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Article

Roles of stakeholders for adopting sustainable design in buildings

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Abstract: Buildings account for the highest carbon dioxide emissions during their operation stage, primarily due to high energy use for heating, cooling, and lighting, which in turn contribute to global warming and climate change. Such impact can be considerably reduced through crafting sustainable design (SusD) in buildings. So, availability of relevant information, professional guidance to clients, and appropriate decision-making are crucial. A study summarized the findings from a questionnaire survey conducted in Brunei with 122 responses. The results revealed that architects, consultants, and government are more important stakeholders to assist with SusD adoption, while clients and developers are important stakeholders in decision-making. The results appreciate the roles of clients and architects to a higher degree, despite a comparatively higher number of private projects in Brunei with relatively more influence of contractors. This was interpreted as having a good degree of awareness of the survey participants towards the role of SusD and who actually can better contribute to SusD adoption. However, the outcome also revealed inconsistent perception among the respondents, both within and between different groups based on their affiliations and nature of job. This inconsistency implies the need for appropriate training or education to enhance awareness of SusD, make pertinent information available, and develop appropriate skills.

Keywords: buildings; carbon dioxide emissions; energy consumption; sustainable design

1. Introduction

The construction industry is blamed for its adverse impact on the natural environment [1], owing to high energy consumption and environmental pollution [2]. Buildings account for a large proportion of these, which are rapidly increasing due to the increase in population, extended building use, and demand for comfort and satisfaction. As a result, global greenhouse gas (GHG)/ carbon dioxide (CO_2) emissions throughout the building life cycle are also increasing, which has been estimated to reach 42.4 billion tonnes/year by 2035, 43% more than the 2007 level [3]. This is considered one of the key reasons for global warming and climate change. It is reported that 80%–90% of such emissions occur during the building operation stage, mainly due to energy use for space heating and cooling, lighting, and other applications. Such energy use and relevant GHG emissions can be considerably reduced by adopting various energy efficiency measures and sustainable design approaches at the design stage [4–6].

Sustainable design (SusD) uses two natural elements (i.e., the sun and wind) and focuses mainly on reducing energy consumption and CO_2 emissions. Other benefits include reducing water and material use and improving indoor air quality and occupant comfort [7]. This is achieved by applying 'passive' principles in various architectural and structural design methodologies that exploit the design and properties of the building envelope to reduce energy demand and maximize or minimize heat losses and heat gains [8]. Such passive design is associated with longer life spans or durability, lower life cycle costs, and higher benefits in energy saving [9,10] that can reduce energy consumption of up to 50%–60% [11–13]. Despite such benefits, the knowledge and awareness of construction stakeholders about SusD appears to be limited.

A crucial condition for the adoption of SusD is the availability of relevant information, knowledge, and interest among construction professionals and/or stakeholders [14], since a lack of adequate knowledge of SusD applications and their benefits may hinder the professional guidance, which can negatively influence the building owners to adopt SusD [15]. Lack of awareness and relevant knowledge plays a critical role in decision-making on adopting SusD. Prior knowledge, information, and understanding could make better decisions whether to adopt SusD, but their absence makes it impossible, as they do not know who to take the decision of adopting SusD [16,17]. Admittedly, effective adoption of SusD requires the knowledge, understanding, consciousness, and commitment of all stakeholders in their individual actions [18], especially potential building owners, to know who (i.e., which stakeholder or party) can help them with proper information and guidance on SusD so that they can select that party for their buildings and who actually should influence or take the decision of adopting SusD.

Unfortunately, hot and humid developing countries like Indonesia, Malaysia, and Brunei are facing these issues, which prevent them from adopting SusD. For example, the low level of awareness and knowledge of SusD is one of the challenges to early adoption of SusD practices in Malaysia [19]. The situation in Brunei Darussalam is not different. As such, in an attempt to assess the awareness of the local industry, the present study focused on identifying the suitable stakeholders who can help potential building owners to consider SusD by providing relevant information and who can guide them to adopt SusD. In addition to generating some degree of awareness among the industry participants, the findings of the study are expected to help the stakeholders in understanding and making decisions about, and selecting the right party for helping with, adopting SusD. The following sections present the relevant literature review, the methodology adopted, results and discussions, and finally, the conclusions.

2. Literature review

The study was undertaken in two stages: a structured literature review focusing on relevant past empirical studies and the practice of SusD. This review is exclusively based on relevant papers published in academic journals. A systematic literature search was performed using three academic listings, namely Science Direct, Taylor & Francis, and Emerald Insight. In order to collect relevant papers for this study, the following five keywords were used: ‘residential building’, ‘energy efficiency’, ‘low carbon building’, ‘passive design’, and ‘optimization’. These were searched within the title, abstract, and contents of the initially identified articles [20,21]. A total of 156 relevant papers were considered valid for further analysis. Each of the selected papers was analyzed for a wider study, in terms of identifying SusD features, motivators, challenges, and strategies for SusD adoption [20–22]. This also covered stakeholders/parties or roles who could help potential building owners/clients with relevant knowledge and information to adopt SusD and who can guide to make decision to adopt SusD, which are being dealt with in this paper.

It was observed that the adoption of SusD in buildings by construction stakeholders is hampered by a number of challenges, including unfamiliarity with SusD technology [23], lack of relevant information [24], and insufficient professional knowledge and expertise [25]. In this regard, the following subsections provide a review of relevant segments of literature on the influence/ability of various stakeholders in terms of providing appropriate information and guidance to potential building owners and helping them to decide if to adopt SusD.

2.1. Assistance to building owners

Many stakeholders or parties can help potential building owners adopt different types and degrees of SusD. According to their roles or skills, they include the project team members like architects, design engineers, contractors, owners or clients, and project managers, as well as building occupants, financial experts, cost consultants, and government agents [26–28]. These project team members deploy their expertise and knowledge to ensure effective collaboration and decision-making and provide owners with relevant information. Their involvement also promotes communication and coordination among different stakeholders, eventually enhancing the overall project outcomes [29]. They are responsible for identifying and implementing SusD, monitoring and evaluating the project's environmental impact, and advocating for sustainable practices [30]. They also contribute to the development of SusD building codes and regulations, ensuring compliance with sustainability standards [29]. Additionally, they actively participate in educating and raising awareness about sustainable practices within the construction industry and society as a whole [26]. Their involvement is crucial in driving the adoption of sustainable practices and achieving long-term environmental goals in construction projects [27]. However, the design team (i.e., architect and/or engineer) and the construction team (i.e., contractor or builder/constructor) are the key stakeholders for SusD adoption because they can help the owner to oversee all phases of construction [28]. On the other hand, local governments and contractors are particularly powerful in several key phases of the construction process [29]. In the design and build system, cooperation between contractor and designer starts early, even during the invitation to tender phase. The involvement of financial experts in this phase helps settle disputes and prevent potential problems [30]. Local governments and contractors are crucial for ensuring that construction projects adhere to environmental and social standards. Their collaboration can lead to innovative solutions to minimize the project's impact on the surrounding community and ecosystem [30–32].

Marichova [33] mentioned that the government plays a major role, along with the contractor and design team in the construction market, in order to ensure the efficient use of technology, which in turn accelerates its adoption. Moreover, the government and client generally have a major role to play both at the project and industry level [34]. Furthermore, consultants also play a role in the SusD adoption, along with the design team and on behalf of the client. The consultants play a greater role with the government in incorporating green or sustainable components early in the design stage so that a more holistic SusD is achieved [35]. Additionally, consultants play a crucial role in determining project success and technical aspects of performance. It is also argued that clients and architects are the most important stakeholders to be involved during the pre-feasibility phase, whereas government, contractors, and consultants are the least important during the pre-construction stage [30,34]. However, these stakeholders bring expertise in environmental regulations, energy efficiency, and SusD practices, making their roles essential [31]. Structural designers/consultants collaborate closely with architects and clients to ensure that sustainable goals are achieved, providing guidance on material selection, energy systems, and SusD strategies [34]. Their involvement throughout the project lifecycle ensures that SusD principles are seamlessly integrated into the construction process [35].

2.2. Decision-making

A "group" of individuals and groups is typically involved in the decision-making of a building project, including clients, users, building professionals, and external parties [36,37]. It is reported that the decision of whether to build green (that is, to use SusD) is made early in a project's development process by stakeholders like developers, investors, and the client. Early participation of key project stakeholders (i.e., client, designer, and contractor) leads to earlier completion of the project and more savings. These stakeholder groups have the highest influence on the decision-making of a project [38,39].

Menassa and Baer [40] argued that stakeholders' involvement in sustainable building construction is increasingly important for their cooperation and end-users' requirements. Tran [41] observed that developers are the key stakeholders in the decision-making process of adopting green building technologies in Vietnam. However, such a decision is likely to be dependent on the readiness level of other project partners, such as the government, designers, and contractors. Nevertheless, the decisions to adopt green buildings are typically taken internally by the developer, client, and investor and rarely include outside consultants [42], although the level of investors' participation in the decision to adopt sustainable features may be insignificant [43]. In addition to their decision-making role, stakeholders are also responsible for setting goals, implementing sustainable development practices, monitoring progress, and engaging with other stakeholders [33]. Moreover, stakeholders contribute substantially to the overall success of sustainable development adoption by providing support, resources, and expertise [34]. Therefore, it is crucial for developers to actively involve key stakeholders throughout the decision-making process to ensure a collaborative and comprehensive approach to sustainability [37].

On the other hand, it was observed in Malaysia that clients and developers are the core parties in construction to make decisions, followed by contractors and investors [44]. However, in a design and build contract, the developer and contractor are key parties in the final decision-making [45]. This is because the complete development of the project belongs to the client or developer, so it is important that they are the ultimate decision-makers [46]. If the client's decision-making process is delayed, it has an impact on the project and the contractor's job. Therefore, although various studies observed different outcomes, every stakeholder is important, with the changing order of importance according to the stage and needs of the project. Thus, construction practitioners may have different perspectives about risks depending on their particular role in the projects [47].

2.3. Roles in focus

The above literature review identified nine stakeholders, namely consultants, financial experts, engineers, architects, government, contractors, clients, developers, and investors. The first seven parties appear to help/assist, and guide potential building owners by providing knowledge and information on SusD, and the last four parties help in decision-making for adopting SusD.

3. Methodology

3.1. Questionnaire development

The information gathered from the literature review guided the design of a questionnaire [48], which was divided into distinct sections. Section A explained the purpose and objectives of the questionnaire. Section B asked for ethical consent and anonymous details of the respondents for the sample composition. Section C listed various stakeholders/parties and asked potential respondents to prioritize who could help the building owner (with information and knowledge) in considering SusD and making the decision to adopt it. Respondents were asked to rank their priorities on a scale from 1 to 5, where 1 = most important, 2 = more important, 3 = average, 4 = less important, and 5 = least important. This means that the lower the eventual score of a party, the higher the importance of that party. The respondents were also requested to add any other relevant party/parties that is/are not listed. In addition, potential respondents were asked to provide any further comments or suggestions relating to the need/priority of the stakeholders and the role they play.

3.2. Data collection and potential respondents

The target population for this study was construction professionals from contractors, consultants, and clients (within the design and development phase of a building project). They were identified from the lists of professionals in Brunei Darussalam issued by the Ministry of Development (MoD) and Public Works Department (PWD) and via the purposive random sampling method. Initially, 399 invitations were sent to construction professionals via email, which included 133 each for clients, contractors, and consultants. The invitation contained a description of the research and its aim. It was also made clear where and how the outcomes of the study will be used. A Microsoft Word file containing a web link was added in the invitations for the respondents to respond using the Word file or online. However, some invitations were bounced back, and the actual distribution was reduced to 381. In order to increase the number of responses and develop interest, potential respondents were offered summary results of the survey. They were reminded each week from the first contact to increase the chance of responding. A total of 142 responses were received, but 20 were excluded due to incomplete or repetitive responses. The remaining 122 responsive responses (as seen in **Table 1**) were used for analysis. This registered a

32% rate of response (122/381), which is more than the average of 30% in most construction management studies [49,50]. So, the rate of response was regarded as acceptable.

Table 1. Demographic profile of respondents.

Variables	Category	Client	Consultant	Contractor	Total	%
ProfessionGroup	Architectural	0	27	0	27	22.1
	Engineering	15	35	8	58	47.5
	Management	14	8	15	37	30.3
	Total	29	70	23	122	100.0
Experience in SusD projects	< 5 projects	19	41	15	75	61.5
	6–10 projects	7	17	2	26	21.3
	11–15 projects	2	6	1	9	7.4
	> 15 projects	1	6	5	12	9.8

3.3. Data analysis

3.3.1. Testing for reliability

Data were analyzed using the SPSS (Statistical Package for Social Sciences, version 27) software. The analysis started with determining the Cronbach's alpha coefficient to measure the reliability or internal consistency of the survey items or factors used in the questionnaire [51]. The Cronbach's alpha coefficient ranges in number from 0 to 1, and the higher the score, the more reliable the survey items or factors/options are, and they consistently measure the same characteristic. To be acceptable, Taber [52] suggested that the Cronbach's alpha value should be higher than the threshold of 0.70, which was found for this study in the range of 0.793 to 0.965, indicating that the data collected was reliable and consistent and therefore suitable for further analysis, as presented in the following subsections.

3.3.2. Testing for normality

There are several methods to assess normality assumptions, including the Shapiro-Wilk test, the Kolmogorov-Smirnov test, and the skewness and kurtosis tests. Kim [53] argued that there is no current gold standard method to assess the normality of data. Shapiro-Wilk test and Kolmogorov-Smirnov test are unreliable for large samples (more than 100), while Skewness and kurtosis test may be relatively correct in both small and large samples [54]. So, for this study, skewness and kurtosis tests were used. It is widely argued that the normality assumption is fulfilled when the skewness and kurtosis coefficient are within the range of −2 to +2 [55–57]. The relevant values obtained from the collected sample were found between −0.053 and +1.071, indicating that respondents agreed on their opinions, which also reduced the occurrence of outliers, so the collected data may be considered as normally distributed. Therefore, the parametric test was employed, as presented in this paper.

3.3.3. Mean score ranking (M)

This study used the mean score ranking technique to prioritize the roles of different parties who can help potential building owners with relevant information and assist in making the decision to adopt SusD. Such an approach is widely used in construction management research, i.e., to rank the relative importance of specific survey items or 'factors' [58]. The mean scores of individual parties were calculated and prioritized with ranks for the total sample and different respondent groups according to their affiliation (i.e., clients, contractors, and contractors) and nature of job (i.e., architectural, engineering, and managerial).

3.3.4. One sample T-test and analysis of variance (ANOVA)

The one-sample T-test compares the mean of sample data to a known value to determine whether a population mean is significantly different from a hypothesized value [59]. This is done by comparing the mean score found in an observed sample to some predetermined or hypothetical value. Typically, this hypothetical value is the population mean or some other theoretically derived value, such as the middle of the measuring scale. The study therefore considered one sample T-test to measure the statistical significance of the mean values for the whole sample and the groups based on affiliation and nature of job. The one-sample t-test was conducted at a 95% confidence interval with the corresponding p-value of 0.05.

One-way ANOVA is a suitable method for comparing the mean scores of more than two groups. In this study, ANOVA was used to check the significant differences in means between the groups based on affiliation and nature of job of the respondents, as explained above.

4. Results and discussions

4.1. Survey demographics

Table 1 shows the respondents' information in two-way groupings: (i) in terms of their affiliation (i.e., 29 clients, 70 consultants, and 23 contractors), and (ii) profession/nature of job (27 architectural, 58 engineering, and 37 management), totaling to 122. The table also shows respondents' experience/involvement in terms of the number of projects considered SusD.

It is seen that respondents' involvement in practicing SusD is much less, with 61.5% in <5 projects and 82.8% (i.e., 61.5 + 21.3) in <10 projects. Only 17.2% of them had involvement in >10 projects. This indicated that the respondents are aware of SusD, but the concept may be relatively new to them, or there is no sufficient demand for SusD from the clients. Nevertheless, all the respondents have some degree of experience on SusD, hence the relevance, quality, and acceptability of their responses to various survey items (i.e., factors and options).

4.2. Client demand

Tables 2 and **3** compare the respondents' opinions on clients' demand for providing SusD in their buildings, based on different groups of affiliation and nature of job, respectively. It is seen that clients have demand of either 'always' or 'often' for SusD only in 30.0% (12.3 + 18.0 ≈ 30.0) cases, in both way groupings based on affiliation and nature of job. The demand in the remaining 70% cases ranges from 'never' to 'sometimes'. This was considered an overall poor or less demand for SusD in Brunei Darussalam, which is also indicated in **Table 1** with relative less experience of the respondents. This situation could be blamed on the existence of numerous challenges in the industry, like justified/additional fees for architects and/or consultants, a higher initial cost of construction, a lack of expertise, and many more [60–62]. This may also be indicative that some clients are still having difficulty transitioning from traditional to new methods of design. In addition, this may also relate to a general lack of interest in undertaking relevant education and technical trainings, which in turn might have resulted from a poor/low awareness of SusD.

Table 2. Demand for sustainable design based on affiliation.

Category	Client	Consultant	Contractor	Total	%
Always	3	6	6	15	12.3
Often	8	12	2	22	18.0
Sometimes	14	30	6	50	41.0
Rarely	2	20	7	29	23.8
Never	2	2	2	6	4.9

Table 3. Demand for sustainable design based on professional groups.

Category	Architectural	Engineering	Management	Total	%
Always	2	8	5	15	12.3
Often	3	11	8	22	18.0
Sometimes	13	22	15	50	41.0
Rarely	8	14	7	29	23.8
Never	1	3	2	6	4.9

4.3. Assistance to building owners

In terms of which party can best help the building owners with relevant information and knowledge and guide to adopt SusD, **Tables 4** and **5** present the mean values, ranks, and significances obtained from the one-sample t-tests within the total sample and different groups of respondents based on affiliation and nature of job, respectively, along with their relevant ANOVA results. All such results (**Tables 4–7**) have been arranged in order of the ranks in the total sample.

Table 4. Assisting SusD adoption: opinion of different groups based on affiliation.

Parties	Total			Client			Contractor			Consultant			A
	M	R	Sig.	M	R	Sig.	M	R	Sig.	M	R	Sig.	
Architects	2.01	1	0.000	1.83	1	0.000	1.70	2	0.000	2.20	2	0.000	0.16
Consultant	2.09	2	0.000	2.70	3	0.496	1.52	1	0.000	1.96	1	0.000	0.00
Government	2.36	3	0.000	2.46	2	0.170	2.67	5	0.260	2.23	3	0.000	0.46
Client	2.61	4	0.014	2.92	5	0.775	2.47	3	0.154	2.51	4	0.031	0.51
Engineer	2.67	5	0.005	3.07	6	0.712	2.59	4	0.143	2.52	5	0.004	0.13
Financial experts	2.86	6	0.377	2.89	4	0.670	2.92	6	0.820	2.88	6	0.537	0.91
Contractor	3.42	7	0.002	4.00	7	0.000	3.61	7	0.064	3.06	7	0.739	0.01

Table 5. Assisting SusD adoption: opinion of different professional groups.

Parties	Architectural			Engineering			Management			A
	M	R	Sig.	M	R	Sig.	M	R	Sig.	
Architects	2.00	2	0.000	2.11	1	0.000	1.86	1	0.000	0.65
Consultant	1.80	1	0.000	2.18	2	0.000	2.17	2	0.001	0.39
Government	2.32	4	0.065	2.27	3	0.000	2.54	3	0.102	0.74
Client	2.19	3	0.028	2.82	5	0.455	2.63	4	0.161	0.30
Engineer	2.70	5	0.259	2.69	4	0.071	2.64	5	0.079	0.98
Financial experts	2.71	6	0.385	2.97	6	0.899	2.80	6	0.519	0.77
Contractor	3.14	7	0.589	3.35	7	0.107	3.69	7	0.004	0.29

Table 6. Deciding SusD adoption: opinion of different parties based on affiliation.

Parties	Total			Client			Contractor			Consultant			A
	M	R	Sig.	M	R	Sig.	M	R	Sig.	M	R	Sig.	
Client	1.52	1	<0.001	1.76	1	0.000	1.22	1	0.000	1.53	1	0.000	0.089
Developer	2.37	2	<0.001	2.76	3	0.129	2.35	2	0.001	2.21	2	0.000	0.016
General contractor	2.70	3	0.002	1.97	2	0.000	3.09	4	0.648	2.87	3	0.295	<0.001
Investors	3.11	4	0.301	3.45	4	0.030	3.04	3	0.862	2.99	4	0.916	0.174

Table 7. Deciding SusD adoption: opinion of different professional groups.

Parties	Architectural			Engineering			Management			A
	M	R	Sig.	M	R	Sig.	M	R	Sig.	
Client	1.41	1	0.000	1.55	1	0.000	1.57	1	0.000	0.738
Developer	2.15	2	0.000	2.36	2	0.000	2.54	2	0.005	0.201
General contractor	3.19	4	0.284	2.47	3	0.000	2.70	3	0.110	0.011
Investors	2.74	3	0.283	3.17	4	0.255	3.27	4	0.115	0.152

It is seen that six out of seven parties have relatively low scores with mean values of less than 3.0 (i.e., the middle of the measuring scale, or average), implying their higher importance. The highest importance has been placed on architects with the least score of 2.01/5.00, indicating they are the most important party in assisting the owners by supplying the relevant information and knowledge and guiding them to adopt SusD. This is followed by consultant (score 2.09, rank 2), government (score 2.36, rank 3) and client (score 2.61, rank 4). This is simply the reflection of industry practice, as architects and consultants come first/earlier in the project environment to formally interact with and suggest the owners/clients on buildings' design and all other issues, based on clients' affordability and other choices, and in compliance with government regulations or initiatives [63]. They are also considered the 'home' of knowledge and expertise of SusD [64].

Such industry response may be reflecting their good sense of awareness towards SusD, despite the fact that Brunei has been recently experiencing building construction mostly in the private sector, where the roles of architects and consultants are minimal [65]. For the private buildings, they merely furnish the initial architectural and structural design/drawings, and then contractors become the most important party to do the remaining works. Nevertheless, contractors cannot change the design, and therefore their role in crafting sustainability aspects in the design is minimal. This is seen to have been clearly expressed by the respondents, as the role of the contractor is seen as the lowest among all the parties with a score of 3.42/5.00, which is also the only party with a score of more than 3.0 (i.e., the average for the measuring scale). Significance levels obtained from the t-tests show that the mean values of all parties in the total sample are significantly important, except for financial experts, indicating the respondents' opinion that financial experts cannot help with the required information and knowledge on SusD, despite their 'more than average' importance with a score of 3.42/5.00.

Table 5 also shows that the scores for individual parties within the three groups of respondents based on 'nature of job' are clearly different, with different highest and lowest scores. However, their relative ranks are somewhat similar to those in the total sample. Expectedly, contractor and 'financial experts' occupy the bottom of the list, and 'consultant' and 'architecture' occupy the top of the table in all three groups. The only slight exception is seen in the 'client' group, in terms of the relative importance of 'financial experts' (rank 3) and 'consultant' (rank 5). This might be due to the reason that clients (as investors) may value the business aspect of their investment more than the technical aspects suggested by the consultants [66]. Significance levels obtained from the t-tests show that the scores of most of the parties are insignificant in general. For example, only the scores of 'contractor' and 'architect' are significant in the client group. Similarly, only the scores of 'consultant' and 'architect' are significant in the contractor group. On the other hand, scores for 'contractor' and 'financial experts' are insignificant only in the consultant group. Thus, contrary to that in the total sample, the levels of importance of SusD attributed to different parties by the three groups of respondents (based on affiliation) are broadly insignificant or inconsistent. However, amidst such conflicting agreement on the mean scores, ANOVA results show that the three groups agree on the relative importance of all the parties, except for 'contractor' and 'consultant'. This might be due to the differential degree of importance expressed by the parties. For example, contractors scored consultants with 1.52, compared to 2.93 by clients, a difference of [(2.93 − 1.52)/4 ≈ 35.25%]. Similarly, consultants scored contractors with 3.06, compared to 4.00 by clients, a difference of [(4.00 − 3.06/4) ≈ 23.5%].

As seen in **Table 5**, the scores by the three groups according to 'nature of job' are different, but their ranks are similar to those in the total sample. Significance levels obtained from the t-tests show that the scores of only three parties are significant and the other four parties are insignificant in all three groups. It is also seen that only the scores of 'architects' and 'consultants' are significant in all three groups, indicating agreement or consistency. The scores of the other five parties are insignificant, at least in two groups. Despite such conflicting agreement of the mean scores, the ANOVA results indicate agreement of the three groups on the relative importance of all the parties. This may be indicative of some degree of consistency or overall awareness at the industry level, but lack of clear knowledge or awareness on specific roles by different parties within different 'professional' groups, as seen in the case of different groups based on affiliation.

The overall results appear to suggest that the Brunei construction industry participants need to be re-trained in terms of specific roles and contributions of various construction project stakeholders. For example, architects and consultants come first in the project scenario. They are knowledgeable and 'home' of relevant expertise, so it is invaluable to provide suitable information and suggest the owners/clients to adopt SusD [67]. However, contractors execute the job, so they need to interact with architects and consultants during the design stage to ensure issues like constructability and reduce the occurrence of conflicts and misunderstandings [68]. Roles and responsibilities of other parties should also be appreciated, since SusD is expected to be practiced under a supportive policy by the government and the willingness of the owners/clients, for example. Also, the role of government may vary depending on its effectiveness; in particular, since the government (or local government) is also the client in public buildings, there may be different regulations or support than in private projects. In fact, contractors, designers (i.e., consultants, architects, and engineers), and clients are directly involved in the execution of a project [69], and they are also the major participants who have a great deal of power that can influence and shape the progress of any project [70].

4.4. Decision-making

In terms of which party can best help in decision-making to adopt SusD, **Table 6** presents the mean values, ranks, and significances obtained from the one-sample t-tests within the total sample and three respondent groups of client, contractor, and consultant, along with their ANOVA results. It is seen in the total sample that 'client' plays the most important role in deciding if to adopt SusD, followed by 'developer' (rank 2), 'general contractor' (rank 3), and 'investor' (rank 4). The preference of the 'consultant' group is the same with the total sample. However, client group considers 'general contractors' (rank 2) are more important than 'developers' (rank 3), while contractor group considers 'investors' (rank 3) are more important than 'general contractors'.

Nevertheless, the scores of the parties both in the total sample and in different groups are mostly less than the average of the measuring scale (i.e., 3.00), and only a very few are slightly more than the average. This may be indicative of the general importance of all the parties in decision-making towards adopting SusD, both within the total sample and individual groups. It therefore conforms to the industry norm that clients are the most important party for any relevant decision-making on building design during the early project stage, while other parties can help with their supporting roles [71].

Significance levels obtained from the t-tests in the total sample show that the scores of three parties are significant and one party (i.e., investor) is insignificant, implying 'investors' are not relevant to decision-making for SusD adoption. This is contrary to Brunei's recent experience with building construction, which has largely occurred in the private sector, where the role of investors is important [72]. Developers of private sector projects often borrow funds from financial institutions, so the investor may appraise the project and see what is included in the project. In any case, investors have taken the bottom of the table with a score of 3.11/5.00, which is also the only role with a score of more than 3.0 (i.e., the middle of the measuring scale), with a relevant importance level of 'less than average'. Moreover, the score of 'developer' in the client group is insignificant, while that for 'general contractor' and 'investors' in the contractor and consultant groups is insignificant. Moreover, ANOVA results show that the three groups agree on the relative importance of 'client' and 'investors' and disagree for 'developer' and 'general contractor'.

Such partial consistencies within the total sample (or, in other words, at the industry level) and both within and between different groups may be indicative of partial awareness both at the industry and group levels. The comparisons between different professional groups are also similar (see **Table 7**). The ranks of different parties in different groups are broadly similar to those in the total sample. Results from one-sample t-tests and ANOVA also show partial consistency within the industry and both between and within different groups of respondents. Interestingly, the three groups agree on the consistency of the scores of 'client', and disagree on the scores of investors.

The overall outcome appears to suggest that the practitioners in Brunei need to undertake suitable training or education in order to develop an appropriate level of awareness on SusD in general and decision-making for SusD adoption in particular. This is expected to allow industry participants to consistently assess the importance levels of various parties and their relative ranks, e.g., on deciding SusD adoption and when to include which party in the SusD process [73]. Usually, clients considerably contribute to the project's original decision-making process regarding design [74], more commonly appoint and engage architects and consultants for incorporating SusD, and typically allow contractors to enter the construction phase [73], after significant decisions have been made [74]. However, contractor involvement in the decision-making from the early design stage improves project performance, which is why they are influential stakeholders along with investors and clients [75].

4.5. Discussions and implications

The study revealed relatively less demand for SusD from clients (**Tables 2** and **3**), some disparity on the role of different parties to provide information and guide the potential building owners (**Tables 4** and **5**), as well as to help decision-making towards SusD adoption (**Tables 6** and **7**). All these together may be indicating many potential reasons, like lack of interest [4], cultural inertia [17], lack of training and education [76], lack of suitable fee [77], and lack of information and guidance [17,78]. This may help relevant authorities to look into the issues and design suitable policies to generate a higher level of awareness, information dissemination, create healthy demand for SusD, appropriate training and education, and may result in increased pay/fee for the consultants, as SusD requires more work from the consultants. A common platform may be suitable for such activities.

The findings suggest that construction professionals in Brunei, in particular, would benefit from training on the roles and responsibilities of stakeholders involved in the implementation of SusD. This training would improve communication and collaboration among stakeholders, leading to more successful implementation of SusD in construction projects. Stakeholders also need a clear understanding of the advantages and potential challenges of SusD to effectively advocate for its adoption. By promoting knowledge sharing and continuous learning, stakeholders can collaborate to develop more environmentally friendly and efficient buildings in Brunei. Incorporating SusD in building projects will help reduce the environmental impact of construction activities, including carbon emissions, waste generation, and resource depletion. This will contribute to a more sustainable future for Brunei. Embracing SusD can also help construction professionals attract environmentally conscious clients, creating new business opportunities and enhancing competitiveness in the industry. Therefore, prioritizing ongoing education and training in SusD is crucial for establishing an environmentally responsible and economically viable construction sector in Brunei.

5. Conclusions

Sustainable design (SusD) is a global strategy for building design that aims to reduce energy consumption and carbon dioxide emissions in buildings. However, it is not gaining momentum in developing countries, particularly in hot and humid regions. One potential reason for this is the inadequate knowledge and awareness of the main stakeholders of building construction projects. As such, the present study attempted to address this issue by investigating the level of awareness of SusD within the local industry and identifying the most suitable parties to guide potential building owners in considering SusD and relevant decision-making to its adoption. It was revealed that the respondents consistently agree on the importance of architect and consultant roles in providing support and guidance on SusD, while the client role is the most important to decision-making for adopting SusD. This is in compliance with the existing industry practice.

However, different groups of respondents appear to lack the clear perception of the degree of importance of other roles, both within and between specific groups. This needs to be addressed through carefully designed actions/programmes by the regulatory bodies, namely the government departments, as they develop relevant rules and regulations. They are also the largest clients in developing countries. So, other parties (like architects and consultants) will comply with cliental requirements if to do business and remain in business in the industry. As such, the outcomes of this study will assist the appropriate authorities in comprehending the actions that must be taken to adopt SusD, such as raising awareness to the appropriate degree, making essential information available, and setting appropriate training/education schemes for each interest group of parties to facilitate its implementation and move towards a more carbon-responsive construction industry. The study outcomes and relevant discussions/suggestions are specific to Brunei construction industry, so those may not be applicable elsewhere. However, the methodology developed can be repeated for similar issues elsewhere, with much-needed country- or region-specific adjustments.

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RAA; visualization, NAHJ and MMR; supervision, MMR and RAA; project administration, NAHJ; funding acquisition, MMR. All authors have read and agreed to the published version of the manuscript.

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