for the implementation of sustainable practices in the construction industry.

However, as Zhao et al. (2016) have emphasised, the ways in which developers and other involved agents can innovate in the field of sustainability are still clouded by limited understanding on the subject. Even so, according to Ofek et al. (2018), the pursuit of innovation could be associated with the professional image of companies, positively influencing investments in sustainable buildings since developers may use this image of innovation and environmental responsibility as a marketing tool.

On the other hand, the factor that ranked last was 'I know how to improve the water efficiency of a project' (mean = 3.73), indicating that the professionals do not agree with this statement and therefore lack expertise in this aspect.

Despite being considered one of the most well-known drivers of sustainable buildings, water efficiency in projects can present some obstacles to its application, such as more expensive systems and complex planning and construction processes (Ofek et al., 2018). In any case, knowledge related to practices of water saving and reuse are extremely important and considered one of the most essential drivers of sustainable projects (Tokbolat et al., 2019; Yas and Jaafer, 2020).

It is important to note that factors related to the user's quality of life, as well as resource savings, such as water and energy, and reduced production of waste ranked high in the analysis. This translates into the assumption that professionals from the AEC sector in Recife – PE are aware that sustainable projects present several benefits to users.

This result coincides with those identified in the literature, since several authors report that the benefits inherent to the correct application of sustainable practices are one of the major driving factors of this market (Qian et al., 2016; Darko et al., 2018; Fan and Wu, 2020). Matters that relate to saving resources such as energy and water are attractive as they represent not only a reduction in pressure on scarce natural resources, but also, and most importantly, because they represent lower costs from energy and water bills (Teng et al., 2016). Hence, since these drivers are attractive and appeal to the general public (market/demand), the approach also becomes attractive to the supply side (AEC-related professionals) as the selling or resale value of the project becomes higher (Fan and Wu, 2020).

It is also worth noting that the 'price competitiveness of sustainable materials compared to traditional ones' as well as 'greater knowledge and availability of manufacturers and suppliers of sustainable products/materials' ranked high in the analysis, which means that AEC-related professionals consider the lack of sustainable materials in the market with competitive prices to be a huge barrier. This information aligns with the study conducted by Serpell et al. (2013), which proves that the existence of sustainable materials suppliers in Chile was one of the most relevant drivers to the sustainable building market in the country.

An interesting contrast to note is that the factor that ranked first is the consideration that opportunities for innovation and the development of new technologies in the field of sustainability can promote the adoption of sustainable buildings. This means that most professionals in the AEC sector strongly and consensually agree that exploration and a technological, innovation-fuelled advancement are very important since sustainability is linked to the use of natural resources, but its implementation is subject to the capabilities of existing professionals – as shown in the study conducted by Schneider and Spieth (2013).

The factors that are at the bottom of the list converge with the findings of most of the authors in the literature, who reveal that the lack of environmental awareness and skilled professionals are one of the biggest barriers to the implementation of sustainable practices (Darko et al., 2018). In this research, this can be observed through the factors at the bottom of the ranking list, revealing that most respondents are unaware of which project practices can improve the users' quality of life, which ones can generate less waste, and how to improve a project's energy and water efficiency.

Therefore, the efforts of decision makers should, first of all, focus on educational and training actions to learn about the advantages and implementation of sustainability in construction. In this way, professionals in the AEC sector will be prepared and confident in really building in a sustainable way. At the same time, encouraging the trade of

sustainable materials and suppliers is extremely important so that the sustainable construction market can really sustain itself.

4.3 Analysis of the public of Recife – PE

The questionnaire has indicated that 33 (60%) respondents were female and 22 (40%) were male. When it comes to their age, 6 (10.9%) respondents were 18–24 years old, 24 (43.6%) were 25–30 years old, 9 (16.4%) were 31–40 years old, 7 (12.7%) were 41–50 years old, 6 (10.9%) were 51–60 years old, and finally, 3 (5.5%) were over 61 years old. Regarding their level of education, 33 (60%) respondents claimed to have postgraduate studies, e.g., master's degree or doctorate, 20 (36.4%) have a college degree, 1 (1.8%) respondent has a high school education or less, and 1 (1.8%) respondent said 'other'. None of the respondents has a technical degree.

Concerning their salary information, 3 (5.5%) respondents make less than one minimum wage, 6 (10.9%) make between 1 and 2 minimum wages, 18 (32.7%) make between 3 and 4 minimum wages, 12 (21.8%) make between 5 and 6 minimum wages, 4 (7.3%) make between 7 and 8 minimum wages, and finally, 12 (21.8%) make more than 9 minimum wages. Therefore, this can be considered a diversified sample which is able to really capture the various particularities of the public located in Recife – PE. These data can be seen in Table 3.

Table 3 Profile of the public of Recife – PE

Variable	*Level*	*Frequency*	*Total*	*Percentage*
Sex	Female	33	55	60%
	Male	22		40%
Age	18–24 years old	6	55	10.9%
	25–30 years old	24		43.6%
	31–40 years old	9		16.4%
	41–50 years old	7		12.7%
	51–60 years old	6		10.9%
	61+	3		5.5%
Level of education	High school or less	1	55	1.8%
	Technical school	0		0
	College graduate	20		36.4%
	Postgraduate, master's or doctorate	33		60%
	Other	1		1.8%
Salary information	Less than the minimum wage	3	55	5.5%
	Between 1× and 2× minimum wage	6		10.9%
	Between 3× and 4× minimum wage	18		32.7%
	Between 5× and 6× minimum wage	12		21.8%
	Between 7× and 8× minimum wage	4		7.3%
	More than 9× minimum wage	12		21.8%

This section sought to understand the local knowledge and familiarity in relation to the theme of sustainable construction and to verify if there is a market for sustainable

construction in Recife, that is, if there is a demand for it. To that end, the questionnaire (Table A2) was designed to analyse the residents' perception about the topic. The answers were submitted to a descriptive statistical analysis. To help in the interpretation of the answers, a study of the scale frequency, mean, and SD was also prepared for the answers that were received (Table 4).

Among the 55 answers that were analysed, 38 (69.1%) of the respondents said they were fully aware of what climate change is, while 15 (27.3%) people said they have partial knowledge about the subject. 1 (1.8%) person claimed to be only partially aware of it, and 1 (1.8%) respondent said they were indifferent. Concerning their knowledge about sustainability, 44 (80%) respondents said they were fully aware of what sustainability is, 10 (18.2%) respondents said they had partial knowledge on the subject, and 1 (1.8%) said they were indifferent.

Out of the respondents, 39 (70.9%) totally agreed when asked if they saw sustainability and the preservation of the environment as important issues, 14 (25.5%) said they partially agree, and 2 (3.6) said they were indifferent. Most of the respondents (45 people or 81.8%) said they totally agree with the statement that sustainability and the preservation of the environment have an impact on their lives, while 10 (18.2%) people have partially agreed with the statement.

Table 4 Frequency, mean and SD of the answers to the questionnaire on sustainable construction applied to the public

Question	*Frequency of the answer*					*Mean*	*Standard deviation*
	1	*2*	*3*	*4*	*5*		
1	0	1	1	15	38	4.6364	0.61955
2	0	0	1	10	44	4.7818	0.45910
3	0	0	2	14	39	4.6727	0.54618
4	0	0	0	10	45	4.8182	0.38925
5	0	8	6	27	14	3.8545	0.97026
6	1	1	3	4	46	4.6909	0.81360
7	1	1	1	3	49	4.7818	0.73764
8	2	8	5	17	23	3.9273	1.19961
9	0	0	6	4	45	4.7091	0.65751
10	1	3	3	5	43	4.5636	0.95769
11	14	11	5	14	11	2.9455	1.52046
12	0	1	0	16	38	4.6545	0.58431
13	13	4	4	12	22	3.4727	1.63134
14	5	5	12	13	20	3.6909	1.30345
15	3	5	4	11	32	4.1636	1.22872
16	0	1	2	9	43	4.7091	0.62872
17	0	0	2	1	52	4.9091	0.39781
18	1	0	4	14	36	4.5273	0.79009
19	1	5	2	8	39	4.4364	1.04993
20	1	2	4	5	43	4.5818	0.91674

Concerning their knowledge of what a sustainable construction is, 14 (25.5%) have said they were fully aware of what a sustainable building is, 27 (49.1%) respondents partially agreed with the statement, 6 (10.9%) said they were indifferent, and 8 (14.5%) of them partially disagreed with the statement. On the other hand, when asked if they would like to buy or rent a property that consumes less water and energy, 46 (83.6%) respondents said they totally agree, contrasting with 1 (1.8%) person who totally disagreed.

Most respondents (49 people or 89.1%) said they would totally agree to buy a sustainable property if financial incentives existed, such as easy credit for purchase, easy financing and discounts on taxes, such as Urban Property and Territorial Tax (IPTU). However, the number of those who totally agree drops substantially (23 people or 41.8%) when asked if they would still consider buying a sustainable property if its purchase price was higher than a traditional property, even with the existence of financial incentives. This is a curious statement and an interesting finding, as most respondents have either fully or partially agreed with the statement that taking care of the environment is their responsibility (38 people or 69.1% and 16 people or 29.1%, respectively).

Most respondents (45 or 81.8%) said they would like to understand more about how they can help preserve the environment, just as 43 (78.2%) of them said they would like to have more information about sustainable projects and their benefits. The desire and need for knowledge on this topic are confirmed by the lack of consensus in the answers to the question regarding the knowledge of the benefits of buying or renting a property that has sustainability certification; on this matter, 14 (25.5%) respondents said they were totally unaware of the benefits and 11 (20%) claimed to be only partially aware of them.

Regarding the question whether they knew about the Brazilian National Electric Energy Conservation Program (PROCEL)/energy efficiency label for appliances, only 22 (40%) totally agreed. Still about energy efficiency, 20 (36.4%) respondents said that they have most appliances with an A rating on the PROCEL certification. The number of those interested in energy-saving appliances rises to 32 (58.2%) when asked if they would consider replacing their appliances if financial incentives were available for this purpose (e.g., facilitated financing and purchase discounts).

The number of people interested in acquiring solar panels (solar energy production) to reduce their energy bill if financial incentives were available for this purpose (facilitated financing and purchase discounts) is higher, with 43 (78.2%) people who said they were totally interested in it.

The statement with the highest factor of total agreement among the respondents (52 people or 94.5%) was the belief that the existence of green areas near their residences would improve their quality of life. Respondents were asked if they considered solar orientation (East/West) and natural ventilation when either buying or renting a property and 36 (65.5%) of them said they totally agree, while 1 (1.8%) said he/she totally disagrees.

Regarding the separation of waste into organic and recyclable, 39 (70%) respondents totally agreed to separate waste if their building and city had selective waste collection. Regarding water consumption, 43 (78.2%) respondents said that they would consider replacing the faucets in their homes for ones that consumed less water if financial incentives were available for this purpose (facilitated financing and discounts on purchases).

By analysing the mean and SD of the answers (Table 4), one notices that most respondents had a high degree of agreement with the statements presented in the questionnaire, except for questions 11 and 13, which relate to their knowledge about the

benefits of sustainability certifications and the energy efficiency certification for appliances. About the SD, one cannot say that there was total agreement among the respondents, i.e., the questions were given divergent answers. This suggests that the public of Recife has divided opinions about the factors studied.

4.4 Discussion of the results obtained from the general public

The questionnaire applied to the public living in Recife – PE served to measure the population's knowledge and familiarity with the topic of sustainability. It also managed to examine whether people would be willing to make some lifestyle changes or replace their traditional equipment for more economical ones.

The results show that although most respondents have a high level of education, a high percentage of respondents are not completely sure about what a sustainable building is. This lack of knowledge on sustainable buildings has also been noticed by other authors, such as Darko and Chan (2017).

Nonetheless, even though most people do not fully understand what sustainable construction is, most of them would like to buy or rent a property that consumes less water and energy. This fact justifies the perception of some authors who consider water and energy savings, associated with a lower cost of operation, as one of the biggest motivators of the sustainable construction market (Murtagh et al., 2016; Zhao et al., 2016; Li et al., 2021).

The answers have made clear that most respondents would like to understand more about how to preserve the environment and, also, to have more information about sustainable projects and their benefits. The lack of knowledge that was previously mentioned can and should be associated with people's eagerness to understand more about the subject. Therefore, a driver to overcome this obstacle could be found in raising society's environmental awareness using conferences, seminars, and workshops, as has been stated by Portnov et al. (2018).

These facts should be taken into consideration since much of the mistrust aimed at sustainable projects may be precisely related to the lack of knowledge on the subject and resistance to change. According to Hwang and Tan (2012), knowledge on the part of professionals associated with the environmental awareness of society increases the sustainable construction market.

In the content of the responses to the questionnaire, it is noticeable that some replacements of household appliances and behavioural changes would be well accepted if there were some incentives, such as financial ones, assisting in the purchase of sustainability-minded appliances such as economical faucets, for instance. As highlighted by Darko et al. (2018), energy efficiency decreases not only the pressure on natural resources, but also considerably decreases the monetary value to be paid on energy consumption in the operation of projects, which ends up adding value to the end user and the developer.

Awareness on the production of waste and recycling has been highlighted as an important driving factor for a sustainable future (He et al., 2018), and it has been observed through this survey that the population of Recife would also be willing to recycle their waste if there was some sort of support structure, such as selective waste collection initiatives organised by each building and the city.

Therefore, those who are involved in this discussion could first define a facilitating mechanism for necessary adaptations such as replacing appliances and plumbing fixtures

since, according to this survey, the population of Recife is willing to make the necessary modifications on the condition that there is some assistance with the costs. It would also be relevant to define logistical operations to facilitate selective waste collection, since most respondents would be willing to adopt it.

Crucially, important actions to foster the sustainable construction market should relate to the organisation of educational efforts to raise the population's awareness about climate change, sustainability, and sustainable construction and consumption. The construction market in Recife will only be able to thrive through public awareness of environmental issues coupled with the dissemination of knowledge about the advantages of sustainable construction (Hwang and Tan, 2012).

5 Conclusions

Sustainability represents a broad and necessary mission in the construction industry, incorporating holistic issues such as environmental preservation, economic prosperity, as well as social responsibility. The adoption of a sustainability paradigm in the construction industry is therefore critical, as it aims to reduce the industry's harmful impact. Increasingly in recent times, this topic has drawn the attention of decision makers and various other stakeholders in countries around the world (Sev, 2009).

With the purpose of accelerating and assisting the adoption of sustainable construction practices, this research aimed to analyse the perception of the local market about the main barriers that inhibit the adoption of sustainable practices and the main drivers that influence the decision to use sustainable projects and construction practices. This objective was achieved through a theoretical foundation meant to help investigate the main drivers and barriers to sustainable construction, which was then followed by the application of two questionnaires aiming to analyse the perception of Recife's local construction market.

The understanding, classification and ranking of the questions that were asked (factors) allow those who are interested in this discussion, especially policy makers, to understand what are the key points that future initiatives should focus on to stimulate sustainable construction, aiming for a wider adoption of sustainability in Recife's buildings.

With respect to the findings obtained from the survey applied to professionals in the AEC sector, much of the low adoption of sustainable practices in the city results from the extensive lack of technical knowledge on the subject. This fact was also confirmed through the questionnaire applied to the public living in Recife, who represented the market, since most respondents claim not to have enough knowledge on the subject. However, both professionals and the public agree that a greater availability of information on the subject would be greatly beneficial.

The benefits of sustainability, such as water and energy savings, imply great market attraction, since most consumers have stated that they would like to buy a house that is water and energy efficient. In contrast, some of the professionals in the AEC sector said they did not have full knowledge on how to improve the water efficiency of a project, nor on how to improve the energy efficiency of a project.

This discrepancy generates a dysfunction in the market since there is a demand for more efficient projects despite the lack of public knowledge about sustainability itself. However, the supply is limited, since not only these professionals do not have enough

knowledge on how to elaborate sustainable projects, they also do not believe that there is a market demand for them. Also, aggravating this situation, there are no well-structured and disseminated policies on financial incentives for sustainable construction, nor any sort of assistance for the elaboration of sustainable projects or a wide availability of companies and manufacturers of sustainable products.

That are several factors which influence and inhibit the implementation of sustainable practices in the construction industry in Recife – PE. A wide range of barriers and drivers were identified and examined using a combination of survey methods and the application of questionnaires. The issues influencing the adoption of sustainability in construction were further analysed using the technique of ranking and statistical significance, thus providing a clear understanding of the key issues that should be given priority consideration in efforts to adopt sustainability in construction.

This research analysed 66 responses from AEC industry professionals and 55 responses from the public. Both samples were collected by convenience and the findings follow the characteristics of the studied sample, and cannot be generalised, but can serve as a basis for replication in further research.

The general results of this study present a consensus among professionals in the AEC sector, as verified by Kendall's concordance coefficient. The findings reveal that one of the most favourable ways to promote sustainable construction would be the development of educational and professionalising actions in sustainability for professionals in the AEC sector.

The responses from the public reveal that despite the insecurity regarding the concept of sustainable construction, people from Recife would like to live in an apartment or house that consumes less water and energy. They are also open to the replacing of electronic and plumbing devices, in addition to being willing to purchase solar panels to produce clean energy; if there was funding or any financial assistance to do so. Therefore, it is noticed, mainly, that although incipient, there is a market demand for sustainable projects in Recife – PE.

Although the barriers revealed in this study were cited as inhibitors to the large-scale adoption of sustainable practices in construction, most of them can be offset or overcome through strategies whose development is based on the ranking of motivators elaborated in this research. It is hoped that the results of this study can contribute with valuable information for the formulation of policies in the construction sector and in the large-scale adoption of sustainable practices. The results contribute to an in-depth understanding of the main issues that influence the implementation of sustainability in the sector.

There are some limitations in this research that deserve attention in future work. Although a ranking has been made of the drivers and barriers of sustainable construction, it is valid that the analysed factors are reflected in concrete actions that can be implemented in the management of the city. Therefore, a roadmap capable of guiding the entire sector along a progressively sustainable path, with actions that must be prioritised, aiming at increasing the adaptation of the construction sector to climate change, must be developed.

Among the practical and managerial implications that this study may have, one of them is to serve as a foundation for the effective structuring of political strategies to promote the sustainable construction market in Recife – PE. Through the findings revealed, it is possible to develop action plans or roadmaps capable of guiding the city towards a sustainable future. The ranking of factors proves to be essential for the

development of specific actions, which deserve to be treated as a priority, since they are in accordance with the perception of both professionals in the AEC sector and the public of Recife. In other words, there is the absorption of the market perception of Recife as a whole, both on the supply and demand sides. Actions based on the findings of this research may serve as part of a holistic planning to increase the quality and sustainability of construction projects in the city of Recife as a whole.

Acknowledgements

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001 and the Fundação de Amparo a Ciência e Tecnologia de Pernambuco (FACEPE).

References

Agyekum, K., Adinyira, E. and Ampratwum, G. (2020) 'Factors driving the adoption of green certification of buildings in Ghana', *Smart and Sustainable Built Environment*, Vol. 9, No. 4, pp.595–613.

Andelin, M. et al. (2015) 'Breaking the circle of blame for sustainable buildings – evidence from Nordic countries', *Journal of Corporate Real Estate*, Vol. 17, No. 1, pp.26–45.

Bai, Y., Zhang, Z. and Zhao, W. (2019) 'Assessing the impact of climate change on flood events using HEC-HMS and CMIP5', *Water, Air, & Soil Pollution*, Vol. 230, No. 6, pp.1–13.

Berardi, U. (2013) 'Clarifying the new interpretations of the concept of sustainable building', *Sustainable Cities and Society*, Vol. 8, No. 10, pp.72–78.

Chan, A.P.C., Chan, D.W.M. and Ho, K.S.K. (2003) 'Partnering in construction: critical study of problems for implementation', *Journal of Management in Engineering*, Vol. 19, No. 3, pp.126–135.

Chan, E.H.W., Qian, Q.K. and Lam, P.T.I. (2009) 'The market for green building in developed Asian cities – the perspectives of building designers', *Energy Policy*, Vol. 37, No. 8, pp.3061–3070.

Cohen, C., Pearlmutter, D. and Schwartz, M. (2019) 'Promoting green building in Israel: a game theory-based analysis', *Building and Environment*, Vol. 163, No. 10, pp.106227–106235.

Darko, A. and Chan, A.P.C. (2017) 'Strategies to promote green building technologies adoption in developing countries: the case of Ghana', *Building and Environment*, Vol. 130, No. 2, pp.74–84.

Darko, A. et al. (2018) 'Influences of barriers, drivers, and promotion strategies on green building technologies adoption in developing countries: the Ghanaian case', *Journal of Cleaner Production*, Vol. 200, No. 11, pp.687–703.

Deng, W. et al. (2018) 'Barriers and policy recommendations for developing green buildings from local government perspective: a case study of Ningbo China', *Intelligent Buildings International*, Vol. 10, No. 2, pp.61–77.

Diário de Pernambuco. R. (2016) *A Capital Brasileira da Desigualdade Social* [online] https://curiosamente.diariodepernambuco.com.br/project/recife-capital-brasileira-da-desigualdade (accessed 28 October 2021).

Durdyev, S. et al. (2018) Sustainable construction industry in Cambodia: awareness, drivers and barriers', *Sustainability*, Vol. 10, No. 2, pp.392–402.

Fan, K. and Hui, E.C.M. (2020) 'Evolutionary game theory analysis for understanding the decision-making mechanisms of governments and developers on green building incentives', *Building and Environment*, Vol. 179, No. 7, p.106972.

Fan, K. and Wu, Z. (2020) 'Incentive mechanism design for promoting high-level green buildings', *Building and Environment*, Vol. 184, No. 10, p.107230.

Ferreira, J. and Patino, C.M. (2015) 'O que realmente significa o valor-p?', *Jornal Brasileiro de Pneumologia*, Vol. 41, No. 5, pp.485–485.

Forza, C. (2002) 'Survey research in operations management: a process-based perspective', *International Journal of Operations & Production Management*, Vol. 22, No. 2, pp.152–194.

Freitas, A.L.P. and Rodrigues, S.G. (2005) 'A avaliação da confiabilidade de questionário: uma análise utilizando o coeficiente alfa de Cronbach', *Simpósio de Engenharia de Produção*, Anais, Bauru – SP: UNESP.

Green Building Council Australia (GBCA) 'The dollars and sense of green buildings: building the business case for green commercial buildings in Australia. 2006', *Disponível* [online] http://www.gbca.org.au (accessed 3 de ago. 2021).

He, B.J. et al. (2018) 'Promoting and implementing urban sustainability in China: an integration of sustainable initiatives at different urban scales', *Habitat International*, Vol. 82, No. 12, pp.83–93.

Howell, D.C. (2012) *Statistical Methods for Psychology*, Cengage Learning, USA.

Hwang, B-G. and Tan, J.S. (2012) 'Green building project management: obstacles and solutions for sustainable development', *Sustainable Development*, Vol. 20, No. 5, pp.335–349.

ICLEI (n.d.) *Governos locais pela sustentabilidade*, Recife, Brazil [online] https://americadosul.iclei.org/associados/recife (accessed 12 August 2021).

Isa, N.K.M. et al. (2018) 'An exploration of drivers and strategies for encouraging the delivery of green building projects in housing development', *International Journal of Technology*, Vol. 9, No. 1, pp.1702–1714.

Joachim, O.I. et al. (2017) 'Green and sustainable commercial property supply in Malaysia and Nigeria', *Geographical Review*, Vol. 107, No. 3, pp.496–515.

Kuo, C-F.J. et al. (2017) 'Evaluation of intelligent green building policies in Taiwan – using fuzzy analytic hierarchical process and fuzzy transformation matrix', *Energy and Buildings*, Vol. 139, No. 3, pp.146–159.

Lam, P. et al. (2009) 'Integrating green specifications in construction and overcoming barriers in their use', *Journal of Professional Issues in Engineering Education and Practice*, Vol. 135, No. 4, pp.142–152.

Li, Q. et al. (2021) 'Exploring multi-level motivations towards green design practices: a system dynamics approach', *Sustainable Cities and Society*, Vol. 64, No. 1, pp.102490–102504.

Manoliadis, O., Tsolas, I. and Nakou, A. (2006) 'Sustainable construction and drivers of change in Greece: a Delphi study', *Construction Management and Economics*, Vol. 24, No. 2, pp.113–120.

Marsh, R.J., Brent, A.C. and De Kock, I.H. (2020) 'An integrative review of the potential barriers to and drivers of adopting and implementing sustainable construction in South Africa', *South African Journal of Industrial Engineering*, Vol. 31, No. 3, pp.24–35.

Miguel, P.A.C. (2018) *Metodologia de Pesquisa em Engenharia de Produção e Gestão de Operações*, Elsevier, Rio de Janeiro.

Murtagh, N., Roberts, A. and Hind, R. (2016) 'The relationship between motivations of architectural designers and environmentally sustainable construction design', *Construction Management and Economics*, Vol. 34, No. 1, pp.61–75.

OECD (2007) *Ranking of the World's Cities Most Exposed to Coastal Flooding Today and in the Future* [online] https://climate-adapt.eea.europa.eu/metadata/publications/ranking-of-the-worlds-cities-to-coastal-flooding/11240357 (accessed 28 October 2021).

Ofek, S., Akron, S. and Portnov, B.A. (2018) 'Stimulating green construction by influencing the decision-making of main players', *Sustainable Cities and Society*, Vol. 40, No. 7, pp.165–173.

Olanipekun, A. et al. (2017) 'Project owners' motivation for delivering green building projects', *Journal of Construction Engineering and Management*, Vol. 143, No. 9, p.04017068.

Olanipekun, A.O. et al. (2017) 'Project owners' motivation for delivering green building projects', *Journal of Construction Engineering and Management*, Vol. 143, No. 9, pp.04017068–04017076.

Oliveira, J.C.F. and Melo, F.J.C. (2021) 'Barriers and drivers of sustainable construction: a systematic literature review', *International Journal of Services and Operations Management (PRINT)*, pp.1–20.

Patz, J.A. et al. (2004) 'Unhealthy landscapes: policy recommendations on land use change and infectious disease emergence', *Environmental Health Perspectives*, Vol. 112, No. 10, pp.1092–1098.

PBMC (2016) *Mudanças Climáticas e Cidades. Relatório Especial do Painel Brasileiro de Mudanças Climáticas*, in Ribeiro, S.K. and Santos, A.S. (Eds.), 116pp, PBMC, COPPE – UFRJ, Rio de Janeiro, Brasil, ISBN: 978-85-285-0344-9.

Portnov, B.A. et al. (2018) 'Factors affecting homebuyers' willingness to pay green building price premium: evidence from a nationwide survey in Israel', *Building and Environment*, Vol. 137, No. 6, pp.280–291.

Qian, Q.K., Fan, K. and Chan, E.H.W. (2016) 'Regulatory incentives for green buildings: gross floor area concessions', *Building Research & Information*, Vol. 44, Nos. 5–6, pp.675–693.

Qin, X., Mo, Y. and Jing, L. (2016) 'Risk perceptions of the life-cycle of green buildings in China', *Journal of Cleaner Production*, Vol. 126, No. 7, pp.148–158.

Rajaee, M., Hoseini, S.M. and Malekmohammadi, I. (2019) 'Proposing a socio-psychological model for adopting green building technologies: a case study from Iran', *Sustainable Cities and Society*, Vol. 45, No. 2, pp.657–668.

Ribeiro, W.C. (2008) 'Impactos das mudanças climáticas em cidades no Brasil. Centro de Gestão e Estudos Estratégicos (CGEE)', *Parcerias Estratégicas*, Vol. 13, No. 27, pp.297–321.

Schneider, S. and Spieth, P. (2013) 'Business model innovation: towards an integrated future research agenda', *International Journal of Innovation Management*, Vol. 17, No. 1, pp.1340001–1340015.

Serpell, A., Kort, J. and Vera, S. (2013) 'Awareness, actions, drivers and barriers of sustainable construction in Chile', *Technological and Economic Development of Economy*, Vol. 19, No. 2, pp. 272-288.

Sev, A. (2009) 'How can the construction industry contribute to sustainable development? A conceptual framework', *Sustainable Development*, Vol. 17, No. 3, pp.161–173.

Shan, M., Hwang, B-G. and Zhu, L. (2017) 'A global review of sustainable construction project financing: policies, practices, and research efforts', *Sustainability*, Vol. 9, No. 12, pp.2347–2358.

Sharma, M. (2018) 'Development of a 'green building sustainability model for green buildings in India', *Journal of Cleaner Production*, Vol. 190, No. 7, pp.538–551.

Siegel, S. (1956) *Nonparametric Statistics for the Behavioral Sciences*, McGraw-Hill, USA

Son, H. et al. (2011) 'Implementing sustainable development in the construction industry: constructors' perspectives in the US and Korea', *Sustainable Development*, Vol. 19, No. 5, pp.337–347.

Teng, J. et al. (2016) 'Overcoming the barriers for the development of green building certification in China', *Journal of Housing and the Built Environment*, Vol. 31, No. 1, pp.69–92.

Tokbolat, S. et al. (2019) 'Construction professionals' perspectives on drivers and barriers of sustainable construction', *Environment, Development and Sustainability*, Vol. 22, No. 6, pp.4361–4378.

Tunji-Olayeni, P., Kajimo-Shakantu, K. and Osunrayi, E. (2020) 'Practitioners' experiences with the drivers and practices for implementing sustainable construction in Nigeria: a qualitative assessment', *Smart and Sustainable Built Environment*, Vol. 9, No. 4, pp.443–465.

USGBC (2003) *Building Momentum: National Trends and Prospects for High-performance Green Buildings: Based on the April 2002 Green Building Roundtable and Prepared for the US Senate Committee on Environment and Public Works*, US Green Building Council, Washington, DC.

Wang, W., Zhang, S. and Pasquire, C. (2018) 'Factors for the adoption of green building specifications in China', *International Journal of Building Pathology and Adaptation*, Vol. 36, No. 3, pp.254–267.

World Green Building Council (WORLDGBC) (n.d.) *Green building & the Sustainable Development Goals* [online] https://www.worldgbc.org/sites/default/files/resource/WorldGBC%20SDG%20Graphics%20-%20Portuguese.pdf (accessed 11 August 2021).

Yas, Z. and Jaafer, K. (2020) 'Factors influencing the spread of green building projects in the UAE', *Journal of Building Engineering*, Vol. 27, No. 1, p.100894.

Yin, B.C.L. et al. (2018) 'An evaluation of sustainable construction perceptions and practices in Singapore', *Sustainable Cities and Society*, Vol. 39, No. 2, pp.613–620.

Zaini, A.A. (2017) 'The drivers towards green construction – an empirical study in Malaysia', *Journal of Engineering and Applied Sciences*, Vol. 12, No. 4, pp.814–818.

Zhang, X., Shen, L. and Wu, Y. (2011) 'Green strategy for gaining competitive advantage in housing development: a China study', *Journal of Cleaner Production*, Vol. 19, Nos. 2–3, pp.157–167.

Zhao, D. et al. (2019) 'Framework for benchmarking green building movement: a case of Brazil', *Sustainable Cities and Society*, Vol. 48, No. 7, pp.101545–101556.

Zhao, X., Pan, W. and Lu, W. (2016) 'Business model innovation for delivering zero carbon buildings', *Sustainable Cities and Society*, Vol. 27, No. 11, pp.253–262.

Zhao, X., Pan, W. and Lu, W. (2016) 'Business model innovation for delivering zero carbon buildings', *Sustainable Cities and Society*, Vol. 27, No. 11, pp.253–262.

Appendix

Table A1 Equivalence of questions related to factors

Question		*Driver*	*Barrier*
1	If there were market-based financial incentives, I would feel encouraged to apply the principles of sustainability in the projects I participate.	• Financial and market-based incentives	• Higher upfront and transaction costs • Limited funding/lack of financial incentives • Long payback period • Uncertain costs of the development of sustainable buildings
2	The reduction of operating costs encourage me to apply the principles of sustainability in the projects in which I participate.	• Reduced life costs/lower life cycle costs	
3	If there were gross floor area concessions for sustainable projects, I would feel encouraged to apply the principles of sustainability to the projects I participate.	• Gross floor area concessions	
4	If the prices of sustainable materials were competitive in relation to traditional materials, e.g., if the investment in sustainable materials was equal to that of conventional materials, I would feel encouraged to apply the principles of sustainability in the projects I participate.	• Reduced prices of sustainable building materials	• Lack of available and reliable suppliers/inadequate supply chain for sustainable materials
5	If there were efforts to raise awareness about the preservation of the environment and to disseminate the knowledge of the different options of sustainable materials and systems among the public, I would feel stimulated to apply the principles of sustainability in the projects I participate.	• Raising public environmental awareness	• Low public awareness of environmental issues/sustainable projects
6	If there were better information sharing about sustainable projects and their benefits, I would feel encouraged to apply the principles of sustainability in the projects I participate.	• Better information sharing about sustainable projects and their benefits	• Inadequate, untested, or unreliable sustainable materials, products, or systems • Lack of platforms to disseminate and demonstrate new sustainable technologies • Faulty market information • Unclear definition of sustainable buildings
7	If there were incentives for research and education in sustainable building technologies and methods, I would seek to update and deepen my understanding of this market with greater commitment.	• Incentives for research and education in sustainable building technologies and methods	• Lack of knowledge regarding sustainable technology operations
8	If there were free technical assistance or some type of funding/financial aid for the involvement of sustainability consultants in projects, I would feel encouraged to apply the principles of sustainability in the projects I participate.	• Provide technical assistance for the development of sustainable practices/funding to promote the involvement of sustainability consultants in projects	• High costs of training the workforce with expertise in sustainable buildings • Inadequate technical and institutional capabilities/shortage of skills/lack of knowledge/lack of training and education of project staff and contractors/lack of local institutes for sustainable building research • Lack of development of private entities focused on sustainable projects to encourage sustainable construction
9	I believe that the government and competent bodies should develop stricter legal requirements regarding the sustainable performance of projects (legislation, mandatory standards, inspection, and monitoring).	• Legislation and mandatory standards for sustainability practices	• Inconsistent government policies/lack of legislation/lack of government incentives/insufficient policy implementation efforts

Note: Questionnaire applied to professionals in the AEC sector.

Table A1 Equivalence of questions related to factors (continued)

Question		*Driver*	*Barrier*
10	If sustainable projects could go through a differentiated licensing/approval process, in city halls and competent bodies, and have the process facilitated/accelerated, I would feel encouraged to apply the principles of sustainability in the projects in which I participate.	• Accelerated licensing/approval process for sustainable projects	• Lack of consideration of sustainability criteria in the evaluation of bid proposals
11	If there were more involvement from local authorities and proactive and competent teams in promoting and implementing sustainability, I would feel encouraged to seek guidance and sustainable solutions to implement in the projects I participate.	• Existence and involvement of proactive and competent local authorities and teams in promoting and implementing sustainability	• Low importance attributed to sustainability by leaders and professionals in high positions
12	If fines and penalties were applied for non-compliance with sustainable practices, I believe that designers would prioritise the choice of sustainable solutions.	• Regulation with fines and penalties for non-compliance	• Lack of monitoring and enforcement
13	I consider important to include sustainability criteria in the evaluation of bidding proposals (public projects, PPP, etc.) and I believe that if sustainability criteria were mandatory for these projects, designers would prioritise the choice of sustainable solutions.	• Consideration of sustainability criteria in the evaluation of bid proposals	• Lack of consideration of sustainability criteria in the evaluation of bid proposals
14	Cost-sharing programs between project owners, government agencies and financial institutions and having a sense of reassurance about the return on investment would be encouraging incentives to apply sustainability principles to the projects I participate in.	• Risk-sharing programs between project owners, government agencies, and financial institutions	• Costs involved with monitoring and public dissemination on sustainable building activities and material use • High costs of sustainability certifications
15	I believe that sustainability certifications shed light on relevant sustainability parameters and drive sustainable construction. Therefore, the knowledge, training and dissemination of certifications would help and encourage me to apply their concepts in the projects I participate.	• Development and use of sustainability certifications	• Lack of clarity on the requirements and expected results of sustainability standards and certifications • Lack of standard technical procedures for sustainable construction Small current scale of sustainable buildings/lack of demonstration projects • Complexity and rigidity of requirements and standards/government bureaucracy • Lack of platforms to disseminate and demonstrate new sustainable technologies • Unavailability of standard methods for sourcing and purchasing sustainable materials
16	If there were recommendations and instructions for the effective implementation of sustainability practices, through institutions such as CAU* and CREA**, I would feel encouraged to apply the principles of sustainability in the projects I participate. * Brazilian Council of Architecture and Urbanism. ** Brazilian Regional Council of Engineering and Agronomy	• Availability of an institutional methodology for the effective implementation of sustainability practices/project specifications should consider sustainability	• Lack of clarity on the requirements and expected results of sustainability standards and certifications • Lack of standard technical procedures for sustainable construction Small current scale of sustainable buildings/lack of demonstration projects • Complexity and rigidity of requirements and standards/government bureaucracy • Lack of platforms to disseminate and demonstrate new sustainable technologies • Unavailability of standard methods for sourcing and purchasing sustainable materials

Note: Questionnaire applied to professionals in the AEC sector.

Table A1 Equivalence of questions related to factors (continued)

Question		*Driver*	*Barrier*
17	I consider building in a sustainable way is a personal commitment and/or moral imperative of mine, because taking care of the environment is also my responsibility.	• Personal motivations (moral imperative, personal commitment etc.)	
18	I believe that building in a sustainable way improves the image and reputation of my company and my projects.	• Company image and reputation	
19	I believe that building in a sustainable way generates more publicity and marketing for my company and my projects.	• Increased advertising and marketing through the media	• Limited social and cultural demand/lack of market interest
20	I believe that sustainability offers new market opportunities because there is a demand from clients for sustainable projects.	• New market opportunities/ customer demand	• Limited social and cultural demand/lack of market interest
21	I believe that building in a sustainable way demonstrates corporate responsibility.	• Corporate responsibility	
22	If there were awards and public recognition for sustainable projects, I would feel encouraged to apply the principles of sustainability in the projects I participate.	• Publicly recognise and reward users of sustainable practices	
23	I know how to improve the energy efficiency of a project.	• Energy efficiency	• Resistance to shift from using traditional technologies
24	I believe that the energy efficiency of a project results from the implementation of sustainable practices, so I consider this benefit to be a motivating factor for sustainable buildings.	• Energy efficiency	• Resistance to shift from using traditional technologies
25	I am aware of which project practices would be able to improve the users' quality of life	• Better quality of life	
26	I believe that sustainable projects would be able to improve the users' quality of life, so I consider this benefit to be a motivating factor for sustainable buildings.	• Better quality of life	
27	I am aware of what practices can be implemented to generate less waste.	• Reduction of waste	
28	I believe that sustainable projects generate less waste, so I consider this benefit to be a motivating factor for sustainable buildings.	• Reduction of waste	
29	I know how to improve the water efficiency of a project.	• Water saving	
30	I believe that sustainable projects save water, so I consider this benefit to be a motivating factor for sustainable buildings.	• Water saving	
31	I believe that opportunities for innovation and the development of new technologies in the field of sustainability can promote the adoption of sustainable buildings.	• Opportunities for innovation/ technology development	
32	Greater knowledge and availability of manufacturers and suppliers of sustainable products would encourage me to apply the principles of sustainability in the projects I participate.	• Manufacturers and suppliers that provide sustainable products	• Lack of available and reliable suppliers/inadequate supply chain for sustainable materials
33	I believe that sustainable projects have greater resilience to climate change.	• Increased resilience to climate change	

Note: Questionnaire applied to professionals in the AEC sector.

Table A2 Equivalence of the questions related to the factors

Question		*Driver*	*Barrier*
1	I know what global warming and climate change is.	• Raising public environmental awareness (workshops, seminars and conferences)	• Low public awareness of environmental issues/ sustainable projects
2	I know what sustainability is.	• .Raising public environmental awareness (workshops, seminars and conferences)	• Low public awareness of environmental issues/sustainable projects
3	I care about the preservation and sustainability of the environment.	• Raising public environmental awareness (workshops, seminars, and conferences) • Personal motivations (moral imperative, personal commitment etc.)	• Low public awareness of environmental issues/sustainable projects
4	I believe that the preservation and sustainability of the environment impacts my life.	• Raising public environmental awareness (workshops, seminars and conferences)	• Low public awareness of environmental issues/sustainable projects
5	I know what a sustainable building is.	• Raising public environmental awareness (workshops, seminars and conferences) • Better sharing of information about sustainable projects and their benefits	• Inadequate technical and institutional capabilities/shortage of skills/lack of knowledge/lack of training and education of project staff and contractors/lack of local institutes for sustainable building research • Low public awareness of environmental issues/sustainable projects • Lack of understanding of the operations of sustainable technologies • Faulty market information • Unclear definition of sustainable buildings
6	I would like to buy or rent a property that consumes less water and energy.	• Energy efficiency • Water saving	• Lack of available and reliable suppliers/inadequate supply chain for sustainable materials • Low public awareness of environmental issues/sustainable projects • Limited social and cultural demand/lack of market interest • Resistance to shift from using traditional technologies
7	I would consider buying sustainable housing if there were tax incentives, such as easy credit for purchase and financing, discounts on fees such as IPTU* and taxes in general. *Brazilian Urban Property and Territorial Tax	• Financial and market-based incentives • Risk-sharing programs between project owners, government agencies, and financial institutions • New market opportunities/customer demand	• Higher initial and transaction costs • Limited funding/lack of financial incentives • Inconsistent government policies/lack of legislation/lack of government incentives/insufficient policy implementation efforts • Faulty market information • Limited social and cultural demand/lack of market interest • Resistance to shift from using traditional technologies
8	I would consider buying a sustainable property, even if its purchase price was higher than a traditional property, if there were tax incentives, such as easy credit for purchase and financing, discounts on fees such as IPTU* and taxes in general. *Brazilian Urban Property and Territorial Tax	• Financial and market-based incentives • Risk-sharing programs between project owners, government agencies and financial institutions • New market opportunities/customer demand	• Higher initial and transaction costs • Limited funding/lack of financial incentives • Limited social and cultural demand/lack of market interest • Resistance to shift from using traditional technologies

Note: Questionnaire applied to the general public.

Table A2 Equivalence of the questions related to the factors (continued)

Question		*Driver*	*Barrier*
9	I would like to understand more about how I can help preserve the environment.	• Raising public environmental awareness (workshops, seminars, and conferences) • Personal motivations (moral imperative, personal commitment etc.)	• Inadequate technical and institutional capabilities/shortage of skills/lack of knowledge/lack of training and education of project staff and contractors/lack of local institutes for sustainable building research • Low public awareness of environmental issues/sustainable projects
10	I would like to have more information about sustainable projects and their benefits.	• Raising public environmental awareness (workshops, seminars, and conferences) • Personal motivations (moral imperative, personal commitment etc.)	• Inadequate technical and institutional capabilities/shortage of skills/lack of knowledge/lack of training and education of project staff and contractors/lack of local institutes for sustainable building research • Low public awareness of environmental issues/sustainable projects • Lack of understanding of the operations of sustainable technologies • Lack of development of private entities focused on sustainable projects to encourage sustainable construction • Small current scale of sustainable buildings/lack of demonstration projects • Lack of platforms to disseminate and demonstrate new sustainable technologies • Faulty market information
11	I am aware of the benefits of buying or renting a property that has a sustainability certification.	• Raising public environmental awareness (workshops, seminars, and conferences) • Development and use of sustainability certifications • Availability of an institutional methodology for the effective implementation of sustainability practices/project specifications should consider sustainability	• High costs of sustainability certifications • Low public awareness of environmental issues/sustainable projects
12	I consider that taking care of the environment is my responsibility.	• Raising public environmental awareness (workshops, seminars, and conferences) • Personal motivations (moral imperative, personal commitment etc.)	• Low importance attributed to sustainability by leaders and professionals in high positions • Low public awareness of environmental issues/sustainable projects
13	I know what the PROCEL* Certification/energy efficiency label for appliances is. *Brazilian National Electric Energy Conservation Program	• Raising public environmental awareness (workshops, seminars, and conferences) • Energy efficiency	• Inadequate technical and institutional capabilities/shortage of skills/lack of knowledge/lack of training and education of project staff and contractors/lack of local institutes for sustainable building research • Low public awareness of environmental issues/sustainable projects • Lack of understanding of the operations of sustainable technologies • Limited social and cultural demand/lack of market interest • Resistance to shift from using traditional technologies
14	Most of the appliances in my house have an A rating according to the PROCEL* Certification. *Brazilian National Electric Energy Conservation Program	• Energy efficiency	• Low public awareness of environmental issues/sustainable projects • Limited social and cultural demand/lack of market interest • Resistance to shift from using traditional technologies

Note: Questionnaire applied to the general public.

Table A2 Equivalence of the questions related to the factors (continued)

Question		*Driver*	*Barrier*
15	I would consider replacing my current appliances with ones that consume less energy if financial incentives were available for this purpose (easy financing and purchase discounts).	• Financial and market-based incentives • Energy efficiency • Risk-sharing programs between project owners, government agencies, and financial institutions	• Higher initial and transaction costs • Limited funding/lack of financial incentives • Long payback period • Limited social and cultural demand/lack of market interest • Resistance to shift from using traditional technologies
16	I would consider purchasing solar panels (solar energy production) to reduce my energy bill if financial incentives were available for this purpose (facilitating financing and purchase discounts).	• Financial and market-based incentives • Energy efficiency • Risk-sharing programs between project owners, government agencies and financial institutions	• Higher initial and transaction costs • Limited funding/lack of financial incentives • Long payback period • Limited social and cultural demand/lack of market interest • Resistance to shift from using traditional technologies
17	I believe that having green areas near my house improves my quality of life.	• Raising public environmental awareness (workshops, seminars, and conferences) • Better quality of life (health, comfort, and user satisfaction)	• Inadequate technical and institutional capacity/shortage of skills/lack of knowledge/lack of training and education of project staff and contractors/lack of local institutes for sustainable building research • Low public awareness of environmental issues/sustainable projects
18	I have considered/will consider matters of solar orientation (East/West) and natural ventilation when purchasing/acquiring my property (when either buying or renting).	• Raising public environmental awareness (workshops, seminars, and conferences)	• Inadequate technical and institutional capabilities/shortage of skills/lack of knowledge/lack of training and education of project staff and contractors/lack of local institutes for sustainable building research • Low public awareness of environmental issues/sustainable projects
19	I would separate the garbage in my house into organic and recyclable if my building and the city had selective collection every day.	• Reduction of waste	• Low importance attributed to sustainability by leaders and professionals in high positions • Low public awareness of environmental issues/sustainable projects • Limited social and cultural demand/lack of market interest • Resistance to shift from using traditional technologies
20	I would consider replacing the faucets in my house with ones that consume less water if financial incentives were available for this purpose (facilitating financing and purchase discounts).	• Financial and market-based incentives • Risk-sharing programs between project owners, government agencies and financial institutions • Water saving	• Higher initial and transaction costs • Limited funding/lack of financial incentives • Long payback period • Low public awareness of environmental issues/sustainable projects • Lack of understanding of sustainable technology operations • Limited social and cultural demand/lack of market interest • Resistance to shift from using traditional technologies

Note: Questionnaire applied to the general public.