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Sustainability-Specific Criteria for The Selection of Project Delivery Methods

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Abstract

Sustainable construction is more complex than traditional construction projects with unique characteristics and challenges. Choosing the appropriate delivery method is a crucial decision that can help overcome these challenges and enhance the success rate of sustainable construction projects. However, the selection criteria available in literature mainly focuses on traditional criteria such as cost, quality and time. The significance of these traditional selection criteria for project delivery methods indeed cannot be denied but this current list is far from comprehensive. Therefore, the aim of this paper is to identify and rank sustainability-specific criteria for the selection of project delivery methods. Nineteen criteria were identified that were grouped into five categories: level of integration, green liability, green contract, green team, technology and innovation. A survey was then administered to collect the perceptions of construction professionals in the United Arab Emirates about the significance of these sustainability-specific selection criteria. Thirty responses were collected and analyzed using relative importance index to identify the most significant sustainability-specific criteria. The results revealed that the top five sustainability-specific criteria include: early involvement of key participants, improve the ability to use full potential of BIM, efficiently utilize advanced technological tools to achieve sustainability, ability to use technology to enhance communication and allow for qualification-based procurement.

Keywords

Sustainable construction, Project delivery methods, Selection criteria

1. Introduction

Choosing the appropriate delivery method for construction projects has been identified by many researchers as a key ingredient for the success of the project (El-Sayegh, 2008). Delivery method is typically defined as the approach used to establish a framework of the whole design, procurement and construction processes through the allocation of different responsibilities and tasks to the project's parties in such a way that maximizes their benefits (Tenah, 2001). The most common project delivery methods that have been heavily studied and compared in literature in different countries across the world include design-bid-build (DBB), design-build (DB) and construction management at risk (CMR). DBB is also known as the traditional delivery method where two separate contracts are issued one for the contractor and one for the consultant. CMR is similar to DBB in the aspect of two separate contracts but the construction manager in CMR has the responsibilities of both a general contractor and an owner's agent. DB, one the other hand has only contract where a single entity hires both the contactor and the consultant. This allows for fast tracking as construction activities can begin during the design phase (Akpan et al., 2014; Park & Kwak, 2017).

Available literature focuses on traditional selection criteria of project delivery methods such as cost, quality and time (Oyetunji Adetokunbo & Anderson Stuart, 2006; Qiang et al., 2015). Although, one cannot deny the significance of these traditional criteria, they may not be enough to tackle the unique challenges of sustainable construction projects that are different from conventional construction. For starters, the main difference between sustainable and traditional construction is the heightened need for integrated technology in sustainable construction projects due to their interactive and multidisciplinary nature (Raouf & Al-Ghamdi, 2019). Other challenges include the need for distinct green materials and governmental approvals (Ahmed & El-Sayegh, 2022) .

Therefore, there is a need to bridge this gap in literature and derive sustainability-specific criteria for the selection of project delivery methods, to enhance the success rate of sustainable construction projects. The objectives of this research are as follows:

1. Identify sustainability-specific criteria for the selection of project delivery methods

2. Rank the sustainability-specific selection criteria according to their relative importance index

2. Materials & Methods

This study relies on a mixed method approach that combines both qualitative and quantitative techniques. The first part of this research conducts an extensive literature review to extract sustainability-specific criteria. Mixed approach was used to achieve data triangulation where the drawbacks of one method would reverse the drawbacks of the other. Nineteen sustainability-specific selection criteria were identified post extensive screening of literature with the use of specific keywords such as: selection criteria, project delivery methods and sustainable construction. The selected literature was initially filtered using their abstract to eliminate the ones that are not relevant to the topic. Full length of the retained papers was then screened to extract the sustainability-specific criteria.

While the second part was achieved through a questionnaire survey that was administered to construction professionals in the UAE. The aim of the survey was to collect the perceptions of the construction professionals on the significance of each one of the nineteen sustainability-specific criteria. The first part of the survey gathered information to help generate a respondent's profile such as years of experience, role, project type and average size of projects. While the second part used a Likert Scale of 1-5 to rate the significance of the selection criteria. Where 1 represented very low significance and 5 represented very high significance.

The Relative importance index was then calculated for each selection criterion using Equation 1 (Aghimien et al., 2018; El-Sayegh et al., 2018).

$$RII=\frac{\sum_{i=1}^{5} w_i x_i}{\sum_{i=1}^{5} x_i} \quad \text{..... (1)}$$

Where,

w_i is the weight assigned to the ith response; w_i=1,2,3,4,5 for i=1,2,3,4,5 respectively

x_i is the frequency of the ith response

i is the response category index=1,2,3,4,5 for very low, low, average, high and very high significance respectively.

30 responses were collected as the survey only targeted respondents with either knowledge or experience in sustainable construction, where 33.3% of the respondents had 5-10 years of experience, 50% were contractors, 53.3% worked in local companies while 46.7% worked in international companies. Upon collection of data and analyzing them, the paper will also discuss the top five sustainability-specific criteria and will provide recommendations for the selection of project delivery methods in sustainable construction projects.

3. Results

3. 1 Sustainability-Specific Selection Criteria

Extensive literature review was conducted to extract nineteen sustainability-specific criteria that were categorized into five groups: level of integration, green liability. Green team, green contract, technology and innovation. The categorization of these sustainability-specific criteria followed the research done by Ahmed and El-Sayegh (2023) who developed relevant selection criteria of project delivery methods that increase the success rate of sustainable construction projects The first criteria group level of integration consists of four sub-criteria: early involvement of key participants, joint development of project goals, collaborative decision-making and control, intensified planning (Azhar et al., 2014; Korkmaz et al., 2010; Robichaud Lauren & Anantatmula Vittal, 2011).

While the second criteria group green liability consists of three sub-criteria: allow transfer of green liability, promote early assignment of green certification, promote early green guarantee. Molenaar et al. (Molenaar et al., 2009) defined green guarantee as "the point at which there is a contractual responsibility to achieve the desired green certification." The early allocation of tasks and the commitment to achieve sustainability in a project is crucial for the successful delivery of sustainable construction projects (Enache-Pommer & Horman).

Furthermore, the third criteria group green team consists of four sub-criteria: liability waivers among team players, facilitate open communication between team members, minimize adversarial relationships, capitalize on diversity and new opportunities. Having a team that is able to exchange their ideas to be able to successfully reach their shared goals of achieving sustainability outcomes is a crucial selection criterion (Franz et al., 2017; Manata et al., 2021).

Moreover, the fourth criteria group green contract also consists of four sub-criteria: allow shared risks and rewards, contractual incentive fees and awards, allow or qualification-based procurement and facilitate flexible payment provisions. Indeed, this group aims in attracting more contractors to bid for sustainable construction projects

due to the presence of such contractual incentives and the flexibility to negotiate scope and cost (Ahmad & Aibinu, 2017; Xia et al., 2014).

Lastly the fifth group technology and innovation consist of four sub-criteria: capitalize on innovation, ability to use technology to enhance communication, improve the ability to use full potential of BIM and utilize advanced technological tools to achieve sustainability. In fact, researchers have claimed that maximizing the usage of BIM will not only lead to better co-ordination but also the automation of green certificate attainment and sophistication of life-cycle analysis (Brahmi et al., 2022; Bryde, 2008).

Figure 1 illustrates the nineteen sustainability-specific selection criteria.

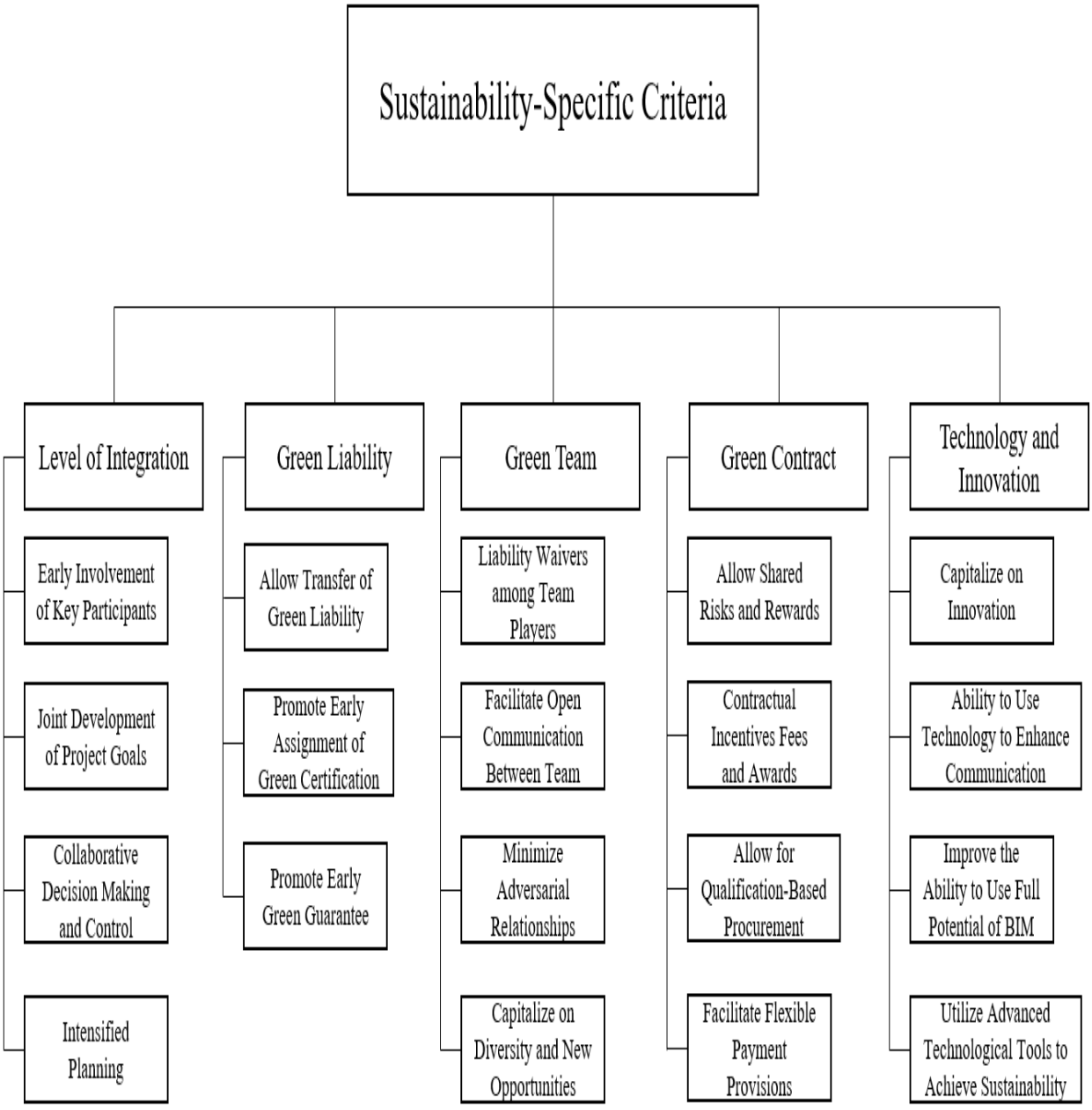

Figure 1. Sustainability-Specific Criteria

3. 2 Significance of The Sustainability-Specific Criteria

Based on the survey results, the relative importance index was calculated for each sustainability-specific criterion. The criteria were then ranked according to their RII. The results are presented in Table 1.

Table 1. RII and Rank of Sustainability-specific Selection Criteria

Sustainability-Specific Selection Criteria	RII	Rank
Early Involvement of Key Participants	4.13	1
Improve the ability to use full potential of BIM	4.00	2
Utilize Advanced Technological Tools for Sustainability	3.93	3
Ability to Use Technology to Enhance Communication	3.93	4
Allow for Qualification-Based Selection	3.90	5
Facilitate Open Communication Between Team Members	3.90	6
Capitalize on Innovation	3.87	7
Allow Shared Risks and Rewards	3.83	8
Joint Development of Project Goals	3.83	9
Collaborative Decision Making and Control	3.80	10
Allow for Transfer of Green Liability	3.77	11
Intensified Planning	3.77	12
Promote Early Green Guarantee	3.67	13
Liability Waivers among Team Players	3.67	14
Facilitate Flexible Payment Provisions	3.63	15
Capitalize on Awards and Contractual Incentive Fees	3.63	16
Promote Early Assignment of Green Certification Responsibility	3.60	17
Minimize Adversarial Relationships	3.43	18
Capitalize on Diversity and New Opportunities	3.13	19

4. Discussion

The results revealed that the top five sustainability-specific criteria were: early involvement of key participants, improve the ability to use full potential of BIM, efficiently utilize advanced technological tools to achieve sustainability, ability to use technology to enhance communication, allow for qualification-based selection. These results confirm the conclusions made by Swarup et al. (Swarup et al., 2011) who stated that involving key participants such as contractors in the early design phases of the project can have a significant impact on the successful delivery of sustainable construction projects as this leads to the creation of a collaborative environment. Moreover, the second most important criterion was the ability to use full potential of BIM. These results are in line with previous studies that emphasized the significance of data-rich BIM that simulates a virtual construction project and enhances the sustainability outcomes of the project. BIM not only demonstrates the geometry and physical properties but the whole building lifecycle with spatial relationships, fabrication and procurement information (Azhar, 2011; Ding et al., 2014).

Furthermore, the fact that three of the technology and innovation criteria made it to the top five selection criteria comes as no surprise. As, Larsson et al. (Larsson et al., 2022) have stated that the implementation of Green Mark Certified projects is positively corelated with the level of technology and innovation adopted in the project. While, the last criterion in the top 5 selection criteria was the qualification-based procurement. This indicates that construction professionals in the UAE have become more aware that the conventional lowest cost procurement approach is not compatible with sustainable construction. This is due to the fact that sustainable construction has its own unique characteristics and challenges that are different from traditional construction projects. This in turn necessitates that contactors have the proper qualification to handle these projects (Ahmed & El-Sayegh, 2022; Yudelson, 2009). On the other hand, selection criteria that made it to the bottom of the list include: capitalize on diversity and new opportunities, minimize adversarial relationships, promote early assignment of green certification responsibility.

5. Conclusions

The move towards sustainable construction has been increasing rapidly throughout the past years. Indeed, sustainable construction projects are more complex than traditional construction projects with unique characteristics and challenges. Choosing the appropriate delivery method is a crucial decision that can help overcome these challenges and enhance the success rate of sustainable construction projects. However, the selection criteria available in literature mainly focuses on traditional criteria such as cost, quality and time. Although, the significance of these traditional selection criteria for project delivery methods indeed cannot be denied but this current list is far from comprehensive as other criteria need to be included to specifically tackle the unique challenges of sustainable construction projects. Therefore, this paper identified and ranked sustainability-specific criteria for the selection of project delivery methods. Nineteen criteria were identified that were grouped into five categories: level of integration, green liability, green contract, green team, technology and innovation. A survey was then administered to collect the perceptions of

construction professionals in the United Arab Emirates about the significance of these sustainability-specific selection criteria. Thirty responses were collected and analyzed. The results revealed that the top five sustainability-specific criteria were: early involvement of key participants, improve the ability to use full potential of BIM, efficiently utilize advanced technological tools to achieve sustainability, ability to use technology to enhance communication and allow for qualification-based procurement. The results of this study recommend emphasizing level of integration and technology when selecting the appropriate project delivery method for sustainable construction projects. The main limitation of this paper is the small sample size due to lack of huge database of construction professionals with experience in sustainable construction in the United Arab Emirates. This paper fills the gap in literature and paves the way to development of a comprehensive decision tool that can help owners in selecting the most appropriate delivery method for their sustainable construction projects based on traditional and sustainability-specific criteria.

References

Aghimien, D. O., Aigbavboa, C. O., Oke, A. E., & Musenga, C. (2018). Barriers to sustainable construction practices in the Zambian construction industry. Proceedings of the International Conference on Industrial Engineering and Operations Management,

Ahmad, T., & Aibinu, A. A. (2017). Project delivery attributes influencing green building project outcomes. *Built Environment Project and Asset Management*, *7*(5), 471-489. https://doi.org/10.1108/BEPAM-11-2016-0066

Ahmed, S., & El-Sayegh, S. (2022). The challenges of sustainable construction projects delivery – evidence from the UAE. *Architectural Engineering and Design Management*, *18*(3), 299-312. https://doi.org/10.1080/17452007.2022.2027224

Ahmed, S., & El-Sayegh, S. (2023). Relevant criteria for selecting project delivery methods in sustainable construction. *International Journal of Construction Management*, 1-9.

Akpan, E. O. P., Amade, B., Okangba, S. E., & Ekweozor, C. O. (2014). Constructability practice and project delivery processes in the Nigerian construction industry. *Journal of Building Performance*, *5*(1).

Azhar, N., Kang, Y., & Ahmad, I. U. (2014). Factors Influencing Integrated Project Delivery in Publicly Owned Construction Projects: An Information Modelling Perspective. *Procedia Engineering*, *77*, 213-221. https://doi.org/https://doi.org/10.1016/j.proeng.2014.07.019

Azhar, S. (2011). Building information modeling (BIM): Trends, benefits, risks, and challenges for the AEC industry. *Leadership and management in engineering*, *11*(3), 241-252.

Brahmi, B. F., Sassi Boudemagh, S., Kitouni, I., & Kamari, A. (2022). IPD and BIM-focussed methodology in renovation of heritage buildings. *Construction management and economics*, *40*(3), 186-206.

Bryde, D. (2008). Perceptions of the impact of project sponsorship practices on project success. *International Journal of Project Management*, *26*(8), 800-809. https://doi.org/https://doi.org/10.1016/j.ijproman.2007.12.001

Ding, L., Zhou, Y., & Akinci, B. (2014). Building Information Modeling (BIM) application framework: The process of expanding from 3D to computable nD. *Automation in construction*, *46*, 82-93.

El-Sayegh, S. M. (2008). Evaluating the effectiveness of project delivery methods. *Journal of Construction Management and Economics*, *23*(5), 457-465.

El-Sayegh, S. M., Manjikian, S., Ibrahim, A., Abouelyousr, A., & Jabbour, R. (2018). Risk identification and assessment in sustainable construction projects in the UAE. *International Journal of Construction Management*. https://doi.org/10.1080/15623599.2018.1536963

Enache-Pommer, E., & Horman, M. Key Processes in the Building Delivery of Green Hospitals. *Building a Sustainable Future*, 636-645. https://doi.org/doi:10.1061/41020(339)65 (Proceedings)

Franz, B., Leicht, R., Molenaar, K., & Messner, J. (2017). Impact of Team Integration and Group Cohesion on Project Delivery Performance. *Journal of Construction Engineering and Management*, *143*(1). https://doi.org/10.1061/(ASCE)CO.1943-7862.0001219

Korkmaz, S., Riley, D., & Horman, M. (2010). Piloting Evaluation Metrics for Sustainable High-Performance Building Project Delivery. *Journal of Construction Engineering and Management*, *136*(8), 877-885. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000195

Larsson, J., Eriksson, P. E., Lingegård, S., & Järvenpää, A.-T. (2022). Innovation outcomes and processes in infrastructure projects–a comparative study of Design-Build and Design-Build-Maintenance contracts. *Construction Management and Economics*, *40*(2), 142-156.

Manata, B., Garcia, A. J., Mollaoglu, S., & Miller, V. D. (2021). The effect of commitment differentiation on integrated project delivery team dynamics: The critical roles of goal alignment, communication behaviors, and decision quality. *International Journal of Project Management*, *39*(3), 259-269.

Molenaar, K., Sobin, N., Gransberg, D., McCuen, T., Korkmaz, S., & Horman, M. (2009). Sustainable, high performance projects and project delivery methods: A state-of-practice report. *White Paper for the Design-Build Institute of America and the Charles Pankow Foundation*.

Oyetunji Adetokunbo, A., & Anderson Stuart, D. (2006). Relative Effectiveness of Project Delivery and Contract Strategies. *Journal of Construction Engineering and Management*, *132*(1), 3-13. https://doi.org/10.1061/(ASCE)0733-9364(2006)132:1(3)

Park, J., & Kwak, Y. H. (2017). Design-Bid-Build (DBB) vs. Design-Build (DB) in the U.S. public transportation projects: The choice and consequences. *International Journal of Project Management*, *35*(3), 280-295. https://doi.org/https://doi.org/10.1016/j.ijproman.2016.10.013

Qiang, M., Wen, Q., Jiang, H., & Yuan, S. (2015). Factors governing construction project delivery selection: A content analysis. *International Journal of Project Management*, *33*(8), 1780-1794. https://doi.org/https://doi.org/10.1016/j.ijproman.2015.07.001

Raouf, A. M., & Al-Ghamdi, S. G. (2019). Effectiveness of Project Delivery Systems in Executing Green Buildings. *Journal of Construction Engineering and Management*, *145*(10). https://doi.org/10.1061/(ASCE)CO.1943-7862.0001688

Robichaud Lauren, B., & Anantatmula Vittal, S. (2011). Greening Project Management Practices for Sustainable Construction. *Journal of Management in Engineering*, *27*(1), 48-57. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000030

Swarup, L., Korkmaz, S., & Riley, D. (2011). Project Delivery Metrics for Sustainable, High-Performance Buildings. *Journal of Construction Engineering and Management*, *137*(12), 1043-1051. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000379

Tenah, K. A. (2001). Project delivery systems for construction: An overview. *Cost Engineering*, *43*(1), 30.

Xia, B., Skitmore, M., Wu, P., & Chen, Q. (2014). How Public Owners Communicate the Sustainability Requirements of Green Design-Build Projects. *Journal of Construction Engineering and Management*, *140*(8), 04014036. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000879

Yudelson, J. (2009). *Green building through integrated design*. McGraw-Hill.

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