Sustainable Construction Industry in Cambodia: Awareness, Drivers and Barriers

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Abstract: Although sustainability is of utmost importance, anecdotal evidence suggests that the concept is not adequately implemented in many developing countries. This paper investigates industry stakeholders' awareness of the current state of, factors driving, and barriers hindering the adoption of sustainable construction (SC) in Cambodia. Using an empirical questionnaire survey targeting local construction professionals, respondents were invited to rate their level of awareness, knowledge and understanding of SC, as well as to rate the level of importance of 31 drivers and 10 barriers identified from the seminal literature. The data set was subjected to the relative importance index method. The results suggest that the industry-wide adoption of SC practices is poor, which is believed to be due to a lack of awareness and knowledge, and reluctance to adopt new sustainable technologies. Furthermore, more efforts must be put into the selection of more durable materials for the extension of buildings' lives and to minimize material consumption, as well as to develop energy-efficient buildings with minimal environmental impact and a healthy indoor environment, so that the ability of future generations to meet their own needs will not be compromised. The outcomes of this study have enriched knowledge about the current state of, drivers of, and barriers to sustainable construction in a typical developing economy. Although the outcomes of this study were a short scoping exercise, it has formed a significant base for future SC work within Cambodia.

Keywords: sustainability; construction industry; Cambodia; drivers; barriers

1. Introduction

The construction industry makes a very significant contribution to the sustainable development of the overall economy by achieving basic objectives of development including employment creation, re-distribution, and the generation of output and income [1]. Furthermore, the construction industry helps by taking a significant role in satisfying basic social and physical needs, including the provision of infrastructure, the production of accommodation, and of consumer goods [2]. It has a highly visible output and stimulates a sizeable amount of economic growth through inter-sectoral linkages between construction and other sectors, giving it a powerful role in economic development [3]. The construction sector evidently has a strong relationship with sustainable development on the 'triple bottom line' of economic growth, environmental impact and social progress [4]. Therefore, the sector cannot be examined by only considering its impact on socio-economic development, but neither

should its environmental and social impact be disregarded [5]. The detrimental effect of the sector on the environment can be explained by the production of 35–40% of CO_2 emissions, 40% of raw materials and 25% of timber consumption, 40% of solid waste production, and it consumes 40% of total energy production and 16% of water usage worldwide [6,7]. Moreover, a sustainable construction industry plays a significant role in balancing human needs through the provision of a safe, healthy and physiologically comfortable building environment, which eventually will enhance human satisfaction and productivity [4].

According to Agenda 21 of the Sustainable Construction Industry in Developing Countries (SCIDC), sustainable construction is perceived to be a holistic and integrative concept striving to restore harmony and balance between the environment, economy and society [8]. The SCDIC definition implies that, initially, approaches to sustainable construction were more concerned with technical issues (resource efficiency and reducing the environmental impacts of construction) rather than the economic and social aspects of sustainability [9]. However, when it comes to developing countries, the adoption of even very basic aspects of sustainability are still in their infancy. For instance, developed countries have been focusing on efficient resource utilization and the reduction of their environmental impact, whereas developing countries have a lower degree of achievement (i.e., the non-existence of building energy codes), which makes the process of adoption challenging.

Drivers for a more sustainable construction industry and barriers to its implementation have received broad attention by researchers worldwide [10–12]. While some studies have presented models or frameworks towards the implementation of sustainability principles [4,13–18], other studies have proposed the benefits/drivers and constraints to a sustainable construction industry [5,6,12,19–21]. Egan [21] identified five key drivers, which are: project team; a quality driven agenda; process integration; leaders' commitment; commitment to people; and a focus on the client. He further quantified and presented seven targets for enhancing levels of sustainability. Also, Vanegas and Pearce [13] presented a framework to increase the sustainability of the construction industry and a road map for industry stakeholders to move toward sustainable infrastructure and facilities. Furthermore, the study identified drivers for change to achieve sustainability of the built environment, which are resource degradation and depletion, and stressed the noticeable influences of the construction industry environment on human health. In another study via case studies, Berardi [22] found that the stakeholders with power, who are uninterested, are the main barrier to the adoption of sustainable practices in construction projects. Lack of information and communication were found to be the reasons for stakeholders being reluctant to adoption. The study further recommends improving the relationship among the construction stakeholders. Albino and Berardi [23] studied three case studies and presented the significance of the integration between construction stakeholders, where a supplier's engagement and design team with special experience in sustainable practices are found to be most significant. From the construction project developers' perspective, Zainul-Abidin [11] investigated the level of knowledge and awareness about sustainable construction in Malaysia. The vast majority of developers were reluctant to implement sustainable construction concepts due to their lack of knowledge and cost concerns, and even amongst large project developers, few were adopting the concepts. In another study, Shen et al. [10] evaluated the feasibility reports of 87 projects in China with regard to their sustainability performance, environmental, economic and social aspects, in particular. The findings mainly revealed that the socio-economic aspect has received the least attention. Survey results of construction practitioners in Chile revealed that larger companies along with those involved in infrastructure projects were more aware of environmental aspects of sustainability, while those in the building sector had the lowest level of awareness [6]. Furthermore, a common problem among stakeholders was found to be a lack of knowledge about sustainability, where, surprisingly, developers were perceived to be the least knowledgeable in both sectors. Chew [24] provides a state-of-the-art review of the strategic thrusts promoted and implemented in Singapore, such as government support, legislation on research and development support, as well as the development of demolition protocols and a sustainable-construction capability development fund.

1.1. Problem Statement

A review of the relevant literature reveals that the status of the industry (in regards to sustainability) in developing countries is not promising, which is apparent from the low level of awareness and the lack of knowledge of its stakeholders. In fact, there is a similar picture in developed countries, as the focus in those countries is mainly on the economic aspects of sustainability [6]. The review also found that the main factors hindering implementation of sustainability in the construction industry are lack of education and training on sustainable construction (SC), technologies, capacities and, more importantly, policies for the development and successful implementation of sustainability practices. The conventional wisdom is that there is a long way to go to achieve a sustainable construction industry, and this process needs an input from all industry stakeholders; however, it is important to get a clear picture of the current situation as a starting point [8,11].

Despite the similarity in findings of previous studies worldwide, the situation in each country, due to its sui generis socio-economic-politic context, requires a particular diagnosis. The intention of this survey-based research is to investigate industry professionals' awareness of the current state of, and their experience-based feedback on the factors driving and hindering, sustainable construction in Cambodia. It is hoped that the outcomes of this study enrich knowledge about the current state of, drivers of, and barriers to sustainable construction in Cambodia and form a significant base for future SC work within the country.

1.2. Construction Industry in Cambodia

Cambodia is one of the developing countries located in South-East Asia, and has been a member of the Association of Southeast Asian Nations (ASEAN) since 1999 [25]. With an annual contribution of 9–10% to GDP, the construction industry is one of the main pillars of the Cambodian economy [25]. Moreover, the industry contributes to the country's employment creation, which accounts for 200,000 jobs per day [26], and the strengthening of allied sectors due to its strong linkages. Due to these achievements of the construction industry, it seems likely that the industry will continue to remain promising, and a driver of the country's economic development and appetite for overseas investors, particularly from the ASEAN region and China [27]. For instance, in comparison with 2015, the sector experienced a marked acceleration in the value of construction project approvals in 2016, which increased by 260% [28]. However, notwithstanding the construction industry's significant economic contribution, sustainability issues in the sector have attracted very little attention from industry practitioners, as the vast majority of construction projects are profit-indexed [29]. Although there are individual LEED (Leadership in Engineering and Environmental Design) awarded construction projects in the country (i.e., Vattanac Capital tower), the level of awareness of, and knowledge about SC is low, which affects the delivery of sustainable projects [29]. Therefore, this study aims to provide a snapshot view of sustainability awareness and knowledge in the Cambodian construction context. Moreover, it is hoped that the quantified drivers and recommendations for overcoming barriers from the viewpoint of industry stakeholders will be useful for the successful implementation of sustainability issues.

2. Literature Review

Sustainability has become such a buzzword, which was defined simply by Pearce [30] as lasting or in perpetuity. In the current body of knowledge, the perception of sustainability is that it only concerns environmental protection [31]. However, other elements of sustainability, which are economic and social, cannot be disregarded and, therefore, in order to keep a balance between the three elements the concept of sustainability should be considered as a holistic and integrative approach [8]. As the construction industry provides various physical facilities (e.g., dams, roads, bridges, residential and commercial buildings, factories, recreational facilities amongst others), these have an impact on society, environment and economy. Therefore, the balance between the three elements of sustainability

plays a significant role in the construction industry compared to other industries, and it is strongly recommended that the industry's success must be considered based on the triple-bottom-line, rather than traditionally used measures focusing on time, cost and quality [32].

Various sustainability-assessment tools and methods have been introduced, particularly by advanced countries and a few developing ones, to assess the sustainability performance of buildings. For instance, in the UK, the Building Research Establishment Environmental Assessment Method (BREEAM) was the first method of rating, assessing and certifying the sustainability of buildings, based on an overall score of pass, good, very good, excellent and outstanding [5]. The Leadership in Energy and Environmental Design (LEED) assessment system, which was developed by the United States Green Building Council (USGBC), rates the sustainability of green buildings according to their design, construction and operation [33,34]. In Hong Kong, Building Environmental Assessment Method (BEAM) Plus is one of the green-building certifications. Compatible with internationally-renowned green-building certifications such as LEED and BREEAM, the original intent of BEAM Plus was to be a voluntary scheme for the assessment of buildings' environmental performance [35]. The International Initiative for a Sustainable Built Environment (iiSBE) developed the SBTool assessment method to rate the sustainability performance of buildings, which focuses on the environmental, economic as well as social aspects of sustainability [36]. Despite the significant impact of the construction industry on economic and social development, the extant literature and the existing sustainability assessment tools suggest that the bulk of the studies and methods on the subject focus on the environmental aspect of construction sustainability [5].

To find ways to implement sustainable construction, firstly it is important to identify possible drivers and constraining factors, so that frontline industry professionals (government authorities, contractors, project managers) can subsequently act upon them effectively. Identification of the factors (both negative and positive) influencing SC is crucial [37], and will facilitate the adoption of those that have a positive effect and in the elimination or control of those that have a negative effect. Thus, Table 1 depicts a snapshot of the studies conducted in different countries focused particularly on sustainability awareness, and the drivers/opportunities to achieve, and barriers hindering, implementation of SC practices. Additionally, it provides a robust backing from the literature to achieve the aim of this study, which is the quantification of those identified drivers and barriers, as well as measuring the awareness of sustainable construction among industry practitioners in Cambodia. This is particularly the case due to the fact that there is a dearth of notable research conducted on the subject in the Cambodian construction context; therefore, an international context is required to identify and adopt the drivers, and remove the factors that hinder implementation of sustainable construction.

Table 1. Overview of the literature on the drivers of, and barriers to, sustainable construction (SC).

Location	Reference	Findings
Korea	Whang and Kim [5]	Environmental: energy efficiency, indoor environmental quality, waste management, management, ecological environment. Economic: life-cycle cost, knowledge management, value for money in delivery, retention of skilled labour, innovation. Social: well-being, community, education/training, service quality, health and safety.
Canada	Ruparathna and Hewage [38]	Barriers: lack of consideration of sustainability criteria in the evaluation of bids, unavailability of standard methods for procurement, lack of knowledge of local conditions, lack of explicit statutory requirements that cover sustainable procurement.
Malaysia	Shafii et al. [9]	Barriers: lack of awareness on sustainable building, lack of training and education, the higher cost of sustainable building options, procurement issues, regulatory barriers, lack of professional capabilities/designers, disincentive factors for local material production, lack of case studies/examples.

Table 1. Overview of the literature on the drivers of, and barriers to, sustainable construction (SC).

Location	Reference	Findings
Chile	Serpell et al. [6]	Drivers: regulations, company awareness, corporate image, client demand, cost reduction, market differentiation, suppliers. Barriers: lack of financial incentives, designers work alone, economic needs of higher priority, environmental costs not included in the cost structure, governmental bureaucracy, lack of knowledge on sustainable technologies, lack of environmental concern, affordability.
Greece	Manoliadis et al. [39]	Drivers: energy conservation, waste reduction, indoor environmental quality, environmentally-friendly energy technologies, resource conservation, incentive programmes, performance-based standards, land-use regulations and urban-planning policies, education and training, re-engineering the design process, sustainable construction materials, new cost metrics based on economic and ecological value systems, new kinds of partnerships and project stakeholders, product innovation and/or certification, recognition of commercial buildings as productivity assets.
US	Ahn et al. [37]	Drivers: energy conservation, improving indoor environmental quality, environmental/resource conservation, and waste reduction. Barriers: first cost premium of the project, long pay-back periods from sustainable practices, tendency to maintain current practices, and limited knowledge and skills of subcontractors.
International experts' survey	Darko et al. [40]	Drivers: greater energy-efficiency of buildings, reduction in the environmental impact of buildings, greater water-efficiency of buildings, enhancement of occupants' health and comfort and satisfaction, good company image/reputation or marketing strategy, better indoor environmental quality.
Finland	Hakkinen and Belloni [41]	Drivers: development of the awareness of clients about the benefits of sustainable building, the development and adoption of methods for sustainable building requirement management, the mobilization of sustainable building tools, the development of designers' competence and team-working, and the development of new concepts and services. Barriers: steering mechanisms, economics, a lack of client understanding, process (procurement and tendering, timing, cooperation and networking), and underpinning knowledge (knowledge and common language, the availability of methods and tools, innovation).
Hong Kong	Lam et al. [42]	Factors: green technology and techniques, reliability and quality of specification, leadership and responsibility, stakeholder involvement, guide and benchmarking systems.
UK	Pitt et al. [43]	Drivers: client awareness, building regulations, client demand, financial incentives, investment, labelling/measurement, planning policy, taxes/levies. Barriers: affordability, building regulations, lack of client awareness, lack of business case understanding, lack of client demand, lack of proven alternative technologies, lack of one single labelling/measurement standard, planning policy.

3. Research Method

This study adopts a mixed-method approach, which includes an in-depth analysis of previous studies on the subject (a qualitative approach) for the identification of the drivers and barriers [6]; a descriptive survey method (Appendix A) for the data collection (a combined qualitative and quantitative approach) from industry stakeholders in Cambodia [44]; and statistical methods that are consistent with the nature of this study, which were used to quantify the collected data in order to prioritise the drivers and barriers in terms of their levels of impact [2].

Content analysis via a systematic literature review was conducted to initially identify and list the general drivers and barriers of SC in the Cambodian context. Table 1 depicts an overview of the literature on the subject worldwide. In addition, in order to assure consistency with the aim of this paper, a descriptive survey method comprising three stages was adopted to investigate a new country-specific set of constructs (drivers and barriers) [45]: the interview, pilot study and open-ended questionnaire.

The target population for the study comprised government representatives, project managers, architects, engineers, contractors and subcontractors in the Cambodian construction sector, as well as academics. The sampling frames of data collection comprised the Ministry of Land Management, Urban Planning and Construction (MLMUPC), the Board of Engineers Cambodia (BEC), Board of Architects Cambodia (BAC), Cambodia Constructors Association (CCA) and the Housing Development Association of Cambodia (HDAC), as they represent the bulk of the actors responsible for a sustainable construction industry. Initially, a convenience sample of two contractors, two architects, one project management consultant and two government representatives agreed to devote their time to participating in face-to-face interviews in order to explore drivers and barriers of SC in the Cambodian context, and to validate the relevance of the factors mainly sourced via the aforementioned content analysis. An open-ended questionnaire was then designed (based on the new constructs identified during the interviews). The questionnaire was divided into three parts. In the first part, the respondents were asked to provide details of their respective demographic backgrounds (i.e., position, length of experience, professional affiliation); the second part focused on measuring their level of awareness, knowledge, and understanding about SC; and the third part sought feedback from industry stakeholders on the drivers and barriers of SC, which were subsequently ranked according to their relevant importance index (RII).

Prior to the administration of the open-ended questionnaire survey, the relevance and clarity of these open-ended questions were pre-tested [46]. Only Cronbach's alpha at a minimum of 0.6 was accepted for this pilot study, following Hinton et al.s' recommendation [47]. A score of 0.875 was achieved for this study, allowing the collection of data via open-ended questionnaire survey. Consequently, during the open-ended questionnaire survey, the respondents were given an opportunity to include any further constraint(s) in the open-ended section of the questionnaire. Emails bearing a link to the online survey were circulated to potential study participants encouraging them to respond before the cut-off date set for receiving responses. Finally, the results were analysed and interpreted accordingly in order to achieve the aim of this paper.

4. Data Analysis

Data preparation is of crucial importance before starting the data analysis stage. This study adopted a Likert scale rating of influence level from 1 to 5 where 1 stands for "Very low" and 5 for "Very high" influence of the drivers and barriers collected via the web-based questionnaire survey. Once the data were prepared in a suitable form for the statistical package used, the next step of the research process adopted in this study was the analysis of the data. This study aimed to prioritise the identified drivers and barriers of SC in Cambodia according to their importance, using the RII method [48,49]. For each driver and barrier, the RII was calculated using Equation (1):

$$\text{RII} = \frac{\sum W}{(A \times N)} \tag{1}$$

where: W = weighting of each driver or barrier given by respondents; A = highest weight, which is 5 for this study; N = total number of respondents. Calculated RIIs range in value from 0 to 1 (0 not inclusive), indicating that the higher the RII, the more important was the driver or barrier.

Finally, for reliability analysis, which is particularly required when the items are used to form a scale (i.e., Likert scale), Cronbach's alpha (Cα) test was used to measure the internal consistency of the set of items forming the scale, which varies from 1.00 (the maximum value of reliability coefficient) to 0.6 (the minimum value of reliability coefficient) [50,51].

5. Results and Discussion

5.1. Survey Results

5.1.1. Demographic Background

The research was conducted between June 2017 and November 2017. Invitations (135 distributed) to participate in the questionnaire survey were sent to potential respondents. By the cut-off date set for the survey, it had been completed by 104 respondents representing companies operating in the architecture, engineering and construction (AEC) sector in Cambodia at various stages of project delivery, as well as government representatives. Table 2 tabulates the participant demographics for this study, where responses from contractors, architects and engineers accounted for 37%, 27% and 20%, respectively. Responses from project consultants and government authorities accounted for 12% and 5%, respectively. Preliminary analysis of the participant demographics showed that the respondents occupied high-ranking positions such as director or executive director, project managers and supervisors with an aggregated average of 6 to 18 years of work experience in the construction industry in Cambodia. The responses were therefore from those with higher status who are responsible for the implementation of sustainable practices in the construction industry.

Table 2. Demographic background of the respondents (*n* = 104).

Respondent	# of Responses	%	Length of Experience *	Affiliation
Contractor	38	37%	11	CCA
Architect	28	27%	7	BAC
Engineer	21	20%	6	BEC
Project consultants	12	12%	13	BEC
Government authority	5	5%	18	

* Average.

5.1.2. Awareness, Knowledge and Understanding of Sustainable Construction

Zainul-Abidin [11] claims that the adoption of SC practices starts with awareness, and that after awareness, knowledge can be a good catalyst in achieving adoption. Therefore, the first objective of this study was to gain an insight into the level of awareness and knowledge about the concept of SC. Respondents were asked to rate their level of awareness (from 0% = not at all aware to 100% = extremely aware) and knowledge (from 0% = no knowledge to 100% = extremely knowledgeable) on SC. It can be seen in Figure 1 that the awareness level of sustainable construction among the respondents ranges between 23% and 5%, which is relatively low. Similarly, the level of knowledge of sustainable construction among the stakeholders is not also promising, which ranges from 27% to 52%. This finding is not surprising as the level of implementation of SC practices in Cambodia overlaps with the level of awareness and knowledge. In his study, Brown [52] identified that a lack of awareness and knowledge on sustainability is one of the factors hindering the implementation of SC practices in the construction industry. It is possible the reason behind the lack of awareness and knowledge could be the lack of concrete, explicit regulations [38] or lack of expressed interest from clients [37]. Furthermore, this finding from the survey is justified by a review of the literature on the subject, which suggests that the low level of knowledge and awareness on the concept of SC is not very different in other developing countries [6].
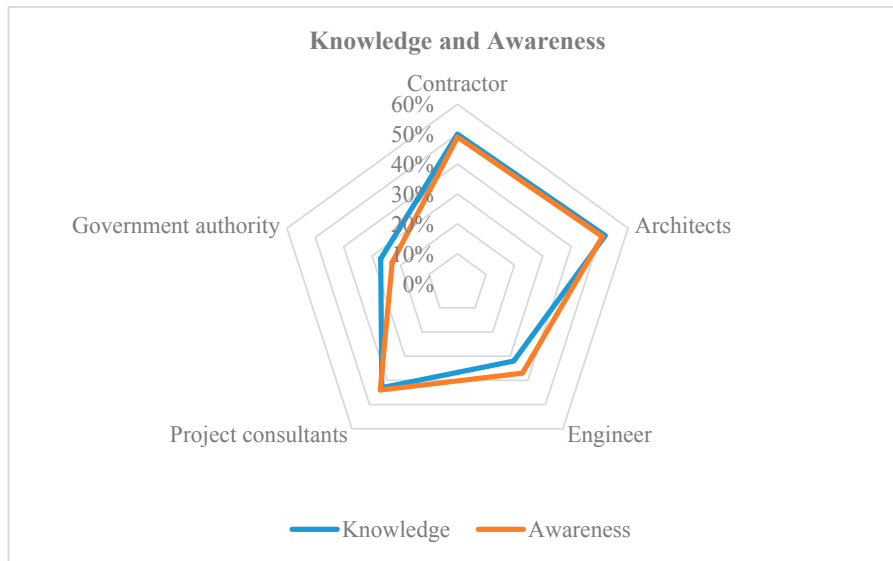
Figure 1. Respondents' levels of awareness and knowledge of SC.

As part of the survey, the respondents were additionally asked to select statement that best fit with their understanding about SC. The statements were written based on the three pillars of sustainable construction: environment; economic, and social issues [4], which are depicted by Figure 2. Statements '*to protect the environment*' and '*efficient use of natural resources*' received the highest percentage of 81% and 72%, respectively, which are both related to the environmental aspect of sustainability. This finding is not surprising, as it is self-evident that the word sustainability has been promoted as environmental awareness or protection of our environment [53]. While the statements related to the social aspect of sustainability, which are '*life quality*' and '*progress in social life*' received moderate percentages of 67% and 51%, respectively, issues related to the economic aspect, which are '*maintains economic growth*' and '*profit-generation without compromising the future needs*' received the lowest percentages of 49% and 43%, respectively. The low percentages of the economic-related issues reveal that the respondents do not know the economic consequences of a sustainable construction industry, which is unsurprising as sustainability has not been discussed at the sectoral level that much [30], particularly in developing countries [6].
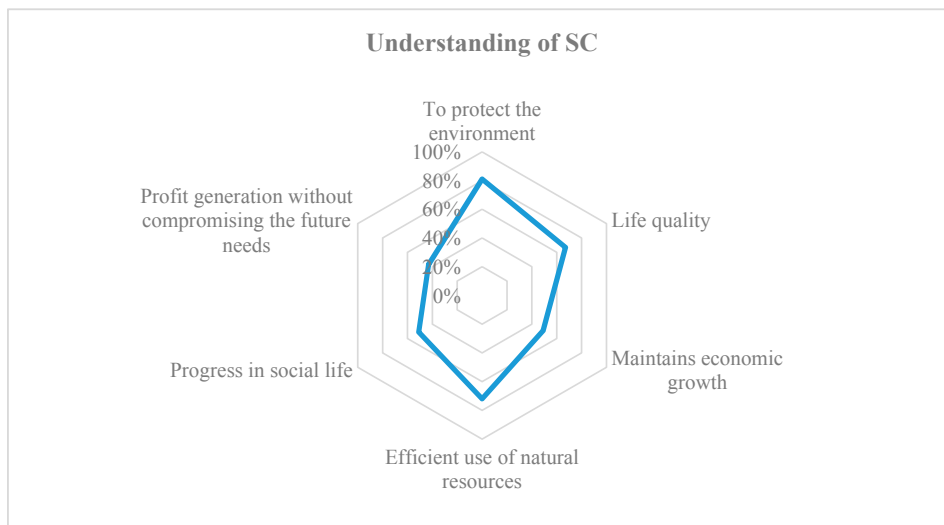

Figure 2. Perceived understanding of SC.

5.2. Drivers of Sustainable Construction

The second objective of this study was to rank the factors, which are believed to be the drivers of the implementation of sustainable construction in Cambodia. The RII method was utilized to rank the drivers of SC under each sustainability pillar (environmental, economic and social), which were identified through a rigorous review of the relevant literature, together with interviews with construction professionals in Cambodia. The following sub-sections present results of the data analysis and discussion on the outcomes of the analytical techniques adopted in this study. However, only the five most significant ranked drivers are considered, as suggested by Durdyev and Ismail [2], thus are further discussed in the following sub-sections.

5.2.1. Environmental Drivers

Table 3 shows the RII of 10 factors, which were identified through a review of the literature, to be environmental drivers of sustainable construction in Cambodia. In addition, SPSS-based results of $C\alpha$ (0.816) show internal consistency between the items within the category [54]. The results clearly show that the respondents perceive the environmental drivers are significant, as the lowest mean score is slightly over 3.50. This finding aligns with the previous discussed results of the respondents' understanding of SC, where the environment-related statements received the highest percentage. Moreover, it has been proven that the construction industry is responsible for a large proportion of carbon-dioxide emissions worldwide, as well as the consumption of energy reserves and natural resources [55], which has an extremely detrimental impact on the environment. Another significant issue worthy of note is that there is not much difference between the perceived ratings of the different environmental drivers, which shows the significance of each individual item under this category.

With an RII of 4.10, the most important environmental driver of SC is perceived to be '*resource conservation*'. This result is justified, as the annual resource consumption of the construction industry worldwide accounts for 40% of the gravel, sand and stone, 25% of the timber and 16% of the water used [56], which makes the construction industry very resource intensive. This finding is consistent with previous findings of Akadiri et al. [57], who described it as achieving more with less, and identified the driver as one the objectives to best achieve the concepts of sustainability in the building sector. Halliday [58] states that the use of stocks of certain resources (material, energy, land and water), which are frequently consumed by the construction industry, should be treated cautiously as their availability is becoming extremely limited. Substitution of those materials with, preferably, renewable ones was recommended, or at least with less-scarce resources. Hence, the use of local supplies and materials, particularly those with low embodied energy [57] to minimise the dependency on imported materials, design for construction, and lifecycle design [59] to minimise material wastage, are some of the initiatives pursued in other countries to create ecologically sustainable buildings, which could be implemented in the Cambodian context.

'*Greater energy efficiency*' ranked as the second most important environmental driver (RII = 3.96) for SC in Cambodia, which is not surprising, as the construction industry is the most dominant energy consumer [60]. Energy consumption by the construction industry in Organization for Economic Co-operation and Development (OECD) countries, which is about 25–40% of total energy consumed, is clear evidence of the dominancy of the sector in this regard [61] and justifies the significant ranking of the driver. Despite its rapid population growth and dynamic economic development, Cambodia is experiencing macro-economic instability, particularly in the monetary domain. The net effect of these factors is due to the rapid growth in demand for energy in Cambodia, but the improvements necessary to compensate for the growing demand do not seem to be occurring at the desired pace [62]. However, meeting energy demand in the country is of strategic importance, and so promotion of energy efficiency and conservation in Cambodia via the implementation of SC practices is vital, particularly to achieve reductions in electricity demand in the construction sector. Consideration of the optimum insulation for buildings in Cambodia is recommended, as almost none of them are insulated and, therefore, energy demand is assumed to be higher than for insulated buildings. Despite its initial

cost, insulation materials are proven to be a significant cost-saving solution by reducing the energy demand of commercial and residential buildings. Furthermore, the implementation of energy-efficiency technologies and energy generation from natural (renewable) resources is recommended. Ultimately, it is hoped that conservation of energy will reduce Cambodia's dependency on imported energy.

Table 3. Relative importance index (RII) of environmental drivers of sustainable construction.

Environmental Drivers (Cα = 0.816)	RII	Rank	Reference
Resource conservation	4.1	1	Dimoudi and Tompa [56]
Greater energy efficiency	3.96	2	Darko et al. [63]
Reduces the environmental impact of buildings	3.85	3	Sev [4]
Improving indoor environmental quality	3.83	4	Darko et al. [40]
Waste reduction	3.83	5	Wong et al. [64]
Land-use regulations and urban planning policies	3.71	6	Ahn et al. [37]
Sustainable construction materials	3.68	7	Sev [4]
Ecological environment	3.62	8	Akadiri et al. [57]
Greater water-efficiency of buildings	3.59	9	Ahn et al. [37]
Environmentally-friendly energy technologies	3.51	10	Chan et al. [65]

Besides being the most energy-consuming end-user, buildings are the major source of both direct and indirect carbon emissions, which has a detrimental impact on our living environment [4]. This justifies the third significant driver '*reduces the environmental impact of buildings*' rated by the respondents. As previously mentioned, the construction industry is one of the most significant contributors to the detriment of the environment, producing large amounts of CO_2 emissions and solid waste, 40% of raw materials, and 25% of timber consumption, and consuming 40% of total energy production and 16% of water usage worldwide [6]. Therefore, the adoption of green building practices or technologies (one of the drivers perceived to be significant with an RII = 3.51) in the construction industry has become strategically necessary to reduce carbon emissions and energy shortages, particularly in developing countries [65]. This driver was followed by '*improving indoor environmental quality*' which was perceived by respondents to be the joint fifth most significant driver. This result aligns with the findings of Ahn et al. [37], where both drivers have been ranked within the top 5 drivers of SC. They claimed that indoor quality of buildings is significant in providing healthy conditions and ensuring the occupants' well-being, as in our modern society, we spend more than 70% of our time indoors [4]. This finding further aligns with the rankings of the drivers under the social category of SC (Table 5), where '*well-being*' and '*health and safety*' are perceived to be the most significant drivers. Receiving the same rating from the respondents, '*waste reduction*' was believed to be driven by the successful implementation of SC practices. This is not surprising, as SC practices promote the use of pre-fabricated building components and adopt modular coordination techniques in construction projects, which avoids measuring and cutting on site [4]. Other factors, which are '*land use regulations and urban planning policies*' [37], '*sustainable construction materials*' [4], '*ecological environment*' [57], and '*greater water-efficiency of buildings*' [37], were perceived to be important in driving change in the construction industry towards the implementation of sustainable practices.

5.2.2. Economic Drivers

As previously mentioned, construction practitioners' perceptions of SC is mainly towards environmental issues. Although the adoption of SC practices is believed to have high initial cost [37], their benefits can be seen in the long-term, for instance the reduced cost of operation and maintenance during the facility's lifecycle [57]. Therefore, the economic aspect of SC practices cannot be disregarded. On this issue, the respondents were asked to rate the economic drivers of SC, and their respective RIIs are tabulated in Table 4. The SPPS-based result of Cα of 0.761 confirms the internal consistency among the economic drivers of SC [51].

Table 4. RII of economic drivers of sustainable construction.

Economic Drivers (Cα = 0.761)	RII	Rank	Reference
Value for money in the delivery	3.58	1	Whang and Kim [5]
Retention of skilled labour	3.51	2	Whang and Kim [5]
Lifecycle cost	3.31	3	Sev [4]
Construction cost efficiency	3.28	4	Akadiri et al. [57]
Quality management for durability	3.27	5	Sev [4]
Innovation/R & D	3.23	6	Chan et al. [65]
Profitability/Productivity	3.23	7	Nahmens and Ikuma [66]
Image and reputation	3.22	8	Serpell et al. [6]
Commercial viability	3.17	9	Whang and Kim [5]
Cost of operation and maintenance	2.82	10	Ahn et al. [37]
Knowledge management	2.71	11	Whang and Kim [5]
Competitive industry	2.65	12	Wong et al. [64]
Support of local economy	2.54	13	Pearce [30]

The relatively lower RII values of the economic drivers compared to the environmental drivers supports the previous finding of this study, where the respondents demonstrated their tendency to have a higher level of understanding towards the environmental drivers of SC. '*Value for money in the delivery*' and '*retention of skilled labour*' are pioneering drivers that received the two highest ratings from the survey participants, which is consistent with the findings of Whang and Kim [5]. The results reveal that the respondents' expectations of, and focus on SC practices is short-term, as the majority of long-term drivers received lower ratings. The higher ratings of '*construction cost efficiency*' and '*quality management for durability*' drivers compared to '*profitability/productivity*' reinforces the short-term expectations of the respondents from SC. It is believed that SC practices will enhance construction productivity on a long-term basis [66], and enhanced productivity drives faster delivery of construction projects with lower cost and higher quality [45,54]. Another finding worthy of note is that drivers such as '*competitive industry*' and '*support of local economy*' received relatively lower ratings, which suggests that the feedback was biased towards the opinions of the professionals at the project level. Finally, despite being one of its long-term benefits [37], '*cost of operation and maintenance*' ranked among the lowest drivers, which reaffirms the recognition of SC practices among the industry practitioners.

5.2.3. Social Drivers

The respondents were asked to rate the drivers under the social pillar of SC, which are presented in Table 5. The Cα of 0.71 further confirms the internal consistency between the social pillars of SC [51]. Compared to the other pillars of SC, social drivers received the lowest ratings on average, which clearly shows the respondents' lack of understanding and knowledge about the correlation between the social drivers and the concept of SC, or the social benefits of SC implementation. This finding is also consistent with the findings depicted by Figures 1 and 2.

Table 5. RII of social drivers of sustainable construction.

Social Drivers (Cα = 0.710)	RII	Rank	Reference
Well-being	3.5	1	Akadiri et al. [57]
Health and Safety	3.48	2	Sev [4]
Culture/heritage	3.35	3	Whang and Kim [5]
Employment	2.74	4	Ofori [67]
Partnership working	2.46	5	Ahn et al. [37]
Service quality	2.46	6	Zainul-Abidin [11]
Security	2.41	7	Whang and Kim [5]
Community	2.32	8	Ahn et al. [37]

Unfortunately, in current building design practices the social aspects of sustainability have been disregarded, or in other words buildings are not designed for humans [57], which affects '*well-being*' (ranked as the highest driver of SC), '*health and safety*' (the second highest driver of SC), physiological comfort and satisfaction, and consequently the productivity of an occupant. In this regard, the selected construction material or preferred design can be energy efficient, cost effective and perform well; however, it should not be considered as a sustainable product or design if it does not provide sufficient comfort for, and improve productivity of the occupant [11]. The driver '*Culture/heritage*' ranked as the third most significant in this category of SC, which confirms the findings of Sev [4]. Although cultural resources are important in transmitting knowledge to the next generation, as far as the authors are aware, in the majority of buildings around the country this issue has been disregarded. Clear evidence of this is that overseas construction investors bring their own designs without taking into account the values of the Khmer culture; however, it is believed that a building design contrary to the urban context will eventually damage the existing cityscape and skyline [4]. An in-depth review of the literature on the subject reveals that only studies from the architectural point of view have considered the cultural aspect to be a driver of SC, while from the contractors' point of view it was disregarded. This clearly indicates that there is disagreement among industry stakeholders on the drivers of SC. Thus, sustainable building design is expected to provide healthy, safe and comfortable indoor conditions while protecting the nature and the cultural heritage of a country. While the perceived less significant social drivers of SC were '*employment*', '*partnership working*', '*service quality*', '*security*', and '*community*', this does not necessarily mean that they can be disregarded. However, this finding shows the misunderstanding of the long-term impact of SC concepts among the respondents. For instance, it has been asserted that successful implementation of SC practices will generate employment growth within a country [67].

5.3. Barriers to Sustainable Construction

Despite the increasing demand for more sustainable construction practices, factors hindering its implementation still exist, which warrants further exploration. Research on the barriers to the implementation of SC practices has gained worldwide attention [37,55,65,68]; however, there is a dearth of studies on the subject from developing countries in the relevant literature [69]. Therefore, this study has identified and ranked the barriers to SC according to their importance level as perceived by industry professionals in Cambodia. Table 6 shows the barriers to SC identified from the literature and their respective rankings. The results reveal that all the barriers are perceived to be significant for successful adoption of SC practices, while the Cα of 0.825 confirms the internal consistency between the items within the category [51].

'*The higher cost of sustainable building option*' barrier was perceived to be the most significant among other barriers to SC in Cambodia. This result reaffirms an element of bias in the perceptions of industry practitioners in SC practices, despite clear evidence that it is possible to procure sustainable buildings without significantly higher initial costs, which is in fact consistent with the outcomes of many studies worldwide [9,37,70–72]. The ranking of the barrier '*long pay-back periods from sustainable practices*' reveals the reluctance of construction companies to invest in environmentally, economically and socially sustainable designs/projects in Cambodia. Furthermore, this result reaffirms the short-term expectations of industry practitioners previously discussed in the economic driver sub-section of this paper.

Table 6. Barriers to implementation of sustainable-construction practices.

Barriers (Cα = 0.825)	RII	Rank	Reference
The higher cost of sustainable-building option	4.17	1	Qian et al. [68]
Lack of government incentives	4.14	2	Chan et al. [65]
Economic needs of higher priority	4.05	3	Serpell et al. [6]
Lack of statutory requirements that cover sustainable procurement	4.00	4	de Souza Dutra et al. [73]
Lack of professional capabilities/designers	3.97	5	Chan et al. [65]
Lack of client demand	3.97	6	Swarup et al. [74]
Lack of training and education	3.88	7	AlSanad [55]
Long pay-back periods from sustainable practices	3.77	8	Ahn et al. [37]
Tendency to maintain current practices	3.73	9	AlSanad [55]
Lack of environmental concern	3.61	10	Serpell et al. [6]

'*Lack of government incentives*' was rated the second most significant barrier, which is justified as it is believed that government's role in promotion of SC practices is unquestionably important [65]. For the adoption of SC practices it is important to promote among, and motivate the industry stakeholders, particularly in Cambodia where SC is in its infancy. To the authors' knowledge there are no government incentives that would trigger the adoption of sustainable-building practices, which perhaps justifies the perception of the respondents towards this barrier. Further, the fourth ranking of the hindering factor of SC, '*lack of statutory requirements that cover sustainable procurement*' reinforces the previous finding of the study, which is in agreement with the outcomes reported by de Souza Dutra et al. [73].

The ranking of third most significant barrier for '*economics needs of higher priority*' [6], implies that sustainability among industry practitioners is not seen as a priority, particularly the social and environmental pillars. This finding, therefore, correlates with the barrier '*tendency to maintain current practices*' [37], which inhibits the implementation of SC practices in Cambodia. The reason for this finding seems to be due to the lack of awareness and knowledge about the SC concept; indeed, it would seem that the current practices of project procurement employed in Cambodia satisfy industry stakeholders.

'*Lack of professional capabilities/designers*' is perceived to be the joint 6th most significant barrier to the adoption of SC practices. This result aligns with the finding of AlSanad [55] and Chan et al. [65] that a lack of skilled professionals limits the implementation of SC practices. This perception is valid, as the majority of construction professionals are unfamiliar/inexperienced with SC practices, and those (very few) who are familiar with SC are either from neighbouring countries, or local professionals educated overseas. It is clear that the country is lacking in the expertise necessary for the uptake of SC, and tertiary education currently remains focused on conventional methods of construction, rather than providing knowledge of SC practices for the future. '*Lack of client demand*' ranked as the other joint 6th most significant barrier to be overcome for successful adoption of SC practices in Cambodia. The relative importance of this barrier aligns with the outcomes reported by Korkmaz et al. [75]. Also, Serpell et al. [6] reported that client demand has a significant influence on encouraging practitioners to implement SC practices on their projects. Furthermore, Swarup et al. [74] identified that clients' strong and continuous commitment towards sustainable practices has an important impact on the achievement of sustainability goals. Although '*lack of training and education*' was ranked 7th among the barriers to SC, the general consensus [6,11] is on the criticality of this barrier in overcoming the aforementioned hindering factors, and in further improving the understanding of '*environmental concern*' among industry practitioners at various levels of responsibilities. The government's support via educational institutions would be beneficial for further improvement of the awareness and knowledge of sustainable-construction practice among future construction professionals.

6. Conclusions

The popularity of sustainable practices has grown over the last decade; adoption levels are increasing and seem set to continue as long as the barriers to its adoption are overcome. Successful

implementation of sustainability principles worldwide have demonstrated the significance of the concept for the reduction of the construction industry's detrimental impact on our environment and social life, as well as sustaining continuous economic contribution. However, notwithstanding its contribution to socio-economic development, unfortunately the implementation of sustainable construction practices in Cambodia does not look promising, which would undoubtedly seem to be the only solution to current and future problems concerning the environment, economy and social life. Although known for its benefits, such as energy and resource conservation, cost efficiency, well-being, consistent quality and health and safety, the adoption of SC at the level it deserves is not easy due to industry- or country-specific barriers. Moreover, rather than focusing on general benefits or barriers, priority must be given to those which fit well with local conditions or are of utmost significance. To this end, being the first work undertaken in the Cambodian construction context, the authors' intention for this survey-based study was to investigate industry practitioners' awareness, knowledge and understanding to develop a picture of the current state of SC, as this is believed to be the stepping stone for successful SC adoption. Furthermore, significance levels of the drivers of, and barriers to, SC were quantified, to encourage widespread implementation of SC practices and to discover strategies to overcome those barriers to successful adoption of the concept in Cambodia.

A questionnaire survey was designed to ask industry stakeholders' viewpoints regarding SC, and to prioritise 31 driving and 10 hindering factors of the adoption of SC principles, which are reported in the relevant literature. Only 104 usable responses (of 135 distributed) were received from construction professionals in Cambodia by the cut-off date set for the survey. Collected data from the respondents using linguistic terms as very low, low, moderate, high and very high for the drivers and barriers, were expressed numerically using a Likert scale. The relative importance index method was further used to quantify the significance level of each identified driver and barrier.

The findings suggest that the level of industry-wide adoption of SC practices is poor, which is believed to be due to the legislative or stakeholder-related factors, namely lack of legislative requirements, lack of education focusing on sustainability, lack of awareness and knowledge, and reluctance to adopt new sustainable technologies. Thus, the first implication of this study for decision makers is to enable a legal and policy environment that will facilitate the achievement of sustainable development through sustainable-construction practices, where government plays significant role. Along with effective enforcement of these policies, it is essential to improve the knowledge and understanding about sustainable practices among the industry stakeholders. Early stage and long-term sustainability awareness and knowledge could be achieved through regular training, seminars and workshops, and more importantly incorporating the concept of sustainability into the higher education curriculum. Moreover, incentives to promote sustainability among practitioners and investors would be crucial, particularly financial incentives for the companies willing to adopt sustainable practices in their projects.

The results of statistical analysis showed that the top 5 environmental drivers were also pioneers among the other pillars of SC in Cambodia, which are resource conservation, greater energy efficiency, reduces the environmental impact of buildings, improving indoor environmental quality, and waste reduction. This result indicates that more effort must be invested in the selection of more durable materials for the extension of buildings' lives and for minimal material consumption. Furthermore, it is essential to develop energy-efficient buildings with minimal environmental impact and a healthy indoor environment; hence, the ability of future generations to meet their own needs will not be compromised.

Despite the factors driving the implementation of SC practices, barriers to SC practices still exist and have been evaluated in this study. The top 5 rated barriers were the higher cost of the sustainable-building option, lack of government incentives, economic needs of higher priority, lack of statutory requirements that cover sustainable procurement and lack of professional capabilities/designers. Although it was not listed as one of the barriers (to avoid duplication), the low level of awareness should be considered as the leading barrier to the adoption of SC practices,

particularly in countries where SC adoption is in its infancy. However, it is worth pointing out that the top barriers are due to the economic concerns of the stakeholders, which reinforces their lack of knowledge about the concept. Moreover, this study reaffirms that the high cost of sustainable practice is perceived to be the most hindering factor worldwide regardless of the socio-economic status of the country.

The findings of this study have enriched knowledge about the current state of, drivers of, and barriers to sustainable construction in a typical developing economy setting. Although the outcomes of this study were a short scoping exercise, it has formed a significant foundation for future SC work within Cambodia. Due to the lack of available information, this study did not provide data on the extent of SC practices in Cambodia. However, the scope of the findings is sufficient to draw a picture of the lack of SC adoption and implementation in the country and report that the drivers are strong enough to motivate policy makers and industry stakeholders to address the barriers and invest in overcoming them. Efforts to overcome these barriers would provide impetus for significant SC adoption and implementation of its benefits, and consequently promote the adoption of SC practices in Cambodia.

Although the study objectives were achieved, further investigation based on a larger sample size of practising professionals is recommended. It is further recommended that feedback from construction clients is obtained in future research, as these clients are key influencers of decisions and outcomes in the project-delivery process.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. The Questionnaire Survey Sample

Part II

Using the 5-point rating scales provided, please rate the level of importance of each item based on your experience? It will be appreciated if you could also suggest other items that have not been included in the list which may drive the sustainable-construction industry in Cambodia.

Table A1. Level of importance: 5 = Very High; 4 = High; 3 = Moderate; 2 = Low; 1 = Very Low.

Drivers of Sustainable-Construction Industry		Level of Agreement					No Idea
		5	4	3	2	1	
Environmental							
1	Resource conservation						
2	Greater energy efficiency						
3	Reduces the environmental impact of buildings						
4	Improving indoor environmental quality						
5	Waste reduction						
6	Land-use regulations and urban planning policies						
7	Sustainable-construction materials						
8	Ecological environment						
9	Greater water-efficiency of buildings						
10	Environmentally-friendly energy technologies						
Other environmental drivers? Please list and assess:							

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