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A Framework to Evaluate Sustainable Construction Principles in Government Building Projects: The Case of Jordan

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ABSTRACT

Purpose - This study aimed to provide a framework that includes the principles of sustainable construction to evaluate their application in the construction of government building projects in various environmental, economic, and social aspects distributed over the project phases throughout its life cycle.

Design/Methodology/Approach - Qualitative methods from literature review and analysis of sustainability assessment tools were used to design the framework. The designed framework included six main categories, comprising 19 indicators that include sustainable building principles to assess application levels in government construction projects. It was used to evaluate the application of sustainability practices in Jordanian government construction projects. 133 questionnaires were distributed to a convenience sample of three government institutions concerned with the design, implementation, and management of government buildings in Jordan.

Findings- After collecting the quantitative data, the results showed that there is an application of six sustainability principles during the initial planning, analysis, and design stages of Jordanian government construction projects. The results focused on the application levels in social sustainability principles versus environmental and economical, especially in the operating stages during the project life cycle.

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Originality- This study contributes by providing a tool to evaluate the sustainability of government construction projects and increase the efficiency and effectiveness of these types of buildings in both the short and long term by making them more sustainable. Subsequently, recommendations are made on reorienting government construction projects toward a sustainable building approach.

Keywords Sustainable construction, Evaluating projects, Framework development, Governmental buildings, Jordan.

Paper type Research paper

1. INTRODUCTION

Sustainable construction is related to environmental, economic, and social development (Maywalda and Riesserb, 2016). The concept of sustainability is beginning to enter the construction sector to improve traditional building patterns, reduce environmental and economic impacts, and increase the quality of life (Dutil et al., 2011). The government construction sector is one of the largest sectors that face many challenges to meet the population's needs for service construction projects and social development, which leads to increased economic burdens and depletion of environmental resources. As a result, there is a need to apply sustainability principles in the government construction sector (Hussin et al., 2013). This application requires standards and an integrated management approach (Morfaw, 2014). Therefore, Building Sustainability Assessment Systems (BSASs) was developed to assess sustainability practices and promote its goals (Lazar and Chithra, 2020).

This study focuses on evaluating the application of sustainability principles in government construction projects and directing this sector towards adopting a

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sustainable construction approach by defining the principles and indicators of sustainability that governments and government construction professionals must be aware of during the implementation and operation of construction projects. In a review of the published studies, there was a focus on sustainable construction in private sector buildings or projects and a lack of research on the government construction sector. Therefore, the importance of this study lies in providing an integrated assessment of the dimensions of sustainability in government construction projects and verifying the application of sustainability principles in this sector.

This study aims to provide a framework for evaluating the application of sustainable building principles to government building projects; it also aims to identify the principles of sustainable construction applied in government construction projects. In addition, it evaluates the level of application of sustainable building principles in government construction projects.

2. LITERATURE REVIEW

An objective strategy was used to organize the literature review of sustainable development. It is divided into central topics, including sustainability concept development, the triple bottom line (TBL) of sustainability, and integrating sustainability in the construction sector. In addition, indicators and assessments are considered for assessing the sustainability of construction.

2.1 Sustainability Models and Sustainable Development: Sustainability is one of the terms that receive the most attention regarding various activities, and it has often been difficult for researchers to define its concepts (Kuhlman and Farrington,2010). It was initially known as 'environmental sustainability, i.e., the concept was limited to

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preserving nature and the ecosystem (Yan *et al.,*2009). A questionnaire survey conducted by (Oladokun et al., 2020) showed that the awareness level of sustainability practices among construction professionals is high in Nigeria. However, it did not develop a model or a framework to enhance the construction practitioners' knowledge of this topic. However, the case of Tanzania (Kongela, 2021) showed a low level of awareness among key stakeholders regarding their potential awareness of sustainability and the built environment.

Hermann Daly's definition included additional needs regarding social justice and economic prosperity (Al-Alhaddi, 2015). One study defined sustainability in a complete phrase as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (Kuhlman and Farrington, 2010). Sustainable development requires integrated strategies for balancing environmental, economic, and social requirements. However, its challenges have become a source of new practices for contributing to building a better society.

2.2 Sustainability in Building Construction Works: Construction contributes significantly to the development of countries by providing infrastructure, housing, and other human resources (Durdyev and Ismail, 2016). Owing to recent developments in the construction industry, it has become one of the industries consuming the most natural resources and raw materials (Vyas et al., 2014).

'Sustainable Building' is a broad and complex concept involving a long-term thinking process related to constructing and managing built environments with a life cycle aspect (Ortiz et al., 2009). Researchers believe that governments can play a valuable and essential role in promoting sustainable development in the construction sector (Yung and Chan, 2002). Governments can set stricter legislation for companies to

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protect the environment and urge them to adhere to sustainability considerations in their projects.

In the construction industry, sustainable construction has attracted the attention of many countries and organizations. The type of buildings that sustainable construction produces provide reduced consumption of materials (land, energy, water) and a lower percentage of pollution during the entire life of the building. Therefore, by understanding the root causes of construction waste, stakeholders (primarily customers and contractors) can better identify areas for improvement to reduce construction waste in countries that desperately need minimal resources and are facing economic hardship (Sweis et al., 2021). Thus, a sustainable building is an integrated structure that can be designed, built, managed, and reused to create harmony with the environment and save significant resources (Kibert, 2016).

The public or government sector is considered one of the critical sectors for construction and infrastructure projects. The government sector must replace the traditional low-cost approach by focusing on the cost-effectiveness of the life cycle during a project's life.

Jordan is considered a developing country suffering from many environmental and economic problems (Ali and Nsairat, 2009). In 1992, the Jordanian government became increasingly aware of environmental issues (Al-Rashdan et al.,1999). According to AlKilani and Jupp (2012), the Institute for Sustainable Development Practices (ISDP) was created based on an energy-efficient building code. Thus, in 2015, Jordan began defining its strategic goals for sustainable development at all levels (Fakhoury, 2015).

2.3 Assessment of Sustainability in Buildings and Rating Systems: Sustainable construction is seen as a tool that contributes to development at the international and

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local levels (Chandratilake and Dias, 2013). As a result, it is necessary to assess the sustainability of built environments. The sustainability of construction works, and buildings are assessed by studying the performance of the building using indicators (Kamali and Hewage, 2015). An environmental impact assessment (EIA) includes three types of tools; The first type is based on a system of standards and assigns scores ranging from 'small' to 'significant' in terms of the impact on the environment, the second type includes life cycle assessment (LCA) base tools that consider the product's environmental impact, and the third type is a mixture of standard and LCA systems (Forsberg, 2004).

LCA is a method used to verify the environmental impact of a particular product or process throughout its life cycle (Finnvedern et al., 2009). Researchers in the construction industry seeks to reduce buildings' environmental impacts by conducting an EIA using an LCA (Odey et al., 2021). An LCA contributes to the sustainability process from the design stage to the operation and demolition stages (Caruso et al., 2017). This assessment aims to integrate environmental, economic, and social considerations during the life cycle within the decision-making process (Hu et al., 2013).

According to Guinée and Heijungs (2011), an LCA includes three methods for integrating the three dimensions of sustainability; From an economic perspective, the cost life cycle (LCC) is an effective tool for evaluating costs on a long-term basis for buildings (Petrovic et al., 2021). According to Finkbeiner et al. (2010), a life cycle sustainability assessment (LCSA) is defined as a comprehensive approach that contributes to measuring the environmental impacts of the life cycle of any product from environmental, economic, and social perspectives. Regarding social life cycle assessment (S-LCA) development which is a new approach being studied and

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developed; In recent years, organizations and researchers have developed systems for assessing sustainability in a built environment that includes social impact on construction sustainability (Lazar and Chithra, 2020).

Most of these systems focus on the environmental dimension of sustainability and less on the economic and social dimensions (Bernardi et al., 2017). However, investing in green buildings (for UAE schools) is a lucrative project in a relatively short period so that it can arouse the interest of various stakeholders. In addition, investments in water conservation, energy upgrades, and solar installations can pay off in three to four years. As a result, there is a need to promote sustainable practices in the construction sector and consider a realistic assessment of the sustainability of buildings (Elkhapery, et al., 2021), While (Dabash et al., 2020) conducted a study to compare local green building rating systems with established international green building rating systems (LEED) to find its effects on cost; the study didn't consider the rating systems mentioned above. Green building rating systems in a manner that encompasses the mechanism, categories, place of establishment, similarities, and differences between both rating systems (Dabash et al., 2020). In general, a BSAS evaluates the level of building sustainability by representing the performance of a building through a set of sustainability indicators. Each system adopts a particular set of indicators depending on the social and cultural environment, making each tool differ from the others. Indicators vary according to different societies, cultures, and environments. Several indicators have been developed for assessing all dimensions of environmental, economic, and social sustainability (Kallaos, 2012).

Previous Studies: Table I summarize previous studies that have been conducted on developing frameworks in sustainable building assessments:

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Table I: Previous studies on developing frameworks in sustainable building assessment

Although previous studies have included sets of sustainability principles, some principles fall under more than one category, and the view provides an opportunity for other, more nuanced interpretations and applications to other construction sectors. Previous studies have focused on four global sustainability assessment systems. Nevertheless, studies have indicated that global sustainability assessment systems cover urban, community, and infrastructure projects (Bernardi et al., 2017).

2.5 Research Gap:

Based on the above literature, discussion, and previous related studies, there is a high percentage of global studies on sustainable construction on private sector buildings or projects, while there is a lack of studies on the government construction sector (as represented by service and community buildings). Few studies have focused on verifying the application of sustainability principles on the ground or concerning specific projects in the business and governments sectors (Valdivia1 et al., 2021), and the need for more studies that focus on building performance evaluations (Neij et al., 2021) Locally, no similar studies in Jordan focused on or evaluated sustainable building practices in government projects. Government projects in Jordan generally lack the use of critical categories during construction and typically focus on things like energy savings and insulation, emphasizing LEED principles more than others. This study attempts to fill the gaps by providing an integrated framework by adopting a wide range of sustainability assessment tools to study government projects.

3. RESEARCH METHODOLOGY

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3.1 Research Design: The study comprised two main stages, as shown in Figure 1. The first stage concerned developing a framework for evaluating the sustainability of government construction projects. The second stage concerned using the designed framework to evaluate the application of sustainability practices in Jordanian government construction projects. This study used various quantitative and qualitative methods to reach its study objectives. The qualitative approach used in the first stage allowed drawing connections between concepts and coverage of reports, books, and peer-reviewed sustainability assessment tools. In the second phase of the study, the quantitative approach made verification more reliable and less open to controversy, interpreted the data and presented results directly, and was less error-prone and subjective.

The study was intended to provide an empirical basis for drawing conclusions about government building project construction and operation management through quantitative research method. However, many other government institutions participate in implementing and managing other types of construction projects, such as the Ministry of Public Works and Housing, which did not include in the research sample.

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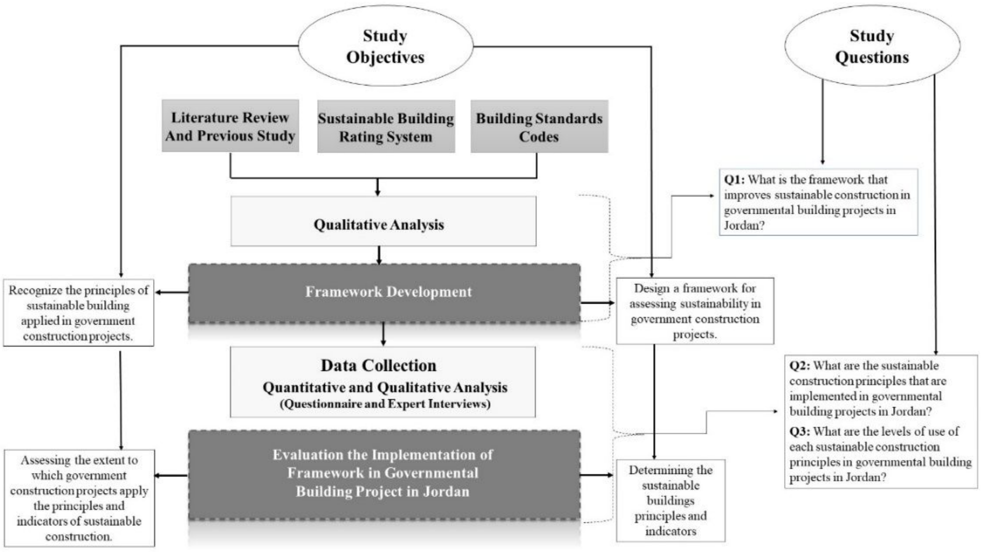

Figure 1: Research diagram adopted in evaluating sustainable construction in Jordanian governmental building projects

3.2 Framework Development: The study relied on a qualitative approach to develop a framework for assessing the application of sustainability principles to government construction projects, where the literature was reviewed for previous studies, analysis of sustainability assessment tools, classification of global sustainability systems to study the previous frameworks, and access to the final version of the proposed framework. New categories of sustainability principles applied to government construction projects have been arrived at. Five new classification systems were added to the results of previous studies and analyzed with greater precision. Figure 2 shows the approach adopted to develop the study framework.

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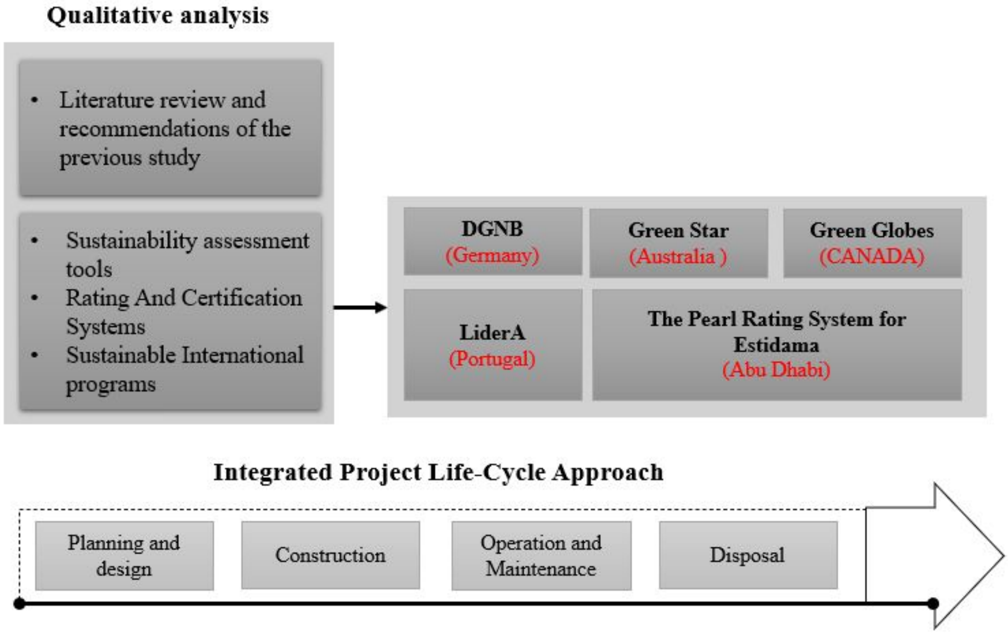

Figure 2: List of rating systems that shows the data sources to formulate the framework

This study analyzed the five sustainability assessment systems for their categories, joint issues, and most critical criteria on which most selected evaluation systems are focused. Nine common categories were analyzed: location and accessibility, indoor environmental quality, water, energy, resources and materials, waste, management, economic quality, and LCA. In this study, two important categories were added to the sustainability analysis for government construction projects. The LCA category focused on assessing a building's performance over the entire life cycle. This was because considerations related to the life cycle phases are sensitive in the development and service projects of the government construction sector. Furthermore, broader analyses were added to the management category, i.e., include analysis of the initial project plans, integrated design processes, responsible building practices, performance compliance, measurement and monitoring, and future adaptation and resilience to increasing government building project efficiency.

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The design of the framework focused on three basic principles; the first principle is specificity in the choice of principles ,including sustainability principles related to different types of development and service projects for government construction, the second principle concerns the integration of the three dimensions of sustainability; the framework includes environmental, economic, and social considerations, the third principle is inclusivity in the framework design.

The final framework contained six main categories, 19 indicators, and 132 criteria for determining the framework's indicators. The main categories and indicators were selected based on environmental, economic, and social considerations, as distributed over the three main phases of the project and throughout the life cycle. Figure 3 shows the critical categories and indicators distributions over the project phases. The selection of framework categories and indicators was based on three main objectives of the sustainability assessment process for government construction projects, as follows:

- Adaptability and flexibility: This can be achieved through a planning process incorporating specific strategies for changing the current and future course of the project.
- The efficiency of solutions and choices: This can be achieved through environmental studies and the development of design and implementation solutions for the analysis, design, and implementation stages.
- Measurement and quality of performance: This can be achieved by ensuring occupant satisfaction and the effectiveness of approaches to environmental issues and by measuring the life cycle performance of the project in the operation, maintenance, and demolition phases.

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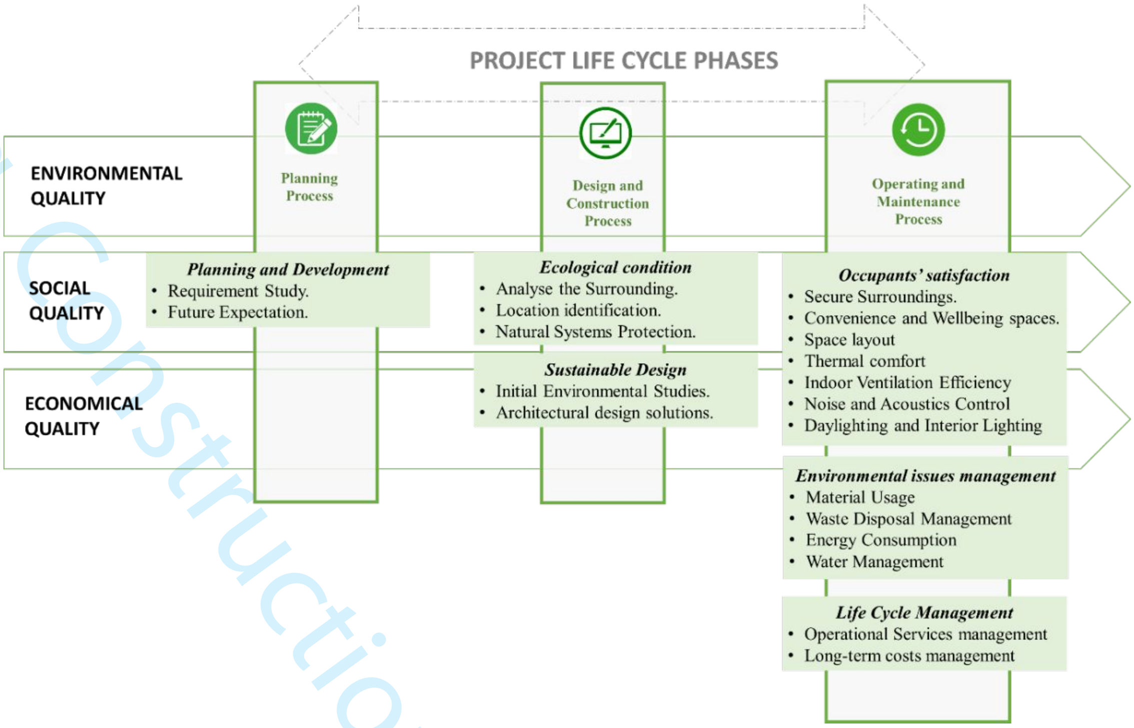

Figure 3: Basic structure of the proposed framework

Table II shows the main categories and indicators of the sustainability assessment framework.

Table II: Suggested sustainability assessment categories and indicators

3.3 Data Collection: The implementation phase of the framework designed to assess the sustainability of government construction projects relied on a variety of quantitative and qualitative methods, including questionnaire design and expert interviews.

A pilot study of the questionnaire was conducted and distributed to 14 engineers. In addition to four expert interviews with construction experts in the government construction sector to help understand the status of government construction projects and their compatibility with the principles of sustainable construction. The scope of the research includes three government institutions responsible for more than 50 regions covering the entire Kingdom.

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The sample size was determined using a confidence level (95%) and margin of error (5%).

The population size was determined based on the statistics of the human resources departments and the heads of departments in the concerned institution. Finally, the required relative sample size was calculated as follows (Kotrlik and Higgins, 2001):

$$[SS = Z^2 \times P \times (1 - P)/C^2] \qquad \ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

Where:

SS: Sample Size

Z: The value of Z (e.g., 1.96 or 95% confidence level)

P: Percentage picking a choice, expressed as a decimal (0.5 used for SS needed)

C: Confidence interval, expressed as a decimal (e.g., 0.05 = $\pm$ 5)

$$\therefore [SS_{adjusted} = SS/(1 + (SS - 1)/Pop)] \quad \ldots\ldots\ldots\ldots \text{(2)}$$

One hundred thirty-three questionnaires were distributed; 25 were electronic questionnaires (designed by Google Form), and the rest were on paper. The Greater Amman Municipality included the most significant number of samples, representing 86% of the total number of questionnaires. Of the 133 questionnaires, 114 (86%) were answered in the departments among three governmental institutions (Amman, Irbid, and Karak) in greater municipalities. Cronbach's alpha was used to test the reliability of each set of questionnaire dimensions. The minimum required for this research to achieve reliability was between 0.70 and 0.80, according to Bland and Altman (1997). The reliability of the survey questions was 0.954 - higher than the imposed minimum for the initial variables (Planning and Development, Ecological Conditions, Sustainable

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Design, Occupants' satisfaction, Environmental Issue Management, and Life Cycle Management).

A one-sample *t*-test with a 95% confidence level was used to assess whether respondents significantly agreed or disagreed with the application of Sustainability Assessment Framework categories. If the significance value is less than the significance level of 0.05, it can be concluded that there are statistically significant differences between the respondents' answers to the questions. In contrast, there are no significant differences if the significance value is greater than this level. Therefore, respondents broadly agreed with applying these indicators and factors. A one-way analysis of variance (ANOVA) was performed to compare the differences in the means between three or more groups. In addition, a Levene's test for homogeneity with an F distribution was performed for each group that was tested using the statistical package for the social sciences (SPSS®) 28.0.

4. DATA ANALYSIS, RESULTS, AND DISCUSSION

This study evaluated the sustainability principles and the extent of their application to Jordanian government building projects. The respondents included 109 engineers and five department heads. The most significant numbers of respondents had experience over ten years (39.5%) and five-to-ten years (36.5%). However, nearly half (46.5%) of respondents had good knowledge regarding sustainable building projects. (39.5%) of the

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respondents agreed that the percentage of projects applying sustainable building principles in government institutions is less than 10%. This may indicate the low level of application of sustainability principles. Therefore, the respondents were asked to evaluate whether the indicators and factors of these categories were applied. The results highlight the most-applied sustainability principles in government buildings and their application levels.

Results may indicate that the focus on applying sustainability principles is centered in the early stages of the project. As shown in Table III, the Sustainable Design category ranks first, with the highest average value of 3.2917. The Life Cycle Management category and management of environmental issues rank last for application.

Table III: Descriptive statistics and t-test of the government buildings sustainability assessment categories

Table IV shows descriptive statistics for each of the six major category indicators. The categories are arranged according to the mean values, where the secure surroundings indicators analyze the surrounding. The indicators for material use, waste disposal management, and long-term cost management have the lowest average values.

Table IV: Descriptive statistics of the government buildings' sustainability assessment indicators

The results in Table V indicate an application of the Requirement Study indicator with an average value of 3.4965, i.e., higher than 3. In contrast, according to the respondents' opinions, the Future Expectation indicator with an average value of 2.6462 (less than three) is not applied.

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Table V: Descriptive statistics and t-test of Planning and Development Category

Results from applying the factors of the requirement study indicator indicate that the factor of studying the general feasibility ranks first, whereas managing and reducing the time required for on-site factors ranks last. The results shed light on the importance of the planning and development stages in achieving sustainability principles. Although the results show applying sustainability principles for achieving a lower initial cost within this stage, the respondents disagree significantly regarding this application. The t-test results show that there are differences between the respondents' answers regarding applying this factor. As a result, it can be concluded that there is an application of the principles for reducing the project's initial cost, but other practices may also be reducing this cost. Results of the t-test confirm that respondents disagree with sustainability principles associated with minimizing future costs through energy efficiency, water quality, and noise pollution.

Results may show that the focus on sustainability-related principles for reducing environmental impacts and preserving natural systems is not applied within government building projects. However, the final decision on this can only be obtained by studying applying the factors for these indicators. Table VI presents the results from the analysis of the Ecological conditions category and its three indicators.

Table VI: Descriptive statistics and t-test of Ecological Condition Category

Results show that government institutions apply sustainability principles to meet the needs of the local community in terms of services. This may contribute to promoting social development and creating new projects. A one-sample t-test was used to check whether respondents significantly agreed with applying these factors; results indicate the respondents did not significantly agree. These results show a disparity in the focus

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on sustainability principles related to protecting natural systems. Table VII presents the results from the analysis of the two indicators of the Sustainable Design category.

Table VII: Descriptive statistics and t-test of Sustainable Design Category

The *t*-test for the Sustainable Design category indicates significant differences in the respondents' opinions on applying these indicators. The ratio between the building area and total land area ranks first, whereas the outdoor landscape design factor ranks last. Results confirm that sustainability-related principles can be applied to the development of architectural solutions. A one-sample t-test was used to check whether the respondents highly agreed with applying these factors.

Table VIII shows the descriptive statistics and t-test results for questions related to applying the Occupants' satisfaction category indicators. Results show no agreement on applying the daylighting and interior lighting indicator within government building projects. This can be explained by studying applying each indicator's factors.

Table VIII: Descriptive statistics and t-test of Occupants' satisfaction Category

According to the respondents' responses, there is an agreement that all factors of the secure surroundings indicator are applied at high rates. The factor concerning providing effective system and design specifications against fires ranks first; the provision of these systems has become a prerequisite from the General Directorate of Civil Defense for designing government projects. Therefore, it can be considered that the sustainability principles for providing safe environments for users are applied within government building projects.

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The results related to the thermal comfort index factors indicate that the factor of providing sunshades and louvers in open spaces, corridors, and parking is the one factor higher than 3, at 3.1228. A one-sample t-test was used to examine whether respondents highly agree with applying these factors within government building projects; the results indicate that the respondents agree that there are differences between the respondents' answers to these questions.

In general, it can be concluded that sustainability principles related to the conservation of resources are not applied in government building projects. The Waste Disposal Management indicator ranks first in terms of the weakness of applying its factors. Table IX summarizes respondents' opinions on these indicators.

Table IX: Descriptive statistics and t-test of Environmental issues management Category

Material usage indicator factors were weakly applied in governmental building projects. The factors related to recycling had the lowest mean values among all factors. Adopting traditional procurement methods and buying materials from unreliable local sources may be why the reason for this non-application. It can be concluded that there is a lack of awareness of the importance of choosing materials.

Respondents' opinions on the application of waste disposal management factors are not applied to a large extent. The results do not mention any application of sustainability principles for making design decisions for the reuse of materials or building structures. This could be interpreted as a lack of awareness of the importance of waste sorting and recycling. Using energy-saving lighting systems is the factor ranked first, with an average value of 3.5263 (i.e., higher than 3). The factor of the effective use of space and management of cooling and heating sources ranks last. This indicates an effort to apply the principles of sustainability related to reducing energy

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consumption. Results show that sustainability-related principles for reducing water consumption are applied within government building projects in more than one way. However, results do not show any sustainability-related principles related to recycling, rainwater reuse, and wastewater treatment on-site; this may be due to a lack of awareness. The t-test was used to assess whether the respondents agreed with applying these indicators and factors; the results indicate that respondents disagree significantly with applying these factors.

The implementation of the Operational Service Management category was examined. The respondents were asked to rate the level of application of these factors and their opinions of the factors. Results indicate a p-value of <.001, i.e., less than 0.05, for this analysis. Table X provides the results from the t-test on applying these indicators to the Life Cycle Management category. Developing operating and maintenance plans for the building in partnership with facility management has the highest mean value, while periodically monitoring the energy and water consumption throughout the building has the lowest mean value. The results indicate a partial application of sustainability principles to improve the performance of the building. At the same time, the results of a review of government organizations' sustainability plans and performance show that they cannot balance these plans with the actual performance of construction projects.

Table X: Descriptive statistics and t-test of Life Cycle Management Category

As a result, they cannot achieve sustainability goals in the operating stages of building projects and the planning stages. This shows that there is a partial application of these principles to improve the performance of the building, but this performance is

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not sufficient to ensure sustainability within the operational stages and achieve the desired benefits.

Table XI shows the ANOVA analysis that was performed to assess whether respondents' responses were statistically different within the three geographical regions (central, north, and south of the Kingdom) concerning the six main categories of assessment, i.e., planning and development, environmental conditions, sustainable design, occupant satisfaction, and management of environmental issues, and life cycle management. Results from Levene's test for homogeneity indicate homogeneity in the variance between the respondents' answers for the six categories. The results of the ANOVA test indicate that all F values are less than the tabular F value of 3.078, and all of them carry significance values greater than 0.05. There are statistical differences between respondents' answers within the three geographical areas regarding the category of Ecological condition. This indicates statistically significant differences between the respondents' answers in the three geographical regions for this category. As for the rest of the categories, there are no statistically significant differences within the three geographical regions. The difference in application between these areas can be attributed to the temporary lack of financial costs and efforts to select project sites in the northern region of the Kingdom.

Table XI: ANOVA test results for geographical areas group

Table XII presents the statistical test results to determine whether there are differences in the respondents' opinions within the five sections in which the survey questions were distributed in different government institutions regarding the six main evaluation categories. Levene's homogeneity test results indicate homogeneity (equal

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variances) among the respondents' opinions in the five government institutions sections for these categories. Results from the ANOVA test show that the F values for the categories Planning and Development, Ecological condition, and Sustainable Design are greater than the tabular F value of 2.46. Results indicate differences between the respondents' opinions from the department of studies and design and all other departments. The respondents' opinions differ between the departments of government institutions to which the survey was distributed. This could indicate a lack of coordination between these departments regarding sustainability in the planning, analysis, and design stages of government building projects. In addition, there is a difference between the opinions of the department of buildings in both the Ecological condition category and Sustainable Design category.

Table XII: ANOVA test results for departments group

Based on the interviews, the focus of government institutions is on exploiting construction without looking out for the environmental benefits. This is owing to a low focus on studying the green areas, despite their limited presence in the area where construction is carried out. Social projects are not selected sustainably, as departments study the effects of projects retroactively after their implementation. This indicates a misapplication in the initial planning of such projects.

5. CONCLUSION AND RECOMMENDATIONS

Quantitative and qualitative that were used in the research methodology aimed to present an integrated framework comprising six main categories, 19 indicators and 132 factors that reflect sustainability principles within the stages of the project during its life

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cycle. This is to verify the application of sustainability principles in government building projects and to assess their status based on the analysis. The results conducted on Jordanian government building projects indicated that there are applications of some sustainability principles in the early stages of the project, including the planning stage, the analysis stage, and the design stage. In addition, the results indicated that the most applied sustainability principles in these projects could be found among the requirements study indicators, Perimeter analysis, safe surroundings, and architectural design solutions.

According to the engineers and experts who have more than 13 years of experience in the government construction sector and who were interviewed, the construction of Jordanian government buildings is primarily to meet the local community's needs and promote social development. This can be explained by the insufficient budget for government construction projects. The objective of government institutions has been to meet ongoing local demand for these projects, provide spaces for local participation and reduce upfront costs.

Survey results show a lack of application and management of principles related to long-term cost management, material reuse, and recycling. Increasing pressure on communities and service projects due to population increase has led to an insufficient budget for government construction projects. This is due to the lack of a particular department responsible for this type of project and the existence of a specialized database for sustainable construction.

The survey's results conflict with the implementation and management principles related to long-term cost management, material reuse, and recycling in Jordanian government construction projects which were emphasized in the basic structure of the proposed framework illustrated in Figure 2 and 3. It was also noted that

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there is a difference in the application of the principles of sustainability within the geographical regions of the Kingdom and the departments of government institutions. The interviewed experts indicated that this is due to the lack of a responsible private administration and specialized database for sustainable building issues. Therefore, it is recommended to increase the awareness of these institutions of the importance of implementing sustainable practices and increase government support for sustainable building issues.

This study; the case of Jordan, can fill the gaps of similar studies that were referred to in the literature review and provide decision-makers in the government construction sector with a tool to identify and evaluate the current sustainability of government building projects and increase their efficiency and effectiveness to reduce costs on government budgets and support sustainable development strategies for countries. The application of sustainability principles in government construction projects is like any noticeable changes in public institutions, requiring a cultural change and raising awareness among decision-makers in these institutions to change the current situation. It will be necessary to recruit development-seeking specialists to implement the models within these institutions. This study has some limitations, but it can apply the results to other countries with similar environmental, economic, and social conditions or re-evaluate government construction projects in other countries. This study's results can be considered a basis for further research on the applications of sustainability in the government construction sector Future work may include developing frameworks that consider infrastructure projects.

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Table I: Previous studies on developing frameworks in sustainable building assessment

Country	Objectives	Methods	Findings	Type of Projects	Author (year)
Global studies	Develop a more comprehensive tool that includes sustainability considerations in developing countries	Primary goals and indicators	Proposed a framework of basic building stages and set specific activities for each stage	Private Sector	Gibberd, Jt. (2005)
	Design a logical performance evaluation framework for sustainable buildings	Classification systems and reviewing the research groups	Created a framework for the sustainable building evaluation system in a programmed manner	Private Sector	Kang, H. J. (2015)
Malaysia	Formulate a theoretical framework that contains sustainability principles	Content analysis	Developed a framework with principles that include the three dimensions of sustainability for Malaysian construction	Private Sector	Mohd Isaet al. (2014)
Kazakhstan	Design a framework for building sustainability assessment for commercial buildings in Kazakhstan	Content analysis	Proposed a framework for assessing the sustainability of commercial buildings	Private Sector	Akhanova et al. (2019)

Table II: Suggested sustainability assessment categories and indicators

Code	Suggested Categories	Suggested Indicators
P. D	Planning and Development	P. D1 Requirement Study P. D2 Future Expectation
E.C	Ecological condition	E.C1 Analyze the Surrounding. E.C2 Location identification. E.C3 Natural Systems Protection
S. D	Sustainable Design	S. D1 Initial Environmental Studies. S. D2 Architectural design solutions.
O. S	Occupants' satisfaction	O. S1 Secure Surroundings. O. S2 Convenience and Wellbeing spaces. O. S2.1 Space layout. O. S2.2 Thermal comfort. O. S2.3 Indoor Ventilation Efficiency.

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			O. S2.4 Noise and Acoustics Control. O. S2.5 Daylighting and Interior Lighting.
E.M	Environmental issues management	E.M1 E.M2 E.M3 E.M4	Material Usage. Waste Disposal Management. Energy Consumption. Water Management.
LC.M	Life Cycle Management	LC.M1 LC.M2	Operational Services management Long-term costs management

Table III: Descriptive statistics and t-test of the government buildings sustainability assessment categories

Category	Sustainable Assessment Categories	Rank	Mean	Std. Deviation
Indicators	Planning and Development	3	3.1776	.43234
	Ecological condition	4	3.1502	.43425
	Sustainable Design	1	3.2917	.42263
	Occupants' satisfaction	2	3.1971	.29635
	Environmental issues management	6	2.5691	.34771
	Life Cycle Management	5	2.6458	.30683
		t	df	Sig. (2-tailed)
	Sustainable Assessment Categories	-2.453	113	.016

Test Value = 3

Table IV: Descriptive statistics of the government buildings sustainability assessment indicators

Category	Sustainable Assessment Categories	Rank	Mean
Indicators	1. Requirement Study	4	3.4965
	2. Future Expectation	15	2.6462
	3. Analyze the Surrounding	2	3.6520
	4. Location identification	9	3.0123
	5. Natural Systems Protection	13	2.7632
	6. Initial Environmental Studies	16	2.5906
	7. Architectural design solutions	3	3.5253
	8. Secure Surroundings	1	3.8567
	9. Space layout	5	3.4620
	10. Thermal comfort	12	2.7661
	11. Indoor Ventilation Efficiency	6	3.3441
	12. Noise and Acoustics Control	8	3.0478
	13. Daylighting and Interior Lighting	10	2.9156

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14. Material Usage	17	2.4376
15. Waste Disposal Management	18	2.3825
16. Energy Consumption	11	2.7785
17. Water Management	14	2.6673
18. Operational Service Management	7	3.1151
19. Long-term costs management	19	2.1765

Table V: Descriptive statistics and t-test of Planning and Development Category

Category	Planning and Development	Rank		Mean	Std. Deviation
Indicators	Requirement Study	1		3.4965	.41582
	Future Expectation	2		2.6462	.65669
				3.1776	.43234
		t	df	Sig. (2-tailed)	Mean Difference
	Planning and Development	4.387	113	<.001	.17763

Test Value = 3

Table VI: Descriptive statistics and t-test of Ecological Condition Category

Category	Ecological condition	Rank		Mean	Std. Deviation
Indicators	Analyze the Surrounding	1		3.6520	.61109
	Location identification	2		3.0123	.48575
	Natural Systems Protection	3		2.7632	.63373
				3.1502	.43425
		t	df	Sig. (2-tailed)	Mean Difference
	Ecological condition	3.692	113	<.001	.15015

Test Value = 3

Table VII: Descriptive statistics and t-test of Sustainable Design Category

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Category	Sustainable Design	Rank	Mean	Std. Deviation
Indicators	Initial Environmental Studies	2	2.5906	.85765
	Architectural design solutions	1	3.5253	.37170
			3.2917	.42263

	t	df	Sig. (2-tailed)	Mean Difference
Sustainable Design	7.368	113	<.001	.29167

Test Value = 3

Table VIII: Descriptive statistics and t-test of Occupants' satisfaction Category

Category	Occupants' satisfaction	Rank	Mean	Std. Deviation
Indicators	Secure Surroundings	1	3.8567	.42528
	Convenience and Wellbeing spaces			
	○ Space layout	2	3.4620	.44844
	○ Thermal comfort	6	2.7661	.61115
	○ Indoor Ventilation Efficiency	3	3.3441	.37715
	○ Noise and Acoustics Control	4	3.0478	.37831
	○ Daylighting and Interior Lighting	5	2.9156	.35100
			3.1406	.31340
			3.1971	.29635

	t	df	Sig. (2-tailed)	Mean Difference
Occupants' satisfaction	7.103	113	<.001	.19714

Test Value = 3

Table IX: Descriptive statistics and t-test of Environmental issues management Category

Category	Environmental issues management	Rank	Mean	Std. Deviation
Indicators	Material Usage	3	2.4376	.57655
	Waste Disposal Management	4	2.3825	.45744
	Energy Consumption	1	2.7785	.58134
	Water Management	2	2.6673	.32943
			2.5691	.34771

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	t	df	Sig. (2-tailed)	Mean Difference
Environmental issues management	-13.232	113	<.001	-.43089

Test Value = 3

Table XI: ANOVA test results for geographical areas group

	Test of Homogeneity		ANOVA		Tukey HSD		
Category	**Groups**	**Levene Sig.**	**F**	**Sig.**	**N**	**Subset for alpha=0.05**	
Planning and Development	Northern Jordan	.062	1.199	.305	22	3.0568	
	Central Jordan				84	3.1994	
	Southern Jordan				8	3.2813	
					Sig.	.299	
					Ryan-Einot-Gabriel-Welsch		
					N	**Subset for alpha=0.05**	
Ecological condition	Northern Jordan	.002	3.206	.044	22	2.9679	
	Central Jordan				8	3.0221	3.0221
	Southern Jordan				84		3.2101
					Sig.	.759	.235
					Tukey HSD		
					N	**Subset for alpha=0.05**	
Sustainable Design	Northern Jordan	.160	1.175	.313	84	3.3264	
	Central Jordan				22	3.1742	
	Southern Jordan				8	3.2500	
					Sig.	.557	
					Ryan-Einot-Gabriel-Welsch		
					N	**Subset for alpha=0.05**	
Occupants' satisfaction	Northern Jordan				22	3.1065	
	Central Jordan				8	3.1447	

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	Southern Jordan	.008	1.565	.214	84	3.2259
					Sig.	.214
					Tukey HSD	
					N	**Subset for alpha=0.05**
Environmental issues management	Northern Jordan	.076	1.061	.350	84	2.5915
	Central Jordan				22	2.4723
	Southern Jordan				8	2.6006
					Sig.	.541
Life Cycle Management	Northern Jordan	.330	.467	.628	84	2.6622
	Central Jordan				22	2.5938
	Southern Jordan				8	2.6172
					Sig.	.800
Tabled F =3.078						

Table XII: ANOVA test results for departments group

	Test of Homogeneity		**ANOVA**		**Ryan-Einot-Gabriel-Welsch**		
Category	**Groups**	**Levene Sig.**	**F**	**Sig.**	**N**	**Subset for alpha**	
Planning and Development	Maintenance and sustain building department	<.001	9.223	<.001	2	2.5625	
	Department of buildings				17	3.0368	
	Department of supervision and project management				47	3.0426	
	Department of planning				10	3.0625	
	Department of Studies and Design				38		3.4704
					Sig.	.374	1.000
Ecological condition	Maintenance and sustain building department	<.001	6.629	<.001	2	2.7941	
	Department of buildings				17	2.9689	

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	Department of supervision and project management				47	3.0063	
	Department of planning				10	3.3000	3.3000
	Department of Studies and Design				38		3.3885
					Sig.	.122	.849
Sustainable Design	Maintenance and sustain building department	.016	4.347	.003	2	2.8750	
	Department of buildings				17	3.0882	
	Department of supervision and project management				47	3.2110	
	Department of planning				10	3.3917	3.3917
	Department of Studies and Design				38		3.4781
					Sig.	.179	.860
						Tukey HSD	
					N	**Subset for alpha**	
Occupants' satisfaction	Maintenance and sustain building department	.151	2.655	.037	17	3.1130	
	Department of buildings				2	3.1184	
	Department of supervision and project management				47	3.1299	
	Department of planning				10	3.2237	
	Department of Studies and Design				38	3.3151	
					Sig.	.679	
Environmental issues management	Maintenance and sustain building department	.356	.725	.577	17	2.4778	
	Department of buildings				47	2.5423	
	Department of supervision and project management				2	2.5854	
	Department of planning				38	2.6175	
	Department of Studies and Design				10	2.6634	
					Sig.	.855	
Life Cycle Management	Maintenance and sustain building department	.533	.615	.653	2	2.4375	
	Department of buildings				17	2.6140	

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	Department of supervision and project management	47	2.6237
	Department of planning	10	2.6438
	Department of Studies and Design	38	2.6990
		Sig.	.505
Tabled F =2.46			