Case Study

Establishing a Green Building Certification Scheme and Standards for Multifamily Residential Buildings: Case of Jordan

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Abstract: Jordan's built environment is considered a major contributor to local environmental concerns. The construction industry faces pressures to increase the sustainability of its practices through the development of green buildings and their associated rating tools. The reliance on international green building rating tools has proven influence on steering the national sustainable route. However, their application remains challenging when considering the contextual particularities and the multiplicity in building types subjected to them, highlighting the need for their customization. This study describes a research that aims at developing a localized green building rating tool that suits the Jordanian context for multifamily housing. It builds upon an investigation of globally/regionally recognized tools, identifying areas of convergence and distinction, for the aim of their consolidation into the proposed scheme. This was achieved through the deployment of the Delphi technique and the Analytic Hierarchy Process in rounds of facilitated local expert discussions. The outcome is a green building tool (Diana) that is suited to the local requirements and the specificity of building type as compared with other rating tools. **DOI: 10.1061/(ASCE)AE.1943-5568.0000468**. *© 2021 American Society of Civil Engineers.*

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Introduction

Human development comes at the expense of a detrimental impact on energy and other resources. Raising the living standard, economic growth, and urban sprawl have had significant effects on the demand for energy and other natural resources (Alawneh et al. 2019a). The resultant population growth and improved technology led to global warming and climate change, which have demanded prompt actions in developed and developing countries to avoid further deterioration being inflicted upon future generations (Ali and Hashlamun 2019; Bilir et al. 2014). Sustainable development has thus risen as a prominent concept to meet the needs of the current generation without compromising the ability of future generations to meet their own needs, providing a particular emphasis on economic, social, and environmental pillars (WCED 1987).

Buildings are among the highest contributors to global issues, consuming 36% of the world's energy, 25% of its water, and 40% of other resources. They also contribute to approximately 39% of CO_2 emissions and 40% of total waste produced (Bernardi et al. 2017; El Hanandeh 2015). The construction sector has gone through astronomical expansion, where in 2016 an estimated 235 billion square meters of total floor area had been constructed, a figure that is mostly expected to double in the next 40 years (Abergel et al. 2017; Chen et al. 2015; Pandey 2018).

Considering the reality of developing countries, experts generally believe that the detrimental impact of construction is even worse compared with developed countries. Developing countries maintain a booming population, which is expected to constitute 98% of the world population by 2025, 40% of which are expected to live in cities, imposing more pressure on the building sector (Alawneh et al. 2018). Jordan is not an exception with its growing population and urbanization movement fueling an expanding construction industry (Al-Azhari and Al-Najjar 2013). Such development is, however, hit with the scarcity in energy and resources in general required to accommodate increasing demand levels (Alyami et al. 2013).

Buildings consume resources throughout their life cycle, not only during their construction (Illankoon et al. 2017; Kang et al. 2016; Yang et al. 2013). They are quite significant as they are closely related to the daily lives of people, who spend most of their time there. They accordingly maintain both short- and long-term influence on people's health and social wellbeing (Kamaruzzaman et al. 2018). In view of that, the impact of buildings on both the environment and society is sizable, should they be unsustainably designed, built, operated, or maintained.

These challenges give rise to the need for comprehensive frameworks that assess the environmental performance of buildings (Alawneh et al. 2019b). For that purpose, and since the 1990s, green building rating tools have undergone extensive development, many of which have subsequently gained considerable recognition (Cole and Jose Valdebenito 2013) resulting in the global adoption of well-established tools (Seinre et al. 2014). Yet, these tools have been criticized by a number of scholars (Ding et al. 2018) mainly for their use in regions for which they were not originally intended and due to the lack of a weighting system that is sufficiently adaptive (Alyami et al. 2015). Accordingly, some scholars attempted to customize some of the rating tools to

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better suit the local context (particularly in developing countries), such as the case of Alyami (Alyami et al. 2013), who developed an assessment tool for the construction sector in Saudi Arabia in light of a prevalent modernistic, lavish living standard impacting its residential building sector, Kamaruzzaman (Kamaruzzaman et al. 2018), who articulated a refurbishment building assessment scheme in Malaysia, and AbdelAzim (AbdelAzim et al. 2017), who developed an energy efficiency rating system for existing buildings in Egypt. Despite such recurring efforts, the developed rating tools remain in need of continuous revision and update.

The research is based on two assumptions; the first being that well-recognized international sustainable assessment tools are not necessarily equally applicable, with the same parameters and/or priorities, for all regions of the world. This is due to the vast differences between the regions based on their specific environmental, economic, and sociocultural conditions (Alyami et al. 2015; Ding et al. 2018). The environmental concern priorities may differ between the Middle East, North America, and Eastern Europe since multiple aspects, such as climatic conditions and natural resources, would significantly vary (Neama 2012; Suzer 2015). Suzer provided examples by suggesting that Middle Eastern countries could assign greater priority to water problems over energy problems because of the water scarcity they faced (Suzer 2015). These regional/national variations are hard to define (AlQahtany et al. 2013), calling for expert judgment when assigning relative importance to the different aspects of sustainability since an "objective scientific weighting" is not possible in a manner that completely addresses such complexity (Suzer 2015). Second, it is hard to choose the right rating tool for a particular building type. For example, even the renowned rating tools of residential buildings may not be appropriate to rate all types of residential buildings due to their variations (Ali and Al Nsairat 2009). These aspects are significant in light of the effort spent in developing and appropriating rating tools, which would be in vain should this happen without reflecting the specific requirements (Lu et al. 2017).

The aim of this research is to develop a tool for rating the "green" practices within multifamily residential buildings in Jordan on two different levels: the building as a whole and the apartment unit specifically. This is achieved by targeting a comprehensive framework with detailed parameters that are sensitive to Jordan's local context and targeted building type. The tool (named "Diana") also includes an adaptive weighting system to measure the level of sustainability of the building under study. To this end, the study relies on research methods centered on the collective knowledge and experience of a selected number of local experts, where their insights were facilitated, aggregated, and analyzed by the use of the Delphi technique (DT) and the Analytical Hierarchy Process (AHP). The anticipated outcome of the research is to ensure the achievement of effective sustainable development: one that is considerate of the Jordanian local context (with focus on its opportunities and challenges) and building types (with focus on their variety) by capitalizing on the available knowledge and technology. This research targets attached multifamily housing, resulting in three important contributions. First, the study emphasizes the importance of the local context as the main driver to customizing a rating tool. Second, although multiple rating tools could emerge within the same local context, they still differ in terms of structure, categories and indicators according to the building type being rated. Third, the study of the multifamily residential building type necessitates going into further detail, moving from the scale of the building to the scale of the apartment unit within, which raises further considerations and complexities.

Literature Review

Green Building Rating Systems

Green building rating tools were developed to provide a set of criteria for designers and contractors to be able to convey sustainable development in building and construction processes and, accordingly, assess building environmental performance (Li et al. 2017; Suzer 2015). The generated ratings can be used as a design or management tool to guide and organize environmental strategies across a building's life cycle (Ali and Al Nsairat 2009), including newly constructed as well as longstanding buildings (Kamaruzzaman et al. 2018). Green buildings rating tools, among their multiple targets, intend to raise the awareness of all stakeholders related to building design and construction. They also aim to provide an unbiased evaluation and a reliable ecolabeling mechanism supporting their sustainable credentials in order to achieve the required recognition (Neama 2012; Suzer 2015).

Two typologies have prominently defined the green building rating tools (Ali and Al Nsairat 2009). The first approach is based on synthesizing environmental indicators based on life cycle assessment (LCA). Examples include BEE (Bureau of Energy Efficiency) in the United States, BEAT (Building Environment Assessment Tool) in Denmark, and KCL-ECO in Finland. This approach, however, is regarded as complex, costly, and time-consuming (Bernardi et al. 2017). The second approach, notably utilized in most green building rating tools, is based on a multicriteria credit system, which assigns a certain amount of credits to a set of specific categories that are considered to have an impact on the overall building sustainability (Ali and Al Nsairat 2009; Bernardi et al. 2017).

Examples of tools developed based on the second approach include the globally recognized BREEAM in the UK (Bre 2018) and GBTool in Canada (IISBE 2005), which have paved the way for other tools that followed, including LEED in the United States (USGBC 2015), along with less prominent tools such as Green Globes in the United States and Canada (GBI 2019) and CASBEE in Japan (IBEC 2017). Green building rating tools remain in a continuous state of development, influencing further tools. QSAS, the Qatari rating system, was developed by studying and adapting six international rating tools (BREEAM, LEED, Green Globes, CEPAS, CASBEE, and SBTool) into the Qatari context. PRS, the Pearl Rating System of ESTIDAMA, was developed as a combination of LEED and BREEAM, locally suited to the priorities of Abu Dhabi (Ahmed 2019).

A number of rating tools have developed multiple subevaluation systems addressing different scales, developmental phases, or building types. For example, LEED includes LEED Building Design and Construction, LEED Interior Design and Construction, LEED Building Operations and Maintenance, LEED Neighborhood Development, and LEED Homes (USGBC 2015). CASBEE consists of construction (housing and buildings), urban (town development), and city management (IBEC 2017). Regarding the construction phase, BREEAM is divided into New Construction (NC), BREEAM in-use, and BREEAM Refurbishment and Fit-Out (RFO) (Bre 2018). These rating tools are also classified into subcategories based on building types addressing their particularities and differences, and realizing their variant physical and natural conditions, occupancy patterns, types of activities, structural and constructional characteristics, and so on. LEED, for example, differentiates between single-family homes and low-rise, mid-rise, and high-rise multifamily residential buildings. BREAAM addresses the differences between single and multiple dwellings, while CASBEE addresses the detached house and the building.

Despite continuous development tailoring to different scales, construction phases, and building types, green building rating tools are envisaged as sometimes unable to objectively reflect the sustainability of a building. Researchers argued for the necessity of reviewing them to better cater for the emerging variety of contextual requirements in order to enhance the actual performance of green buildings at large (Li et al. 2017). Alyami criticized the weight distribution in well-known rating tools such as BREEAM and LEED as globally inapplicable as they do not account for regional variations within the local context of Saudi Arabia (Alyami et al. 2013). Ali and Al Nsairat emphasized the influence of local variations within the Jordanian context and the need for careful customization of international rating tools (Ali and Al Nsairat 2009).

Liu et al. (2005) argued that developing a new rating tool is not easy, mainly because of the complexity and confusion embedded in the task. Chethana argued that there was no consensus around what should be measured and how (Illankoon et al. 2017). Many researchers still attempted to suggest tailor-made approaches for developing rating tools, which mainly emphasized a hierarchical structure. Bragança et al. (2014) suggested two types of indicators: core-indicators (for early building stages) and additional indicators (for later building stages). Ye et al. (2015) identified three layers for structuring a green building standard system. The basic layer provides the basis for the other standards to develop, the general layer provides measures for green buildings to form compliance guidelines, and the specialized layer provides a specialized content and specific provisions. Regardless of the followed method, researchers emphasized the need for the rating tool to be effective, comprehensive, and adaptive to the local context, especially upon considering building types, which could influence its content and use and extend its coverage from merely natural and physical conditions to include social and cultural aspects (Liu et al. 2005).

Green Building Rating Tools: The Jordanian Context

Jordan faces multiple challenges with regard to the rising demand for energy and other resources in light of their severe scarcity. The majority of energy resources (around 98% of local demand), consisting mainly of crude oil, are imported from outside (USAID 2010a). Jordan is considered one of the top four water-stressed countries in the world, being situated within an arid to semi-arid geographic zone (Alnsour 2011; Meaton and Alnsour 2012). Accompanied by Jordan's recent efforts in adopting developmental plans to improve its economic status, it is currently struggling with a rapidly increasing population that grew by 5.3% in 2015, reaching a total of almost 9.5 million (DOS 2017).

Such an economic growth coupled with increasing population resulted in a projected increase in energy demand of at least 50% over the next 20 years, which adds further pressure on natural resources (MEMR 2015). The available water resources per capita are expected to fall from fewer than 100 m^3 per annum in 2016 to about 90 m^3 by 2025 (MWI 2016). This shortage in per capita share has been exacerbated by the larger influx of refugees from neighboring countries, starting in 2011 (Al-Khaza'leh et al. 2020). According to the annual report released by the Ministry of Energy and Mineral Resources, the Jordanian residential sector is consuming approximately a quarter of the national energy (MEMR 2015). The residential sector also presented 45% of the total water demand in 2015 (MWI 2016).

Across the residential marketplace, the multifamily housing sector has grown compared with other building types. According to statistics (DOS 2006), the total number of apartment buildings constructed for residential purposes was 118,976 compared with 353,225 Dar and 7,587 Villa (both being separate single-family homes, with the former having a more traditional design) in 2004. In 2015, published statistics indicated a higher number of apartment buildings standing at 211,496 compared with increasing numbers of 458,005 Dar and 15,217 Villa (DOS 2017). The multifamily buildings have quickly become the most common and dominant building type at present (Al-Azhari and Al-Najjar 2013), further boosted by changes in local laws that regulated unit ownership since 1968, the modification of building height regulations to allow a fourth floor in 1979, and more targeted financial facilities and bank loans (JDLS 1968, 1979).

With multiple challenges facing Jordan, it becomes significant to pave the way toward the expansion in green buildings and rating systems, particularly within the residential sector. Green buildings in Jordan, however, are neither common nor evident in the residential sector. Some researches, such as those by Alkilani and Jupp, Royal Scientific Society (RSS), and Friedrich Ebert Stiftung (FES) attributed this limited coverage to the lack of explanatory models and benchmarks as well as expertise and awareness (Alkilani and Jupp 2012; RSS and FES 2013).

Multiple governmental and nongovernmental institutions, codes, and strategies were developed and endorsed to tackle the challenge faced by the country (JGBC 2017). The Jordan National Building Code Council of the Ministry of Public Works and Housing developed several codes related to energy consumption in buildings, as part of the Jordan National Building Law No. 7 (1997), which included daylighting, solar energy, energy efficient buildings, and thermal insulation (Visser 2012). Further, Jordan's Green Building Guide (JGBG) was drafted in 2009 under the guidance of the Ministry of Public Works and Housing, typically relying on a number of international rating tools such as LEED and BREEAM as a starting point (Zawaydeh 2017). JGBG was designed for new buildings being developed, covering different building types.

The JGBG was finalized in 2013, but it was not until 2015 that it was finally approved to be used (JGBC 2017). It comprises six categories (Tewfik and Ali 2014), each including a number of mandatory, required, and optional aspects. The categories are Management, Sustainable Site, Water Efficiency, Energy Efficiency, Indoor Environment Quality, and Resources and Materials. The mandatory aspects are mainly inspired by the Jordanian National Building Codes; the required aspects are valid for those who wish to qualify for green building evaluation (Shareef and Altan 2017), where the optional aspects are left for the engineer, contractor, and the building owner to choose from based on what best suits the project.

New, localized rating tools are subject to further development and upgrade in order to maintain higher relevance to the local context and, more importantly, the type of building involved. The latter aspect assumes particular importance as most of the current locally developed rating tools generically address residential buildings without enough consideration to their detailed types. The outcome of their use accordingly remains quite limited in a situation where the need arises for maintaining an adequate understanding of the relative aspects of the function within a particular category. Despite this particularity being more recently addressed by a number of international rating tools, the localized tools adapted from them did not consider the same. In JGBG, for example, the different types of single- and multifamily houses including apartment buildings are evaluated utilizing the same rating path, where hotels, motels, and suites are considered under a different path.

Materials and Methods

The research combined qualitative and quantitative approaches with the aim of developing a localized rating tool for multifamily houses in Jordan (Diana). The targeted buildings include mid-rise residential buildings of two, three, or four apartments per floor that share one or two walls along with common-use areas such as stairs and entrances. The natural and physical conditions pertaining to multifamily housing were investigated through interviews with residents, investors and builders along with field observations ahead of incorporating such conditions into the developed rating tool. The research went through a number of key stages:

- Stage I: Defining the level-wise aspects of the system using pilot study, observations, and interviews.
- Stage II: Data collection utilizing focus groups.
- Stage III: Building a conceptual model of the system through DT.
- Stage IV: Offsetting priorities for the selected parameters using AHP.
- Stage V: Using simulation for validating the suggested parameters.

Attention was always given to three main principles throughout the development process: (1) the building life cycle; (2) the dependence on local sustainability priorities including social, economic, and environmental aspects; and (3) the adaptability and adjustability of the tool for implementation on the specific chosen function of the building.

Stage I: Defining the Level-Wise Aspects of the System

The research started with a pilot study initially defining the key potential parameters for consideration in the tool to be developed and how they were subject to change through the years in response to changing requirements. For that purpose, insights were collected through desk research and formal/informal interviews with engineers, governmental employees, and other related participants. Comparisons with other international, regional, and local known rating tools, particularly addressing multifamily buildings, were conducted in order to determine the premier set of aspects that would structure the qualitative research data, being the starting point in the development of the rating tool (Alyami and Rezgui 2012).

Stage II: Data Collection

Focus groups were organized to assist in defining and refining the main parameters related to the sustainability of multifamily buildings and apartment units for consideration in the rating tool under development. Focus groups facilitate the rapid collection of data from carefully recruited participants to contribute in a planned discussion on a particular topic. They enable interactive meetings, sharing of opinions, points of views, and questions, which cater for reaching initial consensus about new concepts or suggestions. Based on the rating tool comparisons concluded in the first stage, an initially suggested framework was developed including categories, core-indicators, and subindicators, which was presented to the participating experts in the form of a report. Focus group discussions were held at the Jordan Engineers Association in Amman with the conducted session lasting for about two hours. The experts discussed the suggested parameters and accordingly shaped a proposal for a green building rating framework. This proposal was arranged in the form of a questionnaire for the next stage.

Stage III: Building a Conceptual Model of the System

Considering the multidimensional nature of the sustainable building rating criteria (Ding 2008), evidence suggests that a consensus-based process is the most effective approach for developing a comprehensive and effective building rating framework (Chew and Das 2008). The DT is utilized as a widely accepted method and a prominent research instrument for conducting detailed examinations and achieving consensus among experts on certain complex issues such as goal setting and policy investigation (Hsu and Sandford 2007). Through this technique, an anonymous and multiphased survey was distributed to the experts across two rounds, where space was provided for the experts to add, remove, adjust, and justify their responses until a consensus was reached.

Sampling

The questionnaire aimed at collecting informed expert feedback in regard to the subject at hand. It was thus supported with individualistic interviews with a representative sample of 26 selected participants at their convenience (Fig. 1). The consent of each participant was obtained after clearly explaining the subject of the research prior to completing the detailed questionnaire.

It was crucial to solicit expert opinions from a range of different fields such as government, academia, and industry (Chang et al. 2007). Representing the private and public sectors as well as NGOs, the participants were chosen to include diverse specialties in the different sustainable building fields including energy efficiency, water efficiency, environment, urban design, renewable energy, materials, and other disciplines. The selection of experts was guided by their knowledge, experience, professional qualifications, and background in the area of the research, ensuring their ability to contribute with useful insights (Burdová and Vilčeková 2012). Moreover, willingness to participate in rounds of facilitated discussions and feedback was also one of the important elements to achieve the sought results (Pill 1971).

Delphi Rounds

The first Delphi round included one-to-one interviews that aimed to determine the importance of the suggested parameters focusing on multifamily residential buildings in Jordan. A questionnaire was utilized for obtaining expert opinions covering three parameter levels: categories, core-indicators, and subindicators. On each level, the experts were asked to rank the viewed parameters according to their importance in establishing a green building rating tool for Jordan. They were also allowed to further add or remove any of the included or relevant parameters based on their experience and views.

In the second round, the experts were provided with the tabulated results of the first round. They were given the opportunity to revise their previous thoughts and reassess their initial judgments to form a more refined and conclusive version (Schuckmann et al. 2012).

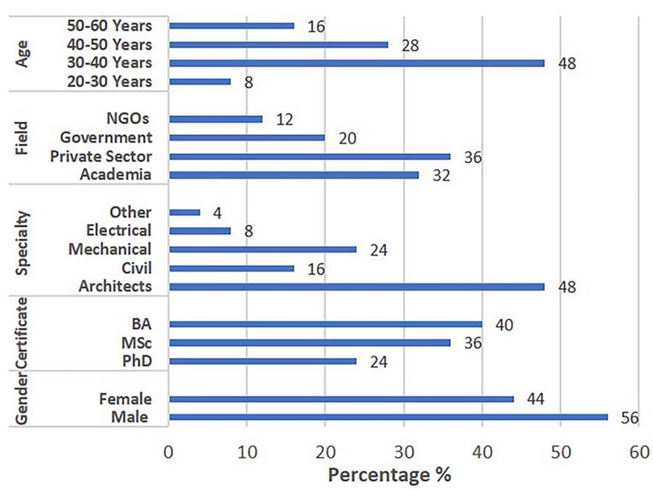

Fig. 1. Distribution of the sample of experts.

After the second round, the tabulated report was provided again to the experts for final approval.

Stage IV: Offsetting Priorities for the Selected Parameters

The weighting system is a viable strategy through which local environmental conditions may be prioritized. It is also considered the heart of any environmental rating scheme since the weight of each parameter in a system affects the overall rating of a building (Ding 2008).

For the purposes of this study, the AHP was selected using the Expert Choice software (Saaty 2000). AHP is considered one of the most common approaches for the development of a weighting system, as previous research has substantiated (Ali and Al Nsairat 2009; Bernardi et al. 2017; Chang et al. 2007; Chew and Das 2008). AHP draws its strength from converting the subjectivity of the research problem into a mathematical form. The AHP is a multicriteria method that consists of a multilevel hierarchical structure that is subdivided into multiple levels (main goal, evaluation parameters, and alternatives) combined together into a comprehensive framework (Aruldoss et al. 2013) (Fig. 2). This method helps in deriving the ratio scales of factors from paired comparisons into hierarchical manageable elements. Compared judgments are made to derive the relative priorities and parameter weights, which are then synthesized into an overall rating framework. AHP accordingly reduces the bias and minimizes common pitfalls (such as lack of focus, planning, participation or ownership) in the decision-making process, which can prevent teams from making the right choice (Chang et al. 2007).

Pair-Wise Comparison Judgments

A nine-point scale was utilized (Table 1) to transform the parameters into numerical quantities that represented the priorities of the parameters (Saaty 2000). Each parameter is placed on one side and a directional value is chosen (from 1 to 9) and placed on the side of the dominant parameter. Considering a structured model consisting of a set of "n" parameters (A_1, A_2, …., A_n), A_1 is compared with all alternatives. The same comparative process is repeated for A_2 and so forth. The chosen number gives an indication of how many times more important one parameter is considered over another.

Synthesis of Priorities

Based on the outcomes of the paired comparisons, square matrices for each level of comparison were generated in order to reach the relative weights of the considered parameters. If the supposed matrix compares a set of "n" alternatives (A_1, A_2, …., A_n), an "n-by-n" matrix is drawn. It is then filled with a rank value "r" obtained from the questionnaire outcomes. If the judgment value favors the alternative being compared, the actual judgment value (r) is used in the upper triangle of the matrix, reflecting a higher importance assigned. If the judgment value assigns more importance to the alternative it is being compared with, the reciprocal value $1/(r)$ is placed. The relative weight of each parameter is calculated by adding up the values of the row corresponding to it and then dividing it over the total numbers in the matrix, as graphically illustrated in Fig. 3.

AHP allows some inconsistency in judgment, since a human is not always consistent. It assumes that any value Consistency Ratio ($CR \leq 0.1$) is considered to be of acceptable consistency. Apart from comparable studies that used AHP for similar tool development (e.g., AbdelAzim et al. 2017; Kamaruzzaman et al. 2018), this study draws its novelty from the introduction of a new sublevel for the parameters within the framework (subindicators that include both building and unit levels), which makes the approach more useful for detailed assessment.

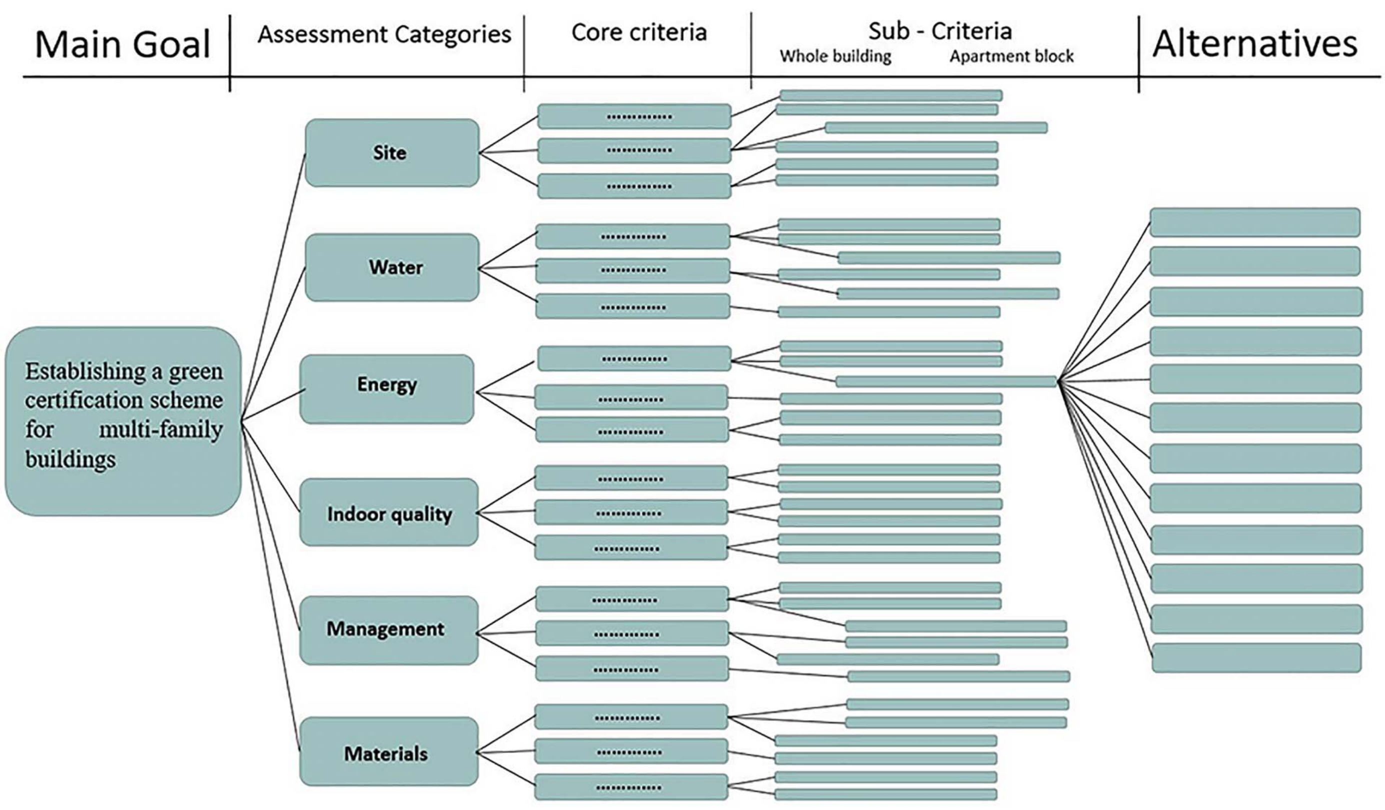

Fig. 2. Criteria for developing factors and indicators of the assessment categories.

Table 1. Saaty's (1–9) scale of relative importance

Scale	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Weak importance	Experience and judgment favor one activity over another
5	Essential or strong importance	Experience and judgment strongly favor one activity over another
7	Demonstrated importance	An activity is strongly favored, and its dominance demonstrated in practice
9	Absolute importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8 Intermediate values between the two adjacent judgments		

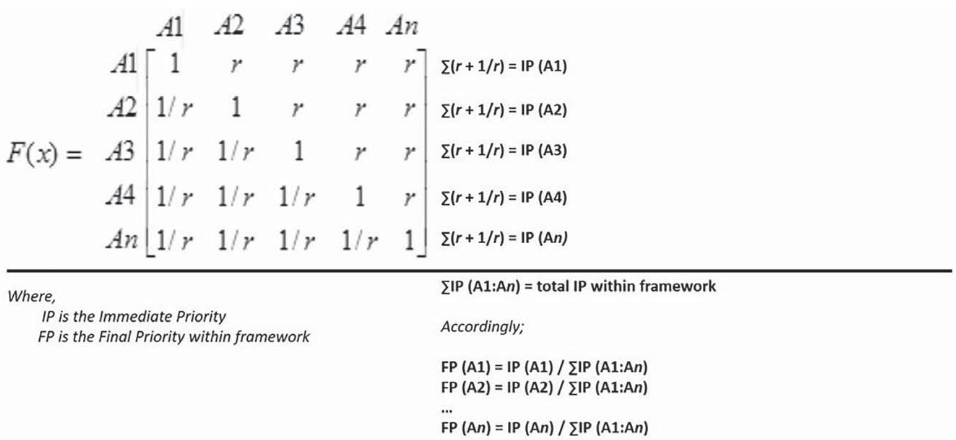

Fig. 3. Matrix utilization to calculate alternative weights.

Stage V: Using Simulation for Validating the Suggested Parameters

To ensure that the new green building rating tool is reliable, it had to be subjected to rigorous testing to verify its applicability. Simulation tests were conducted using Designbuilder software (version 2.2.5.004) in order to quantitatively validate the qualitative feedback received from the experts. The selected subcategory that was chosen for validation was the unit block location within the building under the Energy Efficiency category. It targeted a number of selected parameters relating to the apartment units (floor level and orientation within the same building) and their contribution to sustainability according to calculated versus expected combined heating and cooling loads.

The case study was chosen as a multifamily residential building located in Al Jizah District near Queen Alia International Airport south of the capital city of Amman (latitude 31° N, longitude 36° E). The climate entailed a long cooling period extending from April to October, with a shorter heating period extending from November to March (Fig. 4). Each apartment unit within the building had two shared walls, one with the stairs core and the other with the adjoining apartment unit. The floor area per apartment was 95 m² (13.5 m width × 7 m length) consisting of two bedrooms, living room, kitchen, guest room, two bathrooms, and a balcony, which is a prominent apartment prototype common to Jordan (Fig. 5).

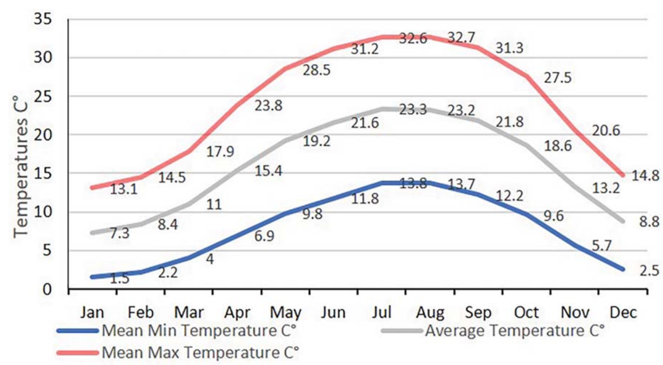

Fig. 4. Monthly minimum, average, and maximum temperatures for Queen Alia Airport location.

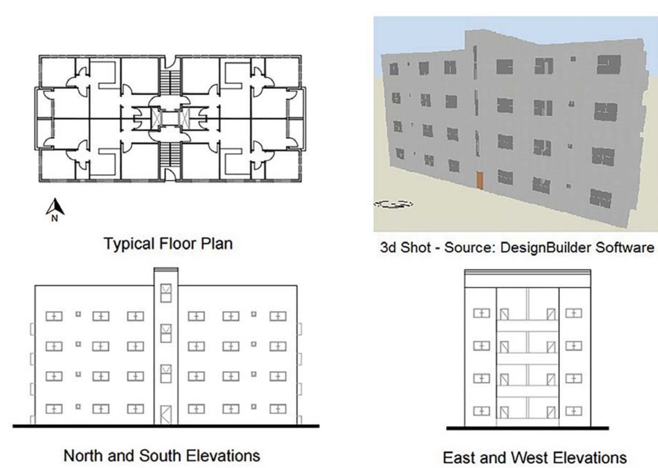

Fig. 5. A three-dimensional view, floor plan, and elevations of the case study.

Results and Analysis

This section presents the results of the research combining the outcomes of the Delphi rounds and AHP, resulting in the proposed rating tool and the outcomes of the model validation through simulation.

Developing the Framework

The research entailed a review of the international rating tools seen as most relevant to multifamily housing, including LEED Multifamily

Midrise, BREEAM multiple dwellings, CASBEE for buildings, Green Globes for multiresidential buildings, in addition to more regional tools such as Estidama Pearl Building Rating Level, GSAS Group Residential and local tools such as the Jordan Green Building Guide. Most known rating tools recognize the majority of the mentioned categories, yet they vary in terms of their detailed parameters and weights. Based on this review and further refinement obtained through the focus groups, the main categories were proposed to be the following: Energy Efficiency, Water Efficiency, Indoor Environment Quality, Materials and Resources, Site Features, Management, and Operations. These categories facilitate the consideration of the key three pillars of sustainability, whereas site selection, energy, water, resources, material, and waste, for example, can define environmental aspects. Comfort, health, indoor environment quality, access to facilities, participation, control, and safety are all examples that can define social aspects. Finally, economic aspects can be introduced through such examples as efficiency of use, life cycle costs, durability, and maintenance.

Furthermore, each rating category was broken down to several core-indicators, varying in number among the different categories. Core-indicators included a varying number of subindicators combining those on the building level and others on the apartment unit level.

Weights of the Selected Parameters

Based on pair-wise comparisons performed by the experts, as explained in the section "Material and Methods", the feedback was analyzed to determine the relative importance of the proposed categories, core-indicators, and subindicators.

In respect to the results of the first Delphi round, Energy Efficiency was regarded as the most important assessment category, obtaining a weight of 35.6%. Water Efficiency came second, weighing approximately 27.4%. With both Energy and Water Efficiency assuming over half of the total relative importance, Indoor Environment Quality, Site Features, Materials and Recourses, and Management and Operations followed obtaining 11.7%, 9.6%, 8.1%, and 7.5%, respectively (as shown in Fig. 6).

The next level of comparison addressed the core- and subindicators that reflected the main topics supporting each category and concluded with their associated weights within the proposed framework, where all resultant parameters and weights were debated and finalized through the second Delphi round.

General Discussion

The proposed priorities were agreed by almost all (89%) of the experts by receiving confirmation by 23 out of the 26 experts consulted, indicating their acknowledgment of the contextual-relevance and importance of the suggested categories, core-indicators, and subindicators. Overall, there was no consensus from the respondents to exclude any of the proposed parameters. However, some suggestions were raised and recirculated with regard to the reallocation of some parameters or the modification of weights assigned.

Reflecting on the outcomes of the discussions, the majority of experts considered Energy Efficiency, Water Efficiency, and Indoor Environment Quality as the top three categories in terms of priority in Jordan. The agreement regarding the highest assigned weights being Energy (35.6%) and Water Efficiency (27.4%) was indicative of the underlying concerns in relation to the Jordanian context. Energy and water resource issues are considered the most important and complex for Jordan and are actually at the top of the national agenda due to their scarcity and the limitations this presents (Nematollahi et al. 2016; Schyns et al. 2015). Ranking Indoor Environment Quality third (11.7%) stems from the role of green buildings in enhancing human wellbeing and comfort (Al-Omari and Okasheh 2017).

The experts justified their opinion on putting Energy Efficiency as the top priority, not only due to the scarcity of energy resources in general but also due to the resulting reliance on imported energy resources that poses a burden on the national economy. In addressing such a concern, envelope insulation and tenant practices were perceived as the two most important core-indicators related to energy efficiency practices, as presented in Table 2. For envelope insulation, the use of high insulation and required thermal resistance for all envelope elements ranked as the highest subindicators. Regarding tenant practices, the use of qualified appliances that achieve the energy star or appropriate rating ranked highest.

Water efficiency was also an issue, if not for its scarcity, then due to the lack of proper consumption management, which is a matter that should be taken into consideration. As Table 3 presents, water leakage prevention and water metering and management ranked as the most important core-indicators related to water efficiency practices. For water leakage prevention, implementing a leak detection system and alarm ranked as the highest subindicator. For water metering and management, installing a submeter for each residential unit ranked as the highest subindicator. This is exacerbated by recognizing the lack of submetering in Jordan with consideration to the majority of projects (USAID 2010b; JGBC 2011), which is magnified by the sharing of meters in between several residential units (Al-Zu'bi 2017).

It is important to realize that the recommendations, whether for energy or water efficiency, were aimed at driving user-sustainable behavior through technical adjustments in a manner that strengthens self-motivation and overall accountability toward efficiency and optimization of use (Sharif 2016). For example, tenant practices were among the highest core-indicators to achieve energy efficiency. Indoor and outdoor total water demand, on the other hand, were important core-indicators to achieve water efficiency, with both being driven by tenant practices. This explains the importance of the social aspects, which were ranked third.

The focus on indoor environmental quality as an important social aspect was a third issue, where emphasis was on providing a healthy environment for building occupants, taking into consideration the impact of the indoor environment on human health and performance. Among these aspects, thermal comfort and healthy air quality were the most important core-indicators based on the experts' view.

	EE	WE	IEQ	MR	SF	MO	Weight	%
Energy Efficiency (EE)		1.557	2.984	4.461	3.724	3.89	0.356	35.60%
Water Efficiency (WE)			2.203	3.701	3.276	3.7	0.274	27.40%
Indoor Environment Quality (IEQ)				1.5	1.052	1.619	0.117	11.70%
Materials and Resources (MR)					1	1.048	0.096	9.60%
Site Features (SF)						1.5	0.081	8.10%
Management and Operations (MO)	Incon: 0.00						0.075	7.50%

Fig. 6. Pair-wise comparison of assessment tool categories.

Table 2. Parameters related to the Energy Efficiency category

Energy efficiency 0.356	Applicable on a whole building	Applicable on apartment unit
Envelope Insulation 0.130	Use high insulation and required thermal resistance for all envelope elements (R, U-values) 0.395 Highly insulated glazed areas (e.g., double skin) 0.307 The glazed area percentage is related to the conditioned floor area space (window to floor area ratio) 0.298	
Tenants Practices 0.091	Use qualified appliances that achieve the energy star or appropriate rate scheme (e.g., dishwasher, refrigerator, TV) 0.392 Develop occupant handbook, manuals or CD prepared by architect or engineer addressing the behavioral practices 0.369 Training occupants in the operation and maintenance of equipment 0.239	
Unit Block Location within the Building 0.078		Ground level, south-east orientation 0.148 Ground level, south-west orientation 0.121 Middle level, south-east orientation 0.111 Middle level, south-west orientation 0.109 Ground level, north-east orientation 0.089 Middle level, north-east orientation 0.077 Upper level, south-east orientation 0.068 Upper level, south-west orientation 0.063 Ground level, north-west orientation 0.061 Middle level, north-west orientation 0.056 Upper level, north-east orientation 0.050 Upper level, north-west orientation 0.046
Passive Techniques Utilization 0.074	Report of analyzing the site potential for implementing passive design solutions 0.252 Building orientation for passive solar 0.236 Improved building fabric 0.180 Fixed or movable shading devices 0.168 The building layout guides wind 0.164	
Apartment's Design Characteristics 0.069		Floor level 0.398 Number of unit walls facing the outdoor 0.350 Number of party walls between units (shared walls) 0.253
Layouts and Building Form 0.066	Courtyard provides the "sides" that enclose one or more open spaces (courtyards) on the site 0.350 Tower (vertical form) 0.334 Block (usually wider than it is tall) 0.316	
Energy Metering 0.064	Submetering the major energy consuming systems separately (e.g., electricity, lighting, water services) 0.293 Install whole building energy total-metering facility 0.245 Monitor onsite energy generation and irrigation system used 0.203	Install energy submetering for each residential unit 0.259
Energy Management 0.061	Connect all systems to a central monitoring system to read records 0.307 Publish energy baseline values and policies by energy organizations 0.199 Nominate qualified engineers and professionals as members of project team 0.167	Transmit the hourly, daily, weekly, monthly, annually consumption data of each unit to enable occupants to read it easily 0.327
HVAC System 0.060	Test the HVAC tightness and perform air leakage test (the efficiency of insulation and sealed ducts) 0.162 Minimize the reheat or recool 0.147 HVAC systems meet the efficiency requirements 0.136 Keep HVAC system entirely within the conditioned envelope 0.128 Use sensors and alert system to control ventilation rates, leaking valves, and CO_2 0.116 Use software and manual controls to prevent the equipment from operating for the entire day 0.113 No mechanical cooling and refrigerant equipment 0.103 HVAC elements are of average size, noise, and flow 0.094	
Lighting 0.060	Avoiding emitted light from building to site 0.589 Achieve recommended exterior light levels 0.411	
Renewable Energy 0.058	Use solar energy (e.g., solar electricity, photovoltaic generation) 0.290 Use offsite renewable generation through direct purchase and signed contract 0.193 Use onsite energy generation systems (e.g., wind) 0.187 Use geothermal system for electrical or thermal energy 0.186 Use organic or agriculture and animal waste to provide energy 0.145	
Hot Water System 0.058	Use a qualified and insulated domestic hot water system 0.257 Use the permitted valves and pipe length from source of hot water to the fixture supply pipe 0.217 Automatic or manual turn on and off switches 0.182 The water circulating pump operates on time control or temperature sensor 0.180 Use a solar water heater 0.164	

Table 2. (*Continued.*)

Energy efficiency 0.356	Applicable on a whole building	Applicable on apartment unit
Individual Apartment Number of Stories 0.050		Single story 0.371 Mezzanine (with intermediate floor that partly open to the floor below) 0.316 Two stories 0.313
Minimum Energy Rate 0.044	Use simulation to calculate the energy baseline performance of a whole building 0.558	Use simulation to calculate energy baseline simulation for each unit 0.442
Efficient Vertical Movement System 0.038	Easily accessible, visible, ventilated stairs 0.371 Use energy efficient lifts, escalators, and moving walks 0.342 Use operation sensors which operate in standby mode when not in use 0.287	L

Table 3. Parameters related to the Water Efficiency category

Water efficiency 0.274	Applicable on a whole building	Applicable on apartment unit
Water Leak Prevention 0.251	Implement leak detection system and alarm 0.518 Allow easy maintenance 0.482	
Water Metering and Management 0.239	Connect all systems to a central monitoring system to read records 0.230 External water use submeter 0.152 Install a total whole building water meter 0.097	Install a submeter for each residential unit 0.291 Transmit the hourly, daily, weekly, monthly, annually consumption data for each unit to occupants to read it easily 0.229
Indoor Total Water Demand 0.153	Use certified high efficiency fixtures and valves 0.347 Implement water use reduction practices 0.339 Calculate the daily estimated usage (liter/person/day) 0.313	
Outdoor Total Water Demand 0.142	Planting native or adapted plants 0.376 Outdoor water reduction practices 0.234 Calculate a baseline for irrigation water consumption 0.146 Use high efficiency external water products 0.136 No external water features 0.108	
Water Quality 0.136	Implement a water contamination management plan 0.509 Minimizing risk of microbial contamination (e.g., Legionnaires' disease) 0.491	
Water Treatment 0.079	Use of captured rainwater 0.346 Use certified water purification and treatments systems 0.215 Use of water treated by a public agency for nonpotable uses or onsite treated 0.209 Using of recycled gray water 0.125 Using of underground water 0.106	

A number of experts, however, had a few notes regarding the assigned weights for the Energy Efficiency and Water Efficiency categories; two of the experts perceived Water Efficiency as the most important, whereby another assigned the highest rank to Indoor Environment Quality, considering that human health, well-being, and comfort cannot be compromised regardless of any resource efficiency sought. Site Features, Materials and Resources, and Management and Operations always followed in order.

With regards to the core-indicators and subindicators, some experts suggested removing, adding, or adjusting a number of them. For example, apartment design characteristics, as a core-indicator, was eventually considered to fit more appropriately under the Energy Efficiency category, although some experts initially suggested moving it under the Indoor Environment Quality category.

Ultimately, the overall parameters were agreed upon with their suggested priorities, resulting in a final framework made of six categories, 90 core-indicators, and 363 subindicators, resulting in a total of 459 parameters.

Outcome Validation through Simulation

Simulation was conducted in order to validate the qualitative feedback received from the experts. It targeted quantitively validating the responses regarding the core-indicator (unit block location within the building) as part of the Energy Efficiency category. In other words, it targeted the contribution of the floor level and apartment orientation (explained in detail as the subindicators) to its sustainability. This core-indicator was ranked third in importance and assigned a relatively high weight by the experts.

Multiple comparisons among the apartment units were conducted. The software was updated with information relating to site and site climatic conditions (based on data sourced from the Royal Scientific Society and Jordan Metrological Department). It was also updated with the assumed activity based on the DOS (2016) report and building construction specifications according to the National Building Code of 2012. Several inspections were made in order to evaluate the different types of internal loads.

Energy use was simulated by taking two periods during the year, corresponding to the heating and cooling periods in Amman. The simulation targeted identifying whether the estimated energy consumption (heating, cooling) may change according to the apartment unit floor level and orientation within the same building.

In the first scenario (east–west main axis orientation), the researcher suggested 12 sample apartments distributed on the ground, middle, and upper floors (with northeast, northwest, southeast, and southwest orientations). The second scenario (north–south main axis orientation) was assumed by replacing the two sides (length and width) of each apartment unit to change the main direction faced.

Energy Efficiency: Scenario I

The required total cooling energy consumption constituted a larger portion in comparison to the heating energy consumption, where the energy multiple was almost threefold. This could be explained by reference to the length of the cooling period throughout the year compared with the heating period in Jordan (Fig. 7).

Fig. 8 shows the annual heating and cooling loads as well as the average load per square meter, noting that the apartments located on the middle level cover the first and second floors of the building.

It can be noticed from Fig. 8 that there is a clear relationship between the heating/cooling loads and the floor level, where the annual heating loads on the ground floor are greater than on the upper floors. Conversely, the annual cooling loads on the ground floor are lower than the annual cooling loads on the upper floors. These relations can be explained when considering the total area exposed to solar radiation throughout the year, where the top floor is more exposed to solar radiation in comparison with other levels, resulting in a higher cooling energy required in summer and less heating in winter.

The simulation also showed that the middle floor levels consume more total energy than the ground and top floors (combined heating and cooling loads). Despite the increasing amount of energy required for cooling as we move up the building, the lower heating loads needed in the top floor reduced its total combined heating and cooling loads to less than the total combined heating and cooling loads of the middle floor levels (Fig. 8).

Upon considering the orientation of the apartment units (Fig. 9), the simulation revealed that units of different orientation vary in their required loads. Apartment units located on the southeast and southwest sides needed more total energy compared with the apartments located on the northeast and northwest sides, with the exception of those on the ground floor. According to Fig. 9, it can be observed that the units on the southern side in general are likely to need more total energy compared with the apartments on the northern side.

Energy Efficiency: Scenario II

Scenario II demonstrated the same with regards to the variance of the heating and cooling loads within the building (Fig. 10). It also demonstrated the same relations considering the total load requirement when different floors are compared (Fig. 11).

However, when considering apartment unit orientation, the outcomes of Scenario II were different, showing that the apartments on the northern side consumed more energy compared with the southern oriented sides (Fig. 12).

Comparison

Based on the compared simulation outcomes (Fig. 13), the total annual heating and cooling loads of the building in Scenario I are lower than Scenario II, which means that when the main axis of the building faced the east–west orientation, it consumed less total energy loads than the building whose main axis faced the north–south orientation. Indeed, this has been highlighted generally by the National Building Code of Jordan (Visser 2012), which recommends, as a best practice, orienting the building's main axis along the east–west direction and designing the most heavily used spaces

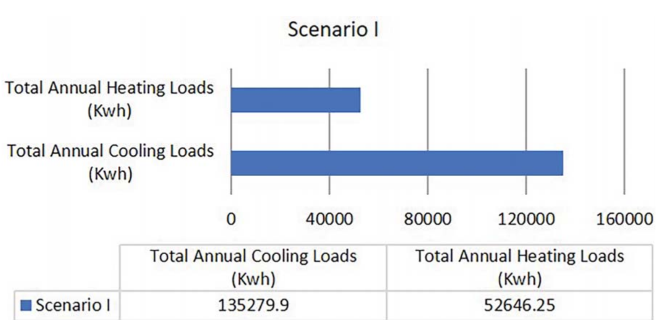

Fig. 7. Total annual heating and cooling loads of the building: Scenario I.

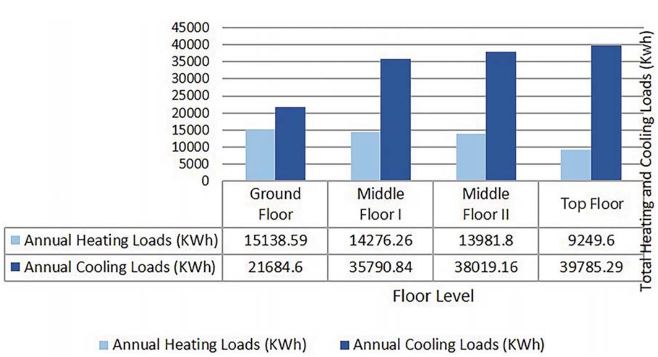

Fig. 8. Total cooling and heating loads needed for each floor level: Scenario I.

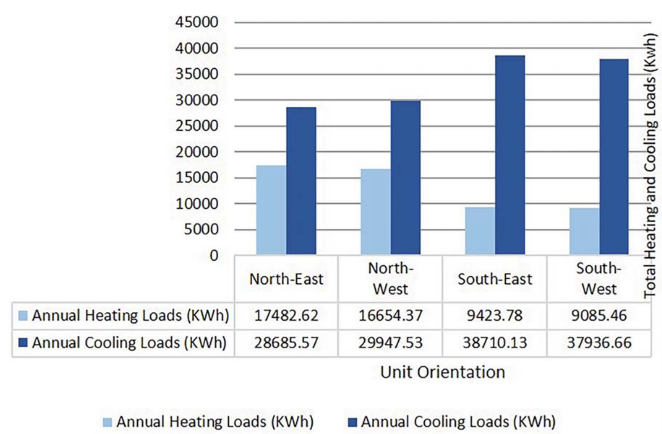

Fig. 9. Total cooling and heating loads needed per apartment orientation: Scenario I.

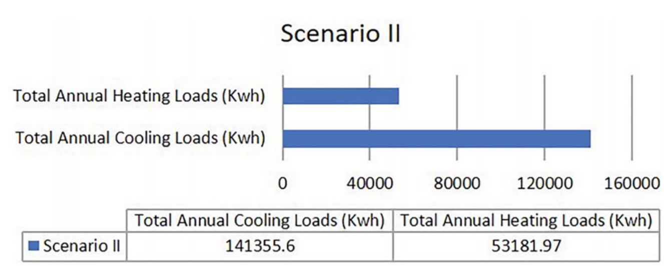

Fig. 10. Total annual heating and cooling loads for the building: Scenario II.

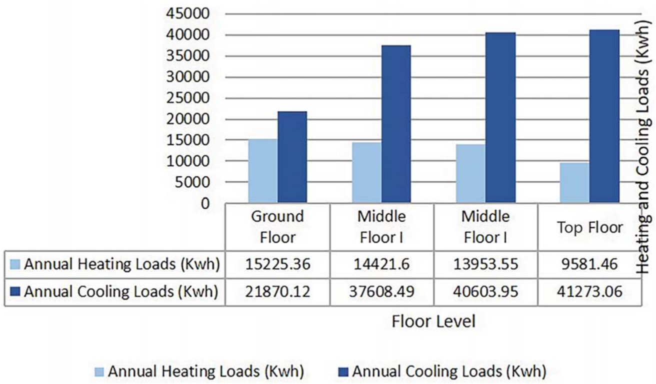

Fig. 11. Total cooling and heating loads needed for each floor level: Scenario II.

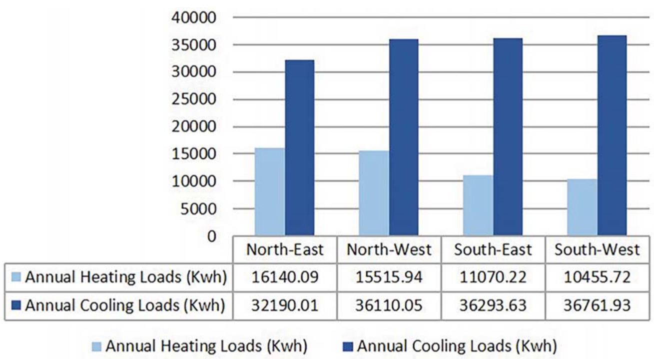

Fig. 12. Total cooling and heating loads needed for each orientation: Scenario II.

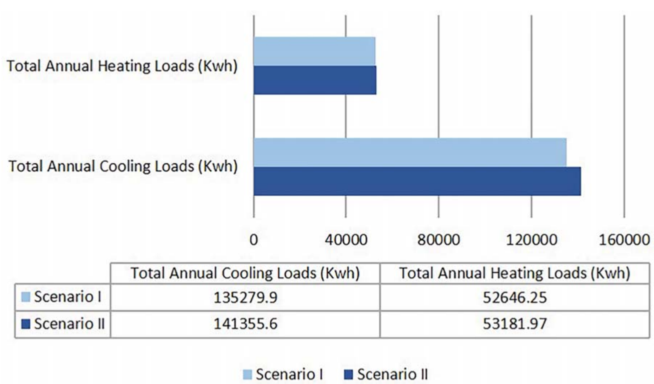

Fig. 13. Comparison for total annual energy loads between Scenario I and Scenario II.

within the building with a southern orientation, since it is more efficient in terms of thermal performance.

In short, the floor levels may be arranged according to the total energy consumption, from the lowest to the highest as follows: ground floor, top floor, and, lastly, the middle floors. With regard to orientation, if the building's long axis is oriented in an east–west direction, the suggested priorities are the northeast, northwest, southwest, and, finally, the southeast units. Conversely, if the building's long axis is oriented in a north–south direction, the proposed priority sequence is the southeast, southwest, northeast, and, finally, the northwest units.

Expert opinions were generally in line with simulation outcomes, as was shown in the priorities assigned to their respective subindicators and their allocation to the building or individual unit level (Table 2). In terms of floor level, experts preferred ground level units with southeast and southwest orientations, followed by middle level units with the same orientation, then ground and middle floor units with a northeast orientation. This was followed by priority to the upper level units oriented toward the southeast and southwest, followed by the ground and middle level units with a northwest orientation. The lowest priority was assigned to the northeast and northwest oriented units on the upper level.

Discussion

When comparing Diana to the benchmark rating tools selected in terms of parameters and their weights (Table 4 and Fig. 14), a number of observations are worth highlighting.

First, a multiplicity of common concerns is shared among most of the rating tools when comparing their categories, such as Energy Efficiency and Water Efficiency, Indoor Environment Quality, Materials and Resources, Service Quality and Site Arrangements. The difference between these rating tools is predominantly in the weights assigned to their respective categories, which are mainly a reflection of the local context from which they originated.

Second, the international tools, such as LEED, BREEAM, and CASBEE, strongly emphasize the Indoor Environment Quality (up to 27%) and Energy Efficiency (up to 39%). Regional and local assessment tools, such as Estidama, GSAS, and JGBG on the other hand place a significant weight on Water Efficiency (up to 27%) compared with other systems (up to 11%). This can be justified by realizing the context-specificity of water issues suffered by Jordan and the Arabian Gulf countries, for example, which are not highly prominent problems in some countries elsewhere. Diana provides focus on Indoor Environment Quality (11.7%) along with Energy Efficiency (35.6%) following the emphasis of international tools. It also assigns a significant weight to Water Efficiency (27.4%) following the regional and local assessment tools in light of the context-specificity of water issues. Accordingly, Diana maintains clear emphasis on both energy and water as main environmental sustainability aspects while incorporating Indoor Environment Quality as a main social aspect.

Third, comparing Diana as a specific localized tool for Jordan concerned with a particular building type (the multifamily residential building) with the localized tool (JGBG), which addresses a wider range of building types, reveals a similar concern. They both provide comparable emphasis on the efficiency categories that directly affect environmental sustainability. However, Diana assigns third priority to Indoor Environment Quality while JGBG prioritizes Materials and Resources and Sustainable Sites instead. This can be explained by the particular concern and emphasis of Diana on the social aspect of sustainability.

Comparing Diana with another localized rating tool, SABA (Ali and Al Nsairat 2009), reveals further differences. While both rating tools target residential buildings, Diana focuses on attached multifamily residential buildings while SABA, tailored ten years earlier, is concerned with detached residential buildings. The focus on attached housing addressed by Diana necessitates going further in depth from the scale of the building down to the apartment unit, which stimulates the incorporation of more subindicators. With such in-depth analysis, Diana has 456 parameters in total compared with the 157 parameters addressed by SABA. Furthermore, while SABA emphasizes the economic aspects within the Jordanian context, Diana explores other social parameters. This is explained through Diana's emphasis on Indoor Environmental Quality, which provides focus on thermal comfort

Table 4. Comparison among weightings of Diana rating tool with international, regional, and local green building rating tools in terms of rating categories

	Multifamily green building assessment tool							
	LEED for mid-rise	BREEAM International New Construction 2016/multiple dwellings	CASBEE for building	Green globes	Estidama pearl building rating system	GSAS group residential	Jordan Green Building Guide (JGBG)	Diana multifamily green building
Location and Transportation	13.6%	6.1%	—	—	—	7%	—	—
Sustainable Sites	6.4%	8.13%	14.9%	11.5%	6.6%	15%	13.3%	9.6%
Water Efficiency	10.9%	6.32%	3%	11%	23.8%	16%	16.7%	27.4%
Energy Efficiency	33.6%	18%	7.5%	39%	24.4%	24%	35.2%	35.6%
Materials and Resources	8.1%	13.21%	14.2%	12.5%	15.5%	12%	15.1%	8.1%
IEQ	16.4%	21.58%	27.1%	16%	20.5%	16%	9.2%	11.7%
Management	—	11.18%	—	5%	7.2%	6%	10.5%	7.5%
Waste	—	6.1%	—	—	—	—	—	—
Pollution	—	9.38%	—	—	—	—	—	—
Quality of Service	—	—	36.3%	—	—	—	—	—
Other	11%	—	—	5%	2%	4%	—	—

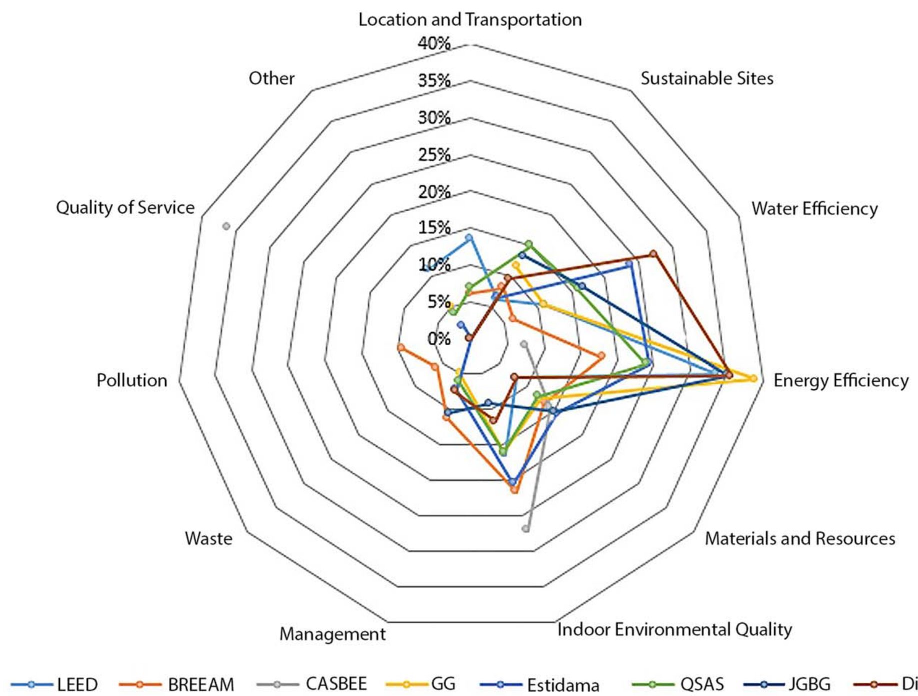

Fig. 14. Comparing category assigned weights for Diana and other green building rating tools.

Table 5. Key defining elements of Diana green building rating tool

Element	Description
Brief	A green building rating tool that targets a balanced and detailed approach to the sustainability concern through the articulation of six main categories, 90 core-indicators and 363 subindicators.
Classification	A hierarchical, multiparameter rating checklist for green buildings that promotes environmental and sustainable performance measures, taking into account environmental, social, and economic considerations.
Rating Stages	The tool is applied to the new construction of multifamily buildings, including the stages of predesign, design, and postdesign.
Scope	Addresses multifamily residential buildings, assessing the building as a whole as well as apartment units within the building. The tool addresses the integration of the building within the community and site along with specific considerations on the apartment units emphasizing matters such as floor levels and orientation, among other aspects.
Hierarchy of Parameters	Parameters are arranged on three levels, the first one includes the main rating categories, the second includes the core-indicators related to each category, and the third includes the subindicators that help achieve green practices to improve the building and apartment unit performance.
Certification Criteria	Based on the total points achieved after going through all weighted parameters. The score achieved in each parameter is multiplied by its assigned weight, where the achieved scores are aggregated into a total number of points. The rating framework entails a maximum of 100 points, where the final score classifies the building performance into three levels; very green (100–80%), green (79%–50%) and not green (below 50%).

Table 6. Distribution of categories and core-indicators (Diana rating tool)

Rating category	Weight	Rating core-indicators	Weight
Energy Efficiency	0.356	Envelope Insulation	0.130
		Tenants Practices	0.091
		Unit Block Location within the Building	0.078
		Passive Techniques Utilization	0.074
		Apartment's Design Characteristics	0.069
		Layouts and Building Form	0.066
		Energy Metering	0.064
		Energy Management	0.061
		HVAC System	0.060
		Lighting	0.060
		Renewable Energy	0.058
		Hot Water System	0.058
		Individual Apartment Number of Stories	0.050
		Minimum Energy Rate	0.044
		Efficient Vertical Movement System	0.038
Water Efficiency	0.274	Water Leak Prevention	0.251
		Water Metering and Management	0.239
		Indoor Total Water Demand	0.153
		Outdoor Total Water Demand	0.142
		Water Quality	0.136
		Water Treatment	0.079
Indoor Environment Quality	0.117	Thermal Comfort	0.081
		Healthy Air Delivery	0.077
		Indoor Air Quality	0.069
		Daylight and Views	0.063
		Tobacco Smoke	0.060
		Combustion Venting	0.059
		Thermal Comfort Monitoring	0.056
		Compartmentalization	0.053
		Acoustic Conditions	0.053
		Indoor Air Quality Management Plan	0.050
		Ventilation Air Quantity	0.049
		Garage Air Quality	0.049
		Chemicals Control	0.045
		Indoor Air Monitoring	0.044
		Illumination Levels	0.043
		Ventilation System Type	0.042
		The Depth of the Apartment Unit	0.042
		A Storage Space Availability	0.034
		Pets and Animal Control	0.033
Site Features	0.096	Project Location	0.077
		Pollution from Construction	0.074
		Safety and Security	0.067
		Public and Private Transportation	0.054
		Building Mass	0.051
		Proximity to Facilities	0.049
		Traffic Conditions	0.047
		Biodiversity Protection	0.045
		Heat Island for Roof and Nonroof Areas	0.043
		Natural Disasters Prevention Plan	0.042
		Townscape Integration	0.041
		Minimize the Parking Footprint	0.040
		Suitable Entrance	0.040
		Pathways	0.039
		Innovate Strategies	0.039
		Outdoor Private Space	0.036
		Expressing the Spaces	0.035
		Lighting	0.033
		Outdoor Comfort	0.033
		Occupant's Participation of Site Facilities	0.032
		Guide Wind into the Site	0.031
		Pest Prevention	0.026
		Noise Pollution	0.026
Material and Resources	0.081	Resource Conservation	0.099
		Recycling Plan	0.081
		Materials Protection	0.074
		Construction Waste Reduction	0.072
		Reuse of Structural and Nonstructural Elements	0.069
		Refrigerants and Fire Suppression	0.068
		Materials Efficiency	0.062
		Regional Materials	0.062
		Exterior Reuse Materials	0.062
		Designing for Durability	0.060
		Recycling Spaces	0.056
		Recycled Contents	0.054
		Designing for Disassembly	0.053
		Material Emissions	0.049
		Clean Diesel Practices	0.040
		Speculative Finishes	0.037
Management and Operation	0.075	Building Life Cycle Cost and Service	0.135
		Integrated Design Process	0.132
		Commissioning	0.105
		Design Development Phase	0.104
		Preconstruction Phase	0.102
		Construction Design Phase	0.101
		Operation and Maintenance Manual	0.096
		Project Brief Phase	0.070
		The Concept Design Phase	0.060
		Recommissioning	0.057
		Workers Accommodation	0.037

and healthy air quality. Social parameters are also important for achieving the prioritized environmental aspects, since the recommendations for energy and water efficiency were highly related to driving user behavior toward sustainability through technical adjustments (Sharif 2016).

Table 5 summarizes the key elements defining the developed Diana green building rating tool.

Table 6 gives the details of the rating tool in terms of the categories and core-indicators it entails. Multiple subindicators were ultimately developed for each core-indicator, where they were classified into the ones applicable on the building level and others that are applicable on the apartment unit level.

Conclusion

The research aimed at developing a comprehensive green building rating tool that caters for the assessment of multifamily residential buildings. It attempted to provide a specific focus on the importance of the local context as the main driver to customizing a rating tool to fit Jordan in a manner that addresses its local opportunities and challenges aligning its path toward sustainability. The research adopted a scientific approach that emphasized utilized comparison with international, regional, and local rating tools as well as collaborations with local expertise to reach a common understanding regarding environmental, sociocultural, and economic aspects that could emerge through the building life cycle. This approach promises to ensure building a more adaptive, and thus more realistic, rating tool that is aware of the local culture, issues, resources, priorities, practices, and institutions.

A faced limitation, however, resembled what has been addressed by Haapio and Viitaniemi (2008), who stressed the need not only to integrate the different environmental, social, and economic aspects of sustainability, but also to balance their importance and capture the interrelationship between them (Haapio and Viitaniemi 2008). Michael et al. explained that the recognition of these interweaving dimensions demands greater clarity and understanding (Michael et al. 2014). This study aimed to promote the sustainability envelop by emphasizing such integration where the local context of Jordan is concerned.

Beyond the differences demonstrated by a comparison with international and regional rating tools, comparing Diana to locally developed rating tools still reveals differences in terms of structure, categories, and indicators according to the building type addressed as well as the prevailing circumstances at the time of development. This study highlights the importance and paves the way for further studies conducted in Jordan to target other building types (residential or nonresidential), providing further insights emerging from their exploration. They can also involve further stakeholders, particularly consumers and end users who may provide insights on the impact of the rating tool (categories and indicators) on their lived experience, as well as building owners and real estate developers who attain particular perceptions of the concept to consider the utilization of rating tools in their buildings and projects. Another extension of this research can be achieved by targeting buildings in different stages of their life cycles, where newly constructed and occupied or refurbished buildings can be considered.

This study is intended to invoke further exploration within the locality of Jordan, or similar countries, through understanding the complexity faced when considering the contextual aspects along with building types and phases, requiring integration across various disciplines and collaborative efforts in research and practice in order to continuously improve and refine current rating tools to better suit the specific demands of the locations they are intended to serve.

Data Availability Statement

All data, models, or code that support the findings of this study are available from the corresponding author upon reasonable request.

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