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Comparative Analysis of Critical Success Factors for Smart and Sustainable Developments Between Organizations and Among Construction Professionals

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Abstract
The development of smart and sustainable infrastructure projects requires great teamwork and a common understanding of the success requirements. There seems to be no general agreement among organizations and construction professionals about critical success factors (CSFs) for smart and sustainable development. This study thus compares CSFs for achieving smart and sustainable developments between organizations and among construction professionals. A questionnaire survey, including 40 CSFs was designed and distributed among various construction professionals working in different organizations and involved in smart construction activities in Abuja, Nigeria. The responses were analysed using the mean score for identifying the level of agreement of the different construction professionals with different CSFs; and one-way analysis of variance for exploring the significant difference among the perception of the construction professionals. The result of the mean score indicates that the different organizational types and construction professionals rated all the CSFs high indicating that there is an agreement with the factors as critical to the success of smart and sustainable developments. The independent samples t-test shows the significant difference with cooperation and participation of stakeholders as well as energy efficiency; while the one-way analysis of variance reveals significant difference with clearly defined goals, cooperation and participation of stakeholders, project procurement system, energy efficiency, waste management and land use change. The study suggests the involvement of organizations and professionals at every stage of the development starting from the design brief to commissioning and maintenance of the project.

Keywords
Construction, Critical Success Factors, Smart Buildings, Sustainability, Nigeria

1. Introduction

Although the construction industry performs an essential role in enhancing the quality of life of users through the provision of critical infrastructure, it has also been a source of depletion of the natural environment and its resources (du Plessis 2007). There have been series of harmful activities traced to the construction industry, including the depletion of non-renewable resources, destruction of landscapes, creation of health and safety problems as well as generating large quantities of wastes and altering the natural ecosystem, (Azapagic 2004; Kibert 2013). This has led construction industry experts to adopt different strategies for tackling the problems posed to recipients of infrastructural developments from the construction industry, particularly involving a more thoughtful and responsible approach with the future generation in mind (Bakens 2005; Dania 2016).

In the last few years, smart city concepts and sustainable developments have been positive urban planning practices and initiatives to ensure the increasing population in urban areas live comfortably, enjoy a good quality of life and improve the performance of the construction industry. The underpinning principle for these concepts has been to concurrently align the economic, social and environmental dimensions in the development of infrastructure as well as the performance and functionality of construction projects (Dania 2016). However, teamwork and a common understanding of the concept of sustainable development and smart city, as well as the knowledge of critical success factors (CSFs) for smart and sustainability development among the different construction professionals that execute construction projects, is vital. Therefore, this study seeks to compare CSFs for achieving smart and sustainable developments among construction professionals. This will enhance the mutual understanding of the CSFs factors among the construction professionals for the success of infrastructural developments.

2. Professionals Involved in Construction Developments

A construction professional refers to individuals with a career in a construction-related discipline, including architects, quantity surveyors, engineers, builders, etc. They have adequate training, skills, competence and technical know-how to produce aesthetically, affordable and structurally sound living environment for the comfort and liveability of humans. For instance, an architect is a licensed professional trained with the art and science of building design and concept for structured which provides images and plan for the overall aesthetics and appearance of buildings (Fame Pyramids Limited 2017). The architects preserve, improve and create the quality required of the built environment through the integration of the concept of sustainable community development (Chansomsak and Vale 2009).

Quantity surveyors are construction economists who fulfill varied and comprehensive duties to support cost-effective construction and property development projects (Famakin et al. 2014). Engineers involved in construction include structural engineers (i.e. they provide design drawings showing details of the structural element to enable fabrication, installation and connection); mechanical engineers (i.e., they prepare contract drawings for mechanical services required in the building, namely plumbing, ventilation and air condition, fire services, etc); and electrical engineers (who prepare complete drawing showing the electrical services needs, including lighting and power, HVAC systems, alarm systems, etc) (Olatunji et al. 2014). On the other hand, builders are trained construction professionals who study the drawings, schedules and specifications and analyses the buildability and maintainability of the drawings (Fame Pyramids Limited 2017).

3. Critical Success Factors for Smart and Sustainable Development

Critical success factors have been an explorative tool for selecting the most important and decisive factors for achieving the success of construction projects and infrastructure developments. For instance, there have been numerous studies exploring important factors for success of construction projects, including for large-scale construction projects (Nguyen et al., 2004; Toor and Ogunlana 2009); joint venture procurement (Famakin et al. 2012); implementation of public-private partnerships (Alinaitwe and Ayesiga 2013); smart cities (Aldegheishem 2019) etc. Although there is a need to identify a set of common success factors for measuring the success of construction projects, the agreement of construction professionals on the list of identified factors is essential considering the diverse nature of construction projects (Nguyen et al., 2004; Toor and Ogunlana 2009). Based on an extensive literature review, CSF for smart and sustainable developments have been identified and will be discussed subsequently.

The technical factors of sustainability refer to prerequisite skills and expertise needs for implementing smart and sustainable development, including experience and competence, effective project monitoring, management commitment, current technology and methods, project procurement system, etc. Experience and competence are necessary for construction professionals to understand client’s expectations and execute according to their specific requirements (Shen et al. 2017). High-quality workmanship as a requirement is central to integrating sustainability into construction projects because of the use of current construction technology for implementation (Banihashemi et al. 2017; Sfakianaki 2019). Education and training have been a long-term beneficial factor for integrating sustainability in the construction industry (Whang and Kim 2015).

Economically, smart and sustainable buildings often lead to life cycle savings despite the high initial investment and cost (Kats et al. 2003). The enactment of sustainable policies by government and professional institutions aid the implementation of smart and sustainable principles in construction projects (Gan et al. 2015; Banihashemi et al. 2017). In fact, regulations and related legislation are to be updated periodically to the standard requirements of sustainable construction to enhance smart and sustainable urbanization. Land use change, energy efficiency, and waste management have been identified as success factors that contribute significantly to the environment for smart and sustainable developments (Cox et al. 2013; Whang and Kim 2015; Luangcharoenrat et al. 2019).

4. Methodology

4.1 Questionnaire design

Based on extensive literature, a questionnaire survey was designed to investigate the different agreement level of construction professionals with CSFs for smart and sustainable development. The questionnaire consists of two sections: (1) demographic characteristics of construction professionals; and (2) degree of agreement with 40 CSFs.

Respondents were required to rate the degree of agreement with the CSFs ranging from 1 (highly disagree) to 7 (highly agree). The questionnaire was distributed among construction professionals working on smart and sustainable developments in Abuja, Nigeria.

4.2 Data collection and sampling

The survey was distributed to registered construction professionals practicing in Abuja, Nigeria. To identify the respondents for the study, the following criteria were used: (1) they were registered construction professionals working in the Federal capital territory (FCT); and (2) they were currently working on a construction project within the FCT. A total of 75 questionnaires were retrieved from the respondents, including 42.7% working in consulting organizations and 57.3% in contracting organizations. More than one-third (i.e. 34.8%) of the respondents were architects, 26.1% were quantity surveyors, 15.9% were engineers and 23.2% were builders.

4.3 Data analysis

The data collected were analyzed using SPSS 21.0. Firstly, mean score was conducted to identify the level of agreement of the different construction professionals with different CSFs. Lastly, a one-way analysis of variance (ANOVA) was conducted to compare the level of agreement of construction professionals with CSFs for smart and sustainable developments.

5. Results

5.1 Independent Samples T-test for Organizational Agreement with Critical Success Factors of Smart and Sustainable Developments

The differences in the level of agreement with CSF items in consulting and contracting firms were determined using the Independent Samples T-test (refer to Table 1). The results revealed that all the CSFs were not significantly different between the organizations except for cooperation and participation of stakeholders (t = 2.856, p = 0.005) and energy efficiency (t = 2.953, p = 0.004). It is also worthy of note that the different types of organizations rated all the CSFs high, indicating the level of agreement with the factors as critical to the success of smart and sustainable developments.

Table 1 Independent Samples T-test for Organizational Agreement with Critical Success Factors of Smart and Sustainable Developments

CSFs	Consulting		Contracting		Mean Diff	t	Sig.
	Mean	SD	Mean	SD			
Strong commitment	5.531	0.915	5.419	1.332	0.113	0.411	0.682
Enacting required policies	5.750	0.762	5.279	1.436	0.471	1.831	0.072
Clearly defined goals	5.438	1.014	5.256	1.416	0.182	0.647	0.519
Knowledge and awareness	5.688	1.176	5.326	1.393	0.362	1.188	0.239
Constructive relationship	5.281	0.991	5.349	1.193	-0.068	-0.260	0.795
High quality workmanship	5.406	0.979	5.558	1.201	-0.152	-0.585	0.560
Accountabilities and responsibilities	5.531	1.191	5.628	1.113	-0.097	-0.361	0.719
Experience and competence	5.750	1.078	5.814	1.006	-0.064	-0.264	0.792
Minimization of water and noise pollution	5.656	1.035	5.628	0.900	0.028	0.126	0.900
Effective project monitoring mechanism	5.906	0.689	5.837	0.949	0.069	0.348	0.729
Availability of resources	5.625	1.008	5.698	0.939	-0.073	-0.321	0.749
Current construction technology and methods	5.563	0.914	5.581	1.052	-0.019	-0.081	0.935
Governments' support and incentives	5.125	1.314	5.395	1.275	-0.270	-0.897	0.373
Consumer acceptance	5.875	0.907	5.674	1.286	0.201	0.753	0.454
Education and training	5.844	1.194	5.651	1.232	0.193	0.678	0.500
Support from financial institutions	5.281	1.397	5.395	1.116	-0.114	-0.393	0.695
Related technology and sustainable materials	5.656	1.260	5.721	1.141	-0.065	-0.232	0.817
Industrial and/or organizational culture	5.375	1.385	5.558	1.278	-0.183	-0.592	0.556
Initial investment and/or construction costs	5.750	1.107	5.628	1.134	0.122	0.466	0.643
Qualified workers and expertise	5.844	1.110	5.837	1.090	0.007	0.026	0.980
Available construction time	5.750	1.218	5.628	1.024	0.122	0.471	0.639
Support from professional institution	5.625	1.129	5.326	1.210	0.299	1.091	0.279
Cooperation and participation of stakeholders	5.875	0.833	5.233	1.109	0.642	2.865	**0.005****
Project procurement system	5.656	1.234	5.279	1.182	0.377	1.342	0.184
Legal and regulatory framework	5.594	0.979	5.233	1.250	0.361	1.353	0.180

Energy efficiency	5.938	0.669	5.233	1.360	0.705	2.953	**0.004****
Efficient use of resources	5.469	1.459	5.465	1.162	0.004	0.012	0.990
Waste management	5.688	1.306	5.372	1.363	0.315	1.009	0.316
Land use change	5.188	1.355	5.465	1.297	-0.278	-0.900	0.371
Indoor environment quality	5.438	1.190	5.558	1.076	-0.121	-0.459	0.648
Long-term costs	5.469	1.047	5.395	1.237	0.073	0.271	0.787
Affordability	5.656	1.285	5.535	1.054	0.121	0.449	0.655
Production planning	5.750	0.950	5.674	1.063	0.076	0.318	0.751
Impact on health and community	5.906	1.118	5.535	1.077	0.371	1.454	0.150
Awareness	6.031	0.740	5.651	1.089	0.380	1.703	0.093
Durability	5.594	1.188	5.767	0.947	-0.174	-0.705	0.483
Innovation	5.781	0.832	5.651	0.923	0.130	0.629	0.531
Communication	5.625	0.907	5.651	0.897	-0.026	-0.124	0.901
Facilitating green practices	5.719	1.198	5.791	1.059	-0.072	-0.275	0.784
Management and commitment	6.156	0.954	5.860	1.246	0.296	1.120	0.266

Note: S.D. = Standard deviation; Sig. = significance level; and **ANOVA is significant at the 0.01 level (2-tailed).

5.2 One-way Analysis of Variance (ANOVA) for Professionals' Agreement with Critical Success Factors of Smart and Sustainable Developments

The study considered four groups of construction professionals popularly involved in the Nigerian construction industry, namely architect, quantity surveyors, engineers, and builders. To compare their level of agreement among the four groups of construction professionals, the study adopted the one-way between-groups ANOVA. In comparing with the different professionals' groups, the findings (refer to Table 2) reveal that clearly defined goals ($F = 3.179$, $p = 0.030$), cooperation and participation of stakeholders ($F = 3.240$, $p = 0.028$), project procurement system ($F = 2.771$, $p = 0.049$), energy efficiency ($F = 6.595$, $p = 0.001$), waste management ($F = 4.042$, $p = 0.011$) and land use change ($F = 3.071$, $p = 0.034$) were statistically and significantly different.

Table 2 One-way Analysis of Variance (ANOVA) for Professionals' Agreement with Critical Success Factors of Smart and Sustainable Developments

CSFs	Professionals	Mean	SD	F	Sig.
Clearly defined goals	Architect	5.667	0.868	3.179	**0.030***
	Quantity Surveyor	5.611	0.698		
	Engineer	5.091	1.868		
	Builder	4.563	1.548		
	Total	5.304	1.275		
Cooperation and participation of stakeholders	Architect	5.542	0.779	3.240	**0.028***
	Quantity Surveyor	5.944	0.873		
	Engineer	5.636	1.120		
	Builder	4.875	1.360		
	Total	5.507	1.066		
Project procurement system	Architect	5.458	1.103	2.771	**0.049***
	Quantity Surveyor	5.889	0.676		
	Engineer	5.636	1.748		
	Builder	4.750	1.291		
	Total	5.435	1.230		
Energy efficiency	Architect	5.917	0.881	6.595	**0.001****
	Quantity Surveyor	5.889	0.758		
	Engineer	5.727	0.786		
	Builder	4.563	1.548		
	Total	5.565	1.157		
Waste management	Architect	6.000	0.780	4.042	**0.011***
	Quantity Surveyor	5.611	1.145		
	Engineer	5.909	0.944		
	Builder	4.750	1.693		
	Total	5.594	1.240		
Land use change	Architect	5.917	0.929	3.071	**0.034***
	Quantity Surveyor	5.278	1.018		
	Engineer	5.091	1.300		
	Builder	4.813	1.601		

	Total	5.362	1.248

Note: S.D. = Standard deviation; Sig. = significance level; **ANOVA is significant at the 0.01 level (2-tailed); and *ANOVA is significant at the 0.05 level (2-tailed).

5.3 Post-Hoc Tests for Professionals' Agreement with Critical Success Factors of Smart and Sustainable Developments

Post-hoc tests were conducted to explore the differences among the means of three or more groups so as to provide definite information on which groups are significantly different from each other (Pallant 2011). To ascertain which group of construction professionals were responsible for the significant differences among the CSFs, post hoc tests were conducted in this study (refer to Table 3). The results of the post hoc tests revealed significant differences in the respondents' agreement level with clearly defined goals as well as cooperation and participation of stakeholders occurred between the builder and the architect, and between the builder and quantity surveyor. For project procurement system and land use change, the significant difference occurred between the builder and quantity surveyor, and the builder and architect respectively. Lastly, energy efficiency and waste management showed a significant difference between the builder and all other construction professionals.

Table 3 Post-Hoc Tests for Professionals' Agreement with Critical Success Factors of Smart and Sustainable Developments

CSFs	Professionals		Mean Diff.	SE	Sig.
Clearly defined goals	Builder	Architect	-1.104	0.393	**0.007****
		Quantity Surveyor	-1.049	0.419	**0.015***
		Engineer	-0.528	0.477	0.272
Cooperation and participation of stakeholders	Builder	Architect	-0.667	0.328	**0.046***
		Quantity Surveyor	-1.069	0.349	**0.003****
		Engineer	-0.761	0.398	0.060
Project procurement system	Builder	Architect	-0.708	0.382	0.069
		Quantity Surveyor	-1.139	0.407	**0.007****
		Engineer	-0.886	0.464	0.061
Energy efficiency	Builder	Architect	-1.354	0.334	**0.000*****
		Quantity Surveyor	-1.326	0.356	**0.000*****
		Engineer	-1.165	0.406	**0.006****
Waste management	Builder	Architect	-1.250	0.376	**0.001****
		Quantity Surveyor	-0.861	0.400	**0.035***
		Engineer	-1.159	0.456	**0.013***
Land use change	Builder	Architect	-1.104	0.386	**0.006****
		Quantity Surveyor	-0.465	0.411	0.261
		Engineer	-0.278	0.468	0.554

Note: S.E. = standard error; Sig. = significance level; ***ANOVA is significant at the 0.001 level (2-tailed); and **ANOVA is significant at the 0.01 level (2-tailed); and *ANOVA is significant at the 0.05 level (2-tailed).

6. Discussion

The result of the t-test revealed that cooperation and participation of stakeholders and energy efficiency were the statistically significant CSF items between consulting and contracting organizations for smart and sustainable developments; while clearly defined goals, cooperation and participation of stakeholders, project procurement system, energy efficiency, waste management and land use change were the statistically significant CSF items among the construction professionals for smart and sustainable developments.

Table 4 Statistically Significant CSF items in the Study

CSFs	Organizations	Construction Professionals
Clearly defined goals		✓
Cooperation and participation of stakeholders	✓	✓
Project procurement system		✓
Energy efficiency	✓	✓
Waste management		✓
Land use change		✓

The study revealed a significant difference in the agreement of construction professionals with clearly defined goals for the success of smart and sustainable developments. The goals to be attained by each construction professional in any form of development are not often the same. For instance, the architect is concerned with the aesthetics of the design; the builder is focusing on the buildability and functionality of the development; while the quantity surveyor is seeking ways to ensure the cost of the development is within budget and affordable. The difference in the mindset and goals of the construction professionals could affect their perception of the goals for smart and sustainable developments.

Cooperation and participation of stakeholders were revealed to have a significant difference between organizational types and among construction professionals. Many of the developmental projects in the study area do not involve stakeholders at the initial stage of conception. For instance, architects and clients decide on the design. On completion, they may decide to involve the quantity surveyor. This does not give room for stakeholders' involvement in the design and planning for such projects. This could affect their understanding of stakeholder participation and cooperation in smart and sustainable developments.

The project procurement system also shows a significant difference between the builder and the quantity surveyor for smart and sustainable developments. The specific goals of construction development determine the procurement system adopted. For instance, a development that is focussed on buildability could choose the design and build, construction management or management contracting as a procurement route, while a cost-oriented development may choose procurement routes that will indicate the price certainty before the start of the project which suggests a traditional mode of procurement. Therefore, the difference in goal perception could affect the procurement system chosen for smart and sustainable developments.

7. Recommendation and Conclusions

The success of smart and sustainable developments includes many factors ranging from technical, social, economic, legal and environmental. However, organizations and construction professionals may hold different opinions about factors that contribute to the success of smart and sustainable developments. The divergent opinions of organizations and professionals involved in smart and sustainable developments will affect teamwork among the construction members and subsequently affect the achievement of objectives set for the project. The study identified 40 CSFs for smart and sustainable developments and explored the perception of organizations and construction professionals. The findings show that cooperation and participation of stakeholders and energy efficiency were the statistically significant CSF items between consulting and contracting organizations for smart and sustainable developments; while clearly defined goals, cooperation and participation of stakeholders, project procurement system, energy efficiency, waste management and land use change were the statistically significant CSF items among the construction professionals for smart and sustainable developments.

To ensure that the objectives for smart and sustainable developments are achieved, it is essential that organizations and professionals are involved at every stage of the development starting from the design brief to commissioning and maintenance of the project. This will also ensure that all the stakeholders have common goal and understanding of the construction projects. It will also make it easier to agree on the best method of procurement after considering all the available options, and also help to identify other areas requiring discussions and alignment for the success of the project. The present study has only adopted a quantitative method using a self-reported survey to investigate the difference in agreement with CSFs for smart and sustainable development. The study suggests that an objective approach (e.g. on-site observation of the activities of professionals and organizations in a smart and sustainable development) is adopted in the future to cross-validate the current results.

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