Journal of Contemporary Technology and Applied Engineering (JCTAE), **2***(2), 2023, 12-27*

DOI: 10.21608/JCTAE.2023.245112.1019 Published by: *Faculty of Engineering, Kafrelsheikh University*

SUSTAINABLIE BUILDING AND ASSESSMENT CRITERIA FOR RESIDENTIAL BUILDING IN EGYPT AND HOW TO APPLY

Received: 28-10-2023
Accepted: 10-12-2023

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ABSTRACT. Our efficiency at work, our health and our psychological state depend on the internal environment that surrounds us in the architectural vacuum and the world is currently witnessing an era of technological development in building materials and raw materials in all their forms and their impact on the sustainability of buildings that reduce the impact of the built environment on the natural environment and improve the effectiveness of the building to ensure a high-quality life for future generations. The research aims to develop criteria for evaluating the sustainability of buildings that suit the reality of building implementation in Egypt and test their suitability by evaluating a sample of residential buildings implemented in Egypt. The evaluation process was carried out through the design of a measurement tool to measure the level of application of sustainability in residential building projects and distributed to a sample of engineers within the interior design and implementation specialist, where the most important criteria were set for the conditions of Egypt, and the standards were divided into seven axes, under each axis falls a number of sub-criteria and the measurement was made using the five-point "Likert" scale and determining the relative importance for each axis. Through this study, it was concluded that the most important criteria in both the design and implementation stages are energy efficiency as well as the economic aspect, where the most important criteria can be used in designing a sustainable housing model.

KEYWORDS: sustainability criteria, sustainability building, residential buildings, Likert" scale, Egypt.

1. INTRODUCTION

Design is a logical and scientific process that humbles human demands in life. Or it is the creative work that achieves the purposes of man. It is also a translation of a specific topic or a purposeful drawn idea that has a full relationship with the means of implementation and carries inside artistic values, and recently life has become a series of permanent and continuous developments in various fields, especially the establishment, including architecture and interior design, and we see that the rapid development in design, modern technologies, materials and raw materials used.

There is a close link between the environment and construction and therefore there is a mutual influence as the construction sector is one of the main consumers of natural resources such as land, materials, water and energy. In addition, the many and complex operations of the building and construction industry produce large amounts of noise, pollution and solid waste, and the problem of energy waste remains one of the most prominent environmental-economic problems of buildings due to their continuity and sustainability throughout the period of operation of the building [1]. Currently, the world is grappling with a global problem due to the exhaustion of natural resources in the environment. This is a result of traditional construction methods that utilize these resources without taking into account the harmful effects on the environment and future generations. The primary goal of sustainability is to safeguard the natural resources of the environment, such as water and energy, in order to fulfill present requirements without jeopardizing the capacity of future generations to fulfill their own needs [2]. In order to design environmentally friendly buildings, it is necessary to first assess the level of sustainability of these buildings and then develop an economic model to achieve their standards.

1.1. THE CONCEPT OF SUSTAINABILITY:

The United Nations Commission of the United Nations High Commissioner for Sustainable Development has defined sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs, as the basic principles of sustainable buildings are the ability to adapt to the climate and reduce and conserve energy consumption, a healthy building must be designed and constructed in a way that reduces dependence on fuel and other sources of energy that are depleted and polluting the environment [9].

Green building is defined as the result of a design that focuses on increasing resource efficiency – energy, water and materials – while minimizing the impacts of buildings on human health and the environment during the life cycle of a building, through improved design, construction, operation, maintenance and removal [10, 12].

2. RESEARCH PROBLEM:

Interior architecture designers understand the idea of sustainability in design. And focus in the current period on achieving ideas in interior design to comply with the environment using modern technology for materials, materials and to achieve the required sustainability, which has become a necessity in the future.

The construction sector is one of the largest consumers of energy, material resources and water and a large polluter of the environment in addition to the great waste that occurs in the construction sector in all its stages It is also necessary to determine the sustainability standards of residential buildings in order to assess the sustainability of these buildings in order to launch in this field as well as the relative importance of sustainability standards according to the conditions and environment of each country so that it helps in knowing the priorities during design to focus on standards of greater relative importance as it There is currently no information on the level of achievement of sustainability elements in buildings in Egypt.

3. THE IMPORTANCE OF RESEARCH

Access to internal comfort within the architectural space, including the use of space occupants. And to preserve the environment from pollution and harmful substances, saving spending with high quality.

The research is concerned with saving costs and creating a good environment that achieves better housing conditions, as residential buildings were selected in this research due to their social, economic and urban importance, which constitutes a good model for engineering projects.

4. RESEARCH OBJECTIVES:

Shedding light on the use of technology in interior architecture, materials and materials used in it, and highlighting the possibility of adapting the technology of manufacturing raw materials to comply with the environment and meet the needs of environmental designs without damaging design thought. As the designer can replace harmful manufactured materials with materials that preserve the environment and keep pace with technological development in the manufacture of environmental materials.

The research aims at sustainable development and modification of international standards to suit the Egyptian reality and measure the extent to which sustainability standards are applied in Egypt during the design and implementation stages.

5. METHODOLOGY:

In this research, we are interested in studying each of the design and implementation stages because the requirements of each stage differ from the other, as it relied this research on the descriptive approach and the work was done according to the following stages:

• Commitment to standards for the sustainability of residential buildings based on previous research and to suit projects in the State of Egypt.

• Organizing two measurement tools for each of the design and implementation stages for the purpose of assessing the sustainability of residential buildings, where the five-point Likert scale was used for evaluation, as well as the importance of each of the sustainability criteria that was adopted, which was divided into seven axes, and each axis includes a set of sub-criteria, and this was also done for each of the design and implementation stages.

• Processing the results of questionnaires to determine the level of sustainability of residential buildings as well as the weight of each of their criteria. Organize the results of the analysis and display them in the form of charts and tables.

• Analyze and discuss the results obtained.

The study sample is a group of engineers specialized in both the design and implementation phases, who designed residential buildings in the State of Egypt in the new city of El Alamein for the year 2021.

Theoretical framework of the research:

Sustainability criteria: the most appropriate criteria were selected for a set of indicators that form the basis of the formulation of the questionnaire, and then the importance of the indicators was determined through the survey with a number of professionals by inviting individuals from all disciplines to participate, where the following criteria were developed:

{Site sustainability, economic aspects, water efficiency, energy efficiency, materials and resources, quality of the indoor environment, environmental tolerance, cultural and social aspects, quality of service}. Each of these main areas has several indicators, and the triple Likert scale was used, where 3 points represent very important, 2 important, 1 less important, then measuring indicators on an ordinal scale, then the average data points were found to obtain the rank of indicators, and similarly the relative importance index was found RLL.

A tool for assessing sustainability was reached from three levels of indicators by ranks, where the first level consists of indicators with averages ranging between 3-2, where most of the respondents gave these indicators a very important 3 scale: The second level consists of indicators with averages ranging between 1.99 – 1.8 The third level consists of indicators with averages less than 1.8 A three-point system of indicators has been developed based on the levels, where (3) is given to the first level indicator And the number (2) for the second level indicator (1) for the third level index.

In Slovenia (as an important attempt in this area) research was carried out [3]. The aim of the research was to propose a method for assessing the sustainability of a residential building, where the following methodology was followed: After referring to the design documents and international standards, the main areas that suit the conditions of the country were first identified, where each area has several elements and each element has one or more criteria, either measurable or descriptive according to the nature of the standard, and then the indicators are compiled according to their impact on sustainability, where the following criteria were considered: Building architecture, urbanization, building structure, building materials, air conditioning systems, electrical installations, intelligent systems, construction functions, maintenance, As for determining the weights of the standards and then conducting surveys on a test sample from 30 stakeholders closely related to the residential sector in Slovenia, it was concluded that information about the technical quality of certain elements does not satisfy the end users now. The maximum quality is not always optimal for the end user. It also resulted that the most important criterion is Building architecture. where its significance was 3.89.

In Portugal, research was carried out [4] entitled: Assessment of the sustainability of residential buildings in Portugal using the SBToolPT methodology. Objective: Assessment of the sustainability of residential buildings in Portugal to know the sustainability criteria and their applicability, the SBToolPT methodology was followed to assess the sustainability of buildings where this methodology takes into account the three dimensions of sustainability and the final rate of construction depends on the comparison of two criteria: best practice and traditional practice [4].

9 categories of sustainability have also been identified: {Climate Change and Outdoor Air Quality - Land Use and Biodiversity - Energy Efficiency - Materials and Waste Management - Water Efficiency - Health and Comfort of Residents - Facilities - Sustainability Awareness and Education - Building Life Cycle Cost}

The most important results reached: For the environmental dimension, the water efficiency criterion was 1.03, which is the highest evaluation, while the social dimension was the criterion of warnings and the culture of sustainability was the highest, where it took 1.13, while for the economic dimension, the cost of the life cycle was the highest assessment, where this criterion was taken, while the result of the overall evaluation of the construction was taken a grade A, which corresponds to good sustainability.

Research has also been conducted in Slovakia [5].

Objective of the research: To develop a new system for the environmental sustainability of buildings (BEAS) where the following methodology was followed: Develop the main areas and indicators of the BEAS (Building Environmental Assessment System) for evaluation, which were proposed based on the analysis of information available from certain areas, and these indicators also respect the Slovak rules: { Site selection and project planning, building construction, indoor environment, energy performance, water management, waste management}.

A questionnaire was also conducted in order to obtain the weights of the main areas and the weight of each criterion was determined using the Mean Absolute Deviation (MAD) method. And then evaluate the sustainability of residential buildings on ten selected residential buildings where each building was evaluated according to the proposed system in six main evaluations and 52 indicators and each main field has several indicators, where this scale falls from negative (-1) to acceptable (0) good (3 points) and best practices 5 points where the results of the research that the total average score of buildings is 1.47 points from the scale 1- to 5, which is classified as acceptable.

Research was carried out in Spain [8] entitled Proposing a New Approach to Assessing the Sustainability of Residential Buildings in 2019 This study aims to provide a new model for assessing the sustainability of different façade systems from environmental, social and economic perspectives Methodology used: A tree of requirements was created that includes qualitative and quantitative criteria and some indicators were removed or changed based on local characteristics, where the criteria and indicators that were then obtained are based on a comprehensive review of the previous literature, then the weights for each criterion were determined following the Likert five-point scale. Setting the following standards: {Energy efficiency, waste management, carbon dioxide emissions, economic aspects, safety, occupant comfort}.

Findings: A new model for assessing the sustainability of objective facades of buildings MCDM has been proposed where this approach was obtained using MIVES, a multi-criteria decision-making model that tears down key sustainability requirements (economic, environmental and social) and includes the concept of value functions The model presented allows Osama to present these elements by considering three main sustainability criteria divided into 7 sub-criteria and 14 related indicators representing economic, environmental and social requirements where this was presented the model in theory. Research was also conducted in Egypt [11]. The research aims to monitor and analyze the methodology currently used to evaluate and classify buildings in Egypt in order to highlight the available potential that can be exploited and described in this field and also aims to clarify the obstacles and challenges that hinder the evaluation process at present and then propose solutions to these problems so that they can be applied to develop the current methodology for evaluating and classifying sustainable buildings in Egypt.

Research Methodology: The descriptive analytical approach and analysis of the methodology currently used to evaluate and classify sustainable buildings in Egypt were followed in order to identify the most important available potential that can be exploited as well as the obstacles and challenges that must be faced in this context.

The Green Pyramid system was followed in the evaluation process, which is the local classification system for sustainable buildings within Egypt and was adopted based on the third version of the LEED system, where the system consists of seven main classifications similar to the LEED system, which in turn includes some sub-categories where the green pyramid system includes the following criteria: Sustainable location, accessibility, ecology (15% relative weight) Energy efficiency (25%) Water efficiency (30%), materials and resources (10%), environmental quality Interior (10%), Management (10%) The researcher found the most important obstacles facing the assessment of building sustainability in Egypt: The high initial cost of green building projects, the classification process is a complex process and needs many, long and unclear procedures for the designer, modern technologies for sustainability Technologies that are alien to society and need some time to accept, the decline of the criterion of energy saving in the order of priorities for building users who care more about buildings that achieve comfort and quality of the internal environment followed by the cost criterion and then energy comes in the rank The last .

Research was conducted in Kazakhstan in general [7] aimed to identify and explore sustainability issues specific to the region relevant to the local context of Kazakhstan, where the study adopted a qualitative approach to determine the categories and indicators of assessment of building sustainability and used literature review and Delphi technique as the main sources of data collection, developed two sets of evaluation categories and indicators, initial and final, while the weights of indicators were developed by conducting a questionnaire on experts in this field using the Likert five-point scale. Delphi in this study was conducted in the following four phases: {questionnaire design and validation, expert selection, survey, and data analysis}.

Main findings: Experts reached 100% agreement on items such as {thermal comfort, daylight, energy-saving heating and cooling energy-saving equipment, energy saving - reducing electricity consumption, building operation and life cycle costs, and annual operating costs The rest of the elements had a total value greater than 3.80: Thus, the final set of evaluation categories and indicators were considered correct.

There are also international systems for evaluating the sustainability of residential buildings, such as the British BREAM system, and the level of sustainability of the building is determined according to the points obtained, and the American Council developed a green building system (USGBC) in 1998 called this system LEED. LEED is not limited to residential and commercial buildings but goes beyond the effects of construction in the environment, so there is a special LED for each stage of construction (9): LEED standards for design and construction, LEED standards for interior design and construction, LEED standards for operation, LEED standards for structural cortical construction, LEED standards for homes, LEED standards for neighborhood development, where the points were distributed on the standards in the LED system as follows:

Design innovation 11 points, location and links 10 points, site sustainability 22 points, energy and atmosphere 38 points, materials sourced 16 points, indoor environmental quality 21 points, water use efficiency 15 points, awareness and education 3 points. The buildings that obtained this certificate were also classified into 4 ranks according to their application of the required standards and the points obtained as follows [10]:

45-59 points are minimum sustainability, 60-74 silver rating 75-89 gold rating and 90 platinum ratings.

2- A measurement tool to determine the relative importance of sustainability criteria as well as the extent to which sustainability is applied to residential buildings

The measurement tool is a survey that includes a set of questions according to the Likert five-point scale consisting of five degrees from 1 to 5 and each degree expresses the extent to which the standard is applied in reality [1] and a last column has been placed in the measurement tool to express the importance of this standard according to the opinion of the engineer or supervisor.

5.1. OBJECTIVE OF THE MEASUREMENT TOOL:

Knowing the extent to which sustainability standards are applied in residential buildings in Egypt.

5.2. FINDINGS FROM THE MEASUREMENT TOOL:

• Green buildings are expected to increase over the next three years.

• Verify the existence or absence of any system in place regarding the sustainability of residential buildings when designing these buildings

• Know the most important criteria to be included in the design of buildings.

• Obtaining a final assessment of the sustainability of residential buildings in reality if the criteria are weighted and evaluated and thus knowing the impact of the weight of the criterion on the evaluation of residential buildings.

5.3. STANDARDS SET BY THE MEASUREMENT TOOL:

Through previous studies on the development and evaluation of building sustainability standards, the criteria that suit Egypt were chosen, for example, the focus was on the economic aspects that must be taken into account when designing and implementing, as well as the location in terms of proximity to transportation and others to reduce the cost of transportation, as well as energy efficiency to avoid benefiting its sources in order to achieve a lower cost.

As well as focusing on local raw materials to avoid the cost of transportation and operation of local materials, taking into account the selection of environmentally and socially harmless materials in line with the reality of implementation in Egypt, the focus was on the following criteria:

Site sustainability, indoor environmental quality, energy efficiency, water use efficiency, materials and resources, waste management and economic aspects each major criterion included a set of sub-criteria [4-6].

The measurement performance was distributed to a segment of engineers specialized in the design and implementation stages in a project belonging to the National General Services Company contractor in the new city of El Alamein, where the sample includes 10 design engineers and 10 implementation engineers, i.e. 20 engineers out of 40, i.e. the segment that was questioned constitutes 50% of the total number within the project.

We will present a section of the questionnaire questions because its questions are mentioned through the study of the main and sub-criteria.

The questionnaire is filled out by choosing who knows the extent to which the sub-criterion is actually applied on a five-pointed scale ranging from strongly disagree and is represented by the number 1 to strongly agree and represents the number 5 questions have also been developed to determine the number of years of experience after the distribution of questionnaires were collected results and processed these results using the statistical program SPSS, a statistical method to measure the degree of stability of the questionnaire where this program gives an idea of the questions with each other and with all questions in general.

RESULTS AND DISCUSSION:

The Cronbach alpha coefficient was calculated for 20 questionnaires to ascertain the degree of stability of the questionnaire for each major criterion separately. As well as for

the questionnaire as a whole, the results were as follows:

<u>Cronbach alpha coefficient for the design phase 0.927</u>

We note from the previous table that the lowest value of the Cronbach alpha coefficient within the measurement tool for the design stage is 0.610, which is an acceptable value according to Cronbach, whose values range from 0 to 1 and the ratio is acceptable if it is greater than 0.5 and the closer its percentage is to 1, the stronger the stability of the questionnaire, as for the value of the coefficient for the measurement tool as a whole 0.927, where this value is considered excellent and this indicates the strength of the degree of stability of the measuring instrument.

<u>Cronbach alpha coefficient for the design phase 0.811</u>

We note from the previous table that the lowest value of the Cronbach alpha coefficient within the measurement tool for the implementation phase is 0.554, which is an acceptable value according to Cronbach, as for the value of the coefficient for the performance of the measurement as a whole, 0.811, where this value is very good, and this indicates the strength of the degree of stability of the measuring instrument.

Through the answers, we reached the following results:

Table 1. It is part of the questionnaire questions designed.

Criterion	Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Weight
Site Sustainability	Taking into account the suitability of the site when choosing to build on it (e.g. choosing it in pre-exploited lands - choosing it within urban areas)						
	The proximity of the site to public transport is taken into account when choosing it.						
	Taking into account the availability of basic services such as proximity to the commercial area within a specific scope of construction when choosing a construction site.						
	Design the rainwater management system in the project to reduce the amount of wasted water and exposure to pollution.						
Indoor environmental quality	Design of systems for mechanical ventilation in all buildings ... If the answer is positive, answer the following question.						
	Design monitoring and maintenance programs for these devices						
	Designing a carbon dioxide level monitor and an alarm device to alert if its percentage exceeds the permissible limit						
	During the design, natural lighting is used to illuminate the building during the day.						
Energy Efficiency	The efficiency of the building's energy systems is planned during the design process.						
	When planning and designing the energy systems in the building, the minimum energy consumption is taken into account.						
	Renewable energy (such as solar energy) is exploited during the design of the building's energy systems.						
Water Efficiency	Design of a system of collection, storage, treatment and distribution of rainwater for water consumption purposes in the building to reduce dependence on potable water.						
	The production of hot water during design is rationalized through the method used to heat it as well as its consumption through the selection of devices with low fluxes						
	Monitor water consumption through the presence of monitoring devices (such as water meters) and control the flow of water.						

Table 2. Degrees of stability of the measuring instrument for each of the sustainability axes during the design phase

The degree of stability of the questionnaire for the design stage	
Axis	Cronbach alpha
Site Sustainability	0.685
Indoor environmental quality	0.610
Energy Efficiency	0.676
Water Efficiency	0.754
Materials & Resources	0.701
Waste Management	0.786
Economic aspects	0.643

Table 3. Degrees of stability of the measurement tool for each of the sustainability axes during the implementation phase

The degree of stability of the questionnaire for the design stage	
Axis	Cronbach alpha
Site Sustainability	0.668
Indoor environmental quality	0.626
Energy Efficiency	0.761
Water Efficiency	0.587
Materials & Resources	0.554
Waste Management	0.721
Economic aspects	0.633

Chart (1) shows that 55% of the respondents are aware of the sustainability of buildings, while 25% do not have any knowledge about it, while the percentage of 20% was for respondents whose knowledge is somewhat acceptable, through these percentages, we conclude that the survey was carried out on a segment of engineers with good knowledge of green buildings, and this is a good indicator of our findings, as the sample constitutes 50% of the total number of engineers within the company and they are experienced, while the remaining percentage is from New engineers who do not have sufficient experience in this subject The National General Services Contracting Company was also chosen as the only company in Egypt responsible for designing most of the projects. As for Plan (2), the number of years of knowledge of building sustainability shows that 47% of the number of years of knowledge ranges from 6 to 10 years, while 33% of the respondents have years of experience ranging from 3 to 5 years, while 10% of the respondents have years of knowledge > 10 years, where some of them worked outside Egypt is in this area, while the rest is through access to the Internet.

From these ratios, we can see that the result reached is from a segment with good scientific knowledge and experience. As for the respondent's expectation of the increase in sustainable building projects during the coming periods, the result was as shown in Figure (3) below:

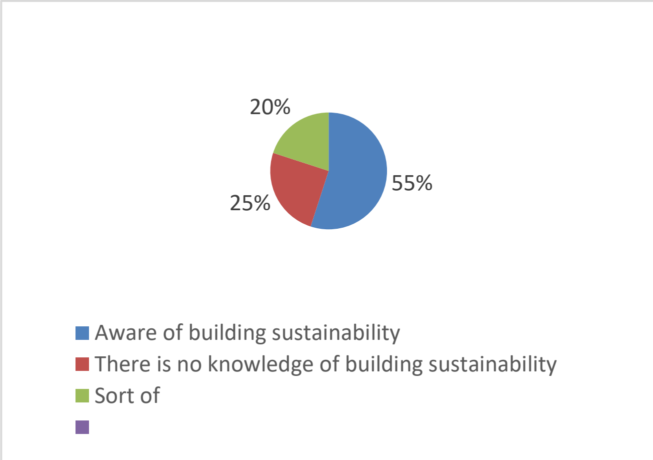

Fig. 1. Chart (1): Percentages of knowledge of respondents.

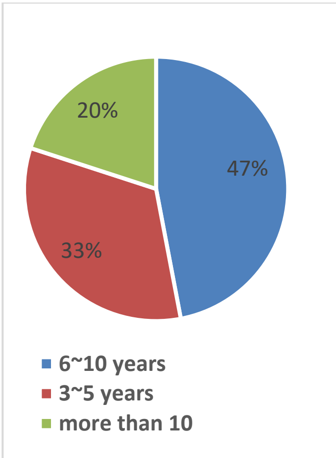

Fig. 2. Chart (2): Percentages of years of knowledge of methods Building sustainability.

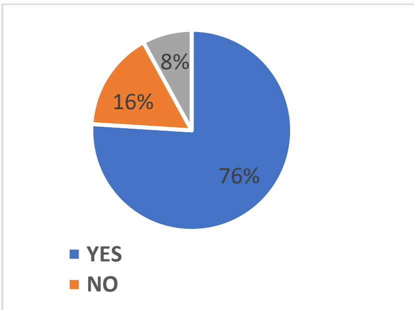

Fig. 3. Chart (3) The percentages of expectations regarding the increase in projects.

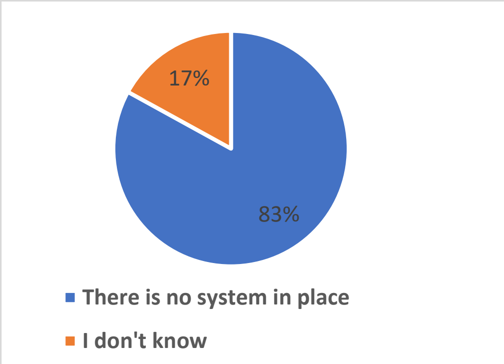

Fig. 4. Chart (4) The percentages of the presence of any system Sustainable buildings in the coming periods. Applied to the sustainability of residential buildings

It was shown from the answers in Chart (3) that the highest percentage is 76% of respondents who expect an increase in green building projects in the coming periods, while the lowest percentage is 8% who do not expect this, while 16% of respondents do not have any knowledge or expectation of this, and this result is good and encouraging. To start strongly on this topic.

As for chart (4), the presence of any applied system related to sustainability when studying projects, the opinion of 83% of respondents was that there is no applied system related to the sustainability of residential buildings, while the percentage of 17% was for respondents who did not have any knowledge about it. Through this result, we reach the necessity of developing a specific model or system to introduce sustainability standards for residential buildings when studying and designing these projects.

Regarding the importance of the main criteria, the result at the design stage is shown in table 4.

You can notice from the table above that the most important main criteria are energy efficiency, which was given a relative importance of 18.8%, followed by the economic aspects, which was given a relative importance of 16.5%, while the site sustainability criterion was given a relative importance of 15.9%, while the least important criterion is waste management, which was given a relative importance. %08.3.

Table 4. The relative importance given to the main criteria during the design phase

Main criterion	Site sustainability	Indoor environmental quality	Energy use efficiency	Energy use efficiency	Materials and resources	Waste management	Economic aspects	Total
Weight (points)	76.69	63.29	90.53	60.10	72.96	39.74	79.47	482.78
Relative importance	15.9 %	13.11 %	18.75 %	12.45 %	15.11 %	08.23 %	16.45 %	100 %

Table 5. Table (5): The relative importance of the sub-criteria within the economic aspects axis during the design phase.

The sub-criterion of the economic aspect's axis	The initial cost of the project is expected	While studying the initial cost of the project, the focus is on making it as low as possible by following modern techniques such as Revit	We seek to reduce the cost of maintenance and operation through attention to design and achieving the required quality	The cost of demolition and renovation is studied during the design process	The total
Importance	86.05	90	85	56.84	317.89
Relative importance	27.05%	37.31%	26.74%	17.90%	100 %

We note in the table above that the highest relative importance was given to the criterion of focus during studying the initial cost of the project, a relative importance of 28.31%, while the criterion of studying the cost of demolition and renovation during the design process takes the lowest relative importance of 17.19%.

We note from the table above that the relative importance is 33.68%, followed by the criterion for exploiting renewable energy, 33.32.92%. As for the lower relative importance, it is for the planning criterion for all energy systems in the building, with a relative importance of 33%.

Table 7 shows in the site sustainability axis that the criterion of taking into consideration the location's proximity to means of transportation takes the highest relative importance at 28.31%, followed by taking into account the suitability of the site when choosing it to build on, which was given a relative importance of 27.45%. As for the least importance, the criterion of designing the rainwater management system on the site was given relative importance. % 21.51

The table 8 shows that the criterion given the highest importance is the selection of local building materials that reduce transportation impacts and enhance local economies, 31.2%, followed by the criterion of taking into account that the materials do not affect human health in the long term or pollute the ecosystem. It was given relative importance, 26.96%, while the least important was the criterion of taking into account flexibility. The building was intended for use and dismantling, where 16.21% importance was given in the implementation phase. The importance was as in table 9.

We note in the table that the most important main criterion is energy efficiency, which was given a relative importance of 21.51%, followed by the materials and resources criterion of 83.15, which corresponds to a relative importance of 20.41%, while the criterion with the least relative importance is 9.47%.

Table 6. The relative importance of the sub-criteria within the energy efficiency axis during the design phase

Sub-criterion of the energy efficiency axis	Planning for all energy systems in the building during the design process	When planning and designing building energy systems, minimum energy consumption is taken into account	Renewable energy such as (solar energy) is exploited during the design of the building's energy systems	The total
Importance	89.74	91.58	90.58	271.90
Relative importance	33%	33.68%	33.32 %	100 %

Table 7. The relative importance of the sub-criteria within the site sustainability axis during the design phase

The sub-criterion within the site sustainability axis	Consider the suitability of the site when choosing it to build on	Taking into account the location's proximity to transportation	Taking into account the availability of basic services such as proximity to the commercial area	Designing the project's rainwater management system to reduce the amount of water lost and exposed to pollution	The total
Importance	84.21	86.84	69.73	66	306.78
Relative importance	27.45%	28.31%	22.73%	21.51%	100 %

Table 8. The relative importance of the sub-criteria within the resources and materials axis during the design phase

Sub-criterion Within an axis Materials and resources	When choosing materials, take into account their long-term impact on... Human health or pollution Environmental system	Choose building materials that mitigate transportation impacts and enhance local economies	Selection of recycled materials Recycle it to reduce the amount of waste that must be disposed of	When designing the building Taking into account its flexibility for use and re-disassemble	The total
Importance	78.68	91.05	72.89	49.21	291.83
Relative importance	26.96%	31.20 %	24.98%	16.86%	100 %

Table 9. Weights and relative importance given to the main criteria during the implementation phase by importance

The main criterion	Site sustainability	Indoor environmental quality	Energy efficiency	Water use efficiency	Materials and resources	trash management	The total
Importance	81.25	60.56	87.64	56.25	83.15	38.61	407.46
Relative importance	19.94%	14.86%	21.51%	13.81%	20.41%	9.47%	100 %

Table 10. The relative importance of the sub-criteria within the energy efficiency axis through the implementation phase

Sub-criterion	Commitment to using equipment and devices High efficiency in the building	Use insulation materials for all external elements in the building	Apply insulation in the building well to prevent heat leakage	Use double glazing for all external openings	The total
Importance	94.44	93.1	97.78	65.28	350.6
Relative importance	26.94%	26.55%	27.89%	18.62%	100 %

We notice from table 11 the highest relative importance is 38.2%, followed by the criterion of not using hazardous materials during the construction process, 35.7%. As for the least importance, the criterion of managing construction waste during the construction and operation process was 26.1%. Also, we note from table 12 that the greatest importance was given to the criterion of coordinating the construction site before starting construction operations, 89.72, which corresponds to a relative importance of 55.21%, while the criterion of taking all necessary measures to prevent pollution resulting from construction operations on the site, 72.78, which corresponds to a relative importance of 44.79%.

We note from table 13 that the greatest importance was given to the criterion of using insulators to prevent the transmission of sound to and from the building (68.61), which corresponds to a relative importance of 28.33%, while the least importance was given to the criterion of maintaining visual comfort through the use of high-frequency lighting (47.5), which corresponds to a relative importance of 19.61%.

Table 11. Weights of sub-criteria within the resources axis during the implementation phase

Sub-criterion	Managing construction violations during the construction and operation process	Take care not to use hazardous materials during the construction process	Taking into account the durability of the materials to be used	The total
Importance	65	89.17	95.28	249.45
Relative importance	26.1%	35.70%	38.20%	100 %

Table 12. Weights of sub-criteria within the site sustainability axis during the implementation phase

Sub-criterion	Take all necessary measures to prevent pollution resulting from construction operations on site	Coordinating the construction site before starting construction operations	The total
Importance	72.78	89.72	162.50
Relative importance	44.79%	55.21%	100 %

Table 13. The relative importance of the sub-criteria within the indoor environmental quality axis

Sub-criterion	Use insulators to prevent sound transmission to and from the building	Installing devices to monitor and document the air quality in the building by referring to the specifications	Consider using materials free of dangerous volatile substances such as mercury and lead so that they do not exceed the permissible limits	Maintain visual comfort by using high frequency lighting	The total
Importance	68.61	60.833	65.28	47.50	242.22
Relative importance	28.33%	25.11%	26.95%	19.61%	100 %

Where a five-point Likert scale was used [1], then the following law was applied to evaluate the level of sustainability [3].

$$S = \frac{\sum_{j=1}^{m} s_j W_j}{5m}.$$

M represents the number of standards in each of the axes studied, SJ is the numerical value of the standard, which ranges from 1 to 5, WJ is the weight of the standard as a percentage and S is the overall evaluation of the sustainability of buildings. The table 14 the evaluation of the sustainability of residential buildings during both the design and implementation stages if the standards are weighted. And if it is not balanced.

We note from table 14 the level of sustainability during the implementation phase is higher than the level of sustainability during the design phase. Also, the level of sustainability when the criteria are weighted is lower than its level when they are unweighted. This is evidence of the extent to which the weights of the criteria influence the evaluation of the sustainability of buildings

The level of sustainability in the implementation stage is higher than in the design stage. This is because the sustainability axes received greater importance in the implementation stage than in the design stage. This led to a higher level of sustainability in the implementation stage than its level in the design stage, except for the water use efficiency criterion, where the level of sustainability in the implementation stage was higher than its level in the design stage. Its sustainability in the implementation stage is lower than in the design stage. This disparity is due to the extent to which each standard is applied in reality. As for assessing the level of sustainability in relation to each of the main standards, the results were as in the following table 15.

Table 14. Evaluation of the sustainability of residential buildings during the design and implementation stages

	Stage	Value	Evaluation Level
Sustainability assessment through the influence of criteria weights	the design	1.6	Very weak to weak
	Implementation	1.8	Very weak to weak
Evaluating the sustainability of residential buildings without the influence of weights	the design	2.2	Weak to average
	Implementation	2.5	Weak to average

Table 15. Evaluation of the level of sustainability of residential buildings for each of the main criteria during the design phase

axis	Evaluation of the level of sustainability under the influence of weight	Evaluation level	Sustainability assessment without weight effect	Evaluation level
Site sustainability	2.3	Weak to moderate	3	middle
Indoor environmental quality	1.2	Very weak to weak	1.9	weak
Energy efficiency	1.8	Very weak to weak	1.9	weak
Water use efficiency	1.6	Very weak to weak	2.9	middle
Materials and resources	1.8	Very weak to weak	2.4	Weak to moderate
trash management	0.6	Very weak	1.6	Very weak to weak
Economic aspects	1.5	Very weak to weak	1.8	Very weak to weak

We notice from the table above the extent to which the weight affects the sustainability assessment for each of its axes, as the level of the building's sustainability assessment decreases when the weights of the criteria are introduced. For example, when the criterion is of great importance and is not applied to the building, this reduces the level of its sustainability more than when the criterion is of little importance and is not applied. Applied to the building.

We note that if the criteria were unweighted, the axes of site sustainability and water use efficiency would have the highest level of sustainability among the axes, but when the weight was entered, the level of sustainability of water use efficiency decreased more than the sustainability of the site. This is a clear explanation for the difference in relative importance, as the site sustainability criterion is more important than the water use efficiency standard.

As we noted previously, the sustainability level of the last criterion decreased by 1.4, while the sustainability level of the site sustainability criterion decreased by 0.4. We also notice from the chart that the higher the relative importance of the criterion, the less the sustainability level is affected after entering the weight.

Improvement in any axis will be reflected in the economic aspects and contribute to improving the level of sustainability because all the studied axes affect the economic aspects. During the implementation phase, the results of the evaluation of each axis are shown in table 16.

Through the table, we can see the impact of weight on sustainability assessment for each of its axes during the implementation phase, as the level of building sustainability assessment decreases when the weights of the criteria are introduced.

It is noted that if the criteria are not weighted, the material and resource criterion takes the highest level of sustainability between the axes, but when the weight entered, the level of sustainability for all axes decreased, but the lowest decrease was for the most important criterion, which is energy efficiency, and the largest decrease was for the least important criterion for waste management, where the decrease in the level of sustainability was 1.2.

Table 16. Evaluation of the level of sustainability of residential buildings for each of the main criteria during the implementation phase

axis	Sustainability assessment by weight effect	Evaluation level	Sustainability assessment without weight effect	Evaluation level
Site sustainability	weak	2.2	Weak to moderate	2.6
Indoor environmental quality	Very weak	1.3	weak	2.2
Energy efficiency	weak	2.3	Weak to moderate	2.6
Water use efficiency	Very weak	1.2	weak	2.2
Materials and resources	Very weak to moderate	1.2.6	middle	3
trash management	Very weak	0.8	weak	2

We can apply these weights to a building by multiplying the points achieved by each alternative by the weight of each axis and then calculating the final assessment of the building's sustainability through the law that was used earlier.

In the research conducted in Slovakia [5] the importance of the criteria as well as the evaluation of the sustainability of buildings resulted from an interdisciplinary point of view, where the research found that the choice of location obtained the greatest importance of 26.60%, the smallest importance was the waste management criterion, and the final evaluation of the building was 1.47, where it is considered according to the levels set for sustainability that the building is acceptable internally, while in Slovenia [3] each sustainability criterion was evaluated separately, knowing that sustainability levels range from 0 To 5, where the research found that the criterion of energy efficiency and building costs has achieved the highest level among the criteria 4 is considered a very good level while the quality of the indoor environment has the lowest level among the criteria of 2.1 where the level of sustainability is considered poor.

In Portugal [4] the researcher found that the economic aspect received the highest importance

100% while the lowest importance was water efficiency 6 and notes that the final evaluation of the building is A, which means that the level of sustainability is good. In Jordan, a green building guide has been developed [10]

The main sections of this alternative: {heritage architecture, environment, materials, energy, water, site, management} are the criteria closest to the Egyptian reality, which has been adopted most of them in this research, but the importance varies according to the conditions of the country where each of the standards of water (35-30) and energy (35-25) the greatest importance and that Jordan is one of the countries of water scarcity and is classified among the five poorest countries in the world with available water resources and there is a rise in energy costs.

In this research, the sustainability assessment of residential buildings during the design and implementation phases was studied, where during the design phase, the energy efficiency criterion received the greatest importance of 18.75%, while the waste management criterion received the lowest importance of 8.23%, as for the sustainability assessment, the site sustainability criterion received a higher sustainability level of 2.3 out of 5 and is classified as weak to medium according to the grades that were previously set, while the waste management standard received a lower evaluation level of 0.6 and the level of The sustainability level assessment for the design phase as a whole was 1.6 and the sustainability level is considered poor according to the evaluation scores.

During the implementation phase, the energy efficiency criterion received the greatest importance of 21.51%, while the waste management criterion received the smallest importance of 9.47%, as for the assessment of the level of sustainability, the standard of materials and resources management received the highest level of 2.6 and is classified as a weak to medium level, while the smallest level was the waste management standard 0.8 and is classified as a very weak sustainability level, while the sustainability level assessment for the implementation phase as a whole resulted in 1.8, where the level of sustainability is considered weak to medium according to the degrees of Pre-set evaluation.

We note through the above that the criterion of energy efficiency often obtains the highest, whether in terms of importance or evaluation, and this is evidence of the importance of this criterion significantly to preserve energy sources for fear of running out in the future, while the lowest criterion, whether in terms of importance or evaluation, is waste management, where we note through previous studies that it is the least important criterion, and this is what resulted with us in this study.

Table 17. Comparison of the classification levels by the number of points of the standards of the Lapid and Yarim scales with the current study levels

LEED		BREAM		Abu Dhabi experience		Evaluation of the current study		Sustainability
Points	Category	Number of points	Points level	Number of points	Points level	Grades	Points level	
59 - 45	minimum	36	the first	Mandatory only	1	1	Very weak	
74 - 60	Silver rating	48	the second	Mandatory + 60 electives	2	2	weak	
89 - 75	Gold rating	57	the third	Mandatory + 85	3	3	middle	
90	Platinum rating	68	the fourth	Mandatory + 115 optional	4	4	Strong	
		87	Fifth	Mandatory + 140 optional	5	5	Very strong	
		90	VI					

Table 17 shows a comparison of the classification levels between the system we have reached and some global systems.

We note through the above table that the criterion reached in this study is in line with international standards, as it is noted in the LEED standard that 59 points out of 136 constitute the minimum and these points constitute relative importance of 43.4%, while in the standard of the study, 2 out of 5 constitute approximately the same percentage 40%, which represents a weak sustainability level, which is a minimum, while 1 out of 5 constitutes 20%, which is a very weak level below the minimum sustainability limit.

Also, in our current study, levels from 1 to 5 include the importance of the standard, where the importance is multiplied by the number given to the standard according to the extent of its application, so the level of sustainability is produced, and on this basis, the evaluation is carried out, but in the LEED standard, points are awarded according to the extent of application of the standard and according to the total points obtained by the building, it is classified as either sustainable at the minimum or classified silver, gold, Platinum, the latter is considered the highest level and is the one who gets 90 points or above out of 136 points.

6. CONCLUSION AND RECOMMENDATIONS

1- The idea of sustainability in interior design must be directed towards an effective influence and element on the environment and the occupants of architectural spaces.

2- Studying the foundations of interior architecture to achieve innovative solutions that are compatible with the environment.

3- Supporting interior architecture designers by local and international institutions for those interested in this field, due to the rapid development in the modern era.

4- Taking advantage of the possibilities of sustainable interior design in the field of reducing energy consumption in internal spaces, researching treatments that contribute to improving the quality of the internal environment, studying the effects of materials, and researching ways to rationalize electricity consumption inside the building.

5- Working on finding local standards (Egyptian specifications) through which to ensure the evaluation of sustainable residential buildings.

6- The sustainability of residential buildings in Egypt is evaluated during the design and implementation stages depending on the standards that have been set, as it resulted in them being very weak and we need to improve the application of their standards during both the design and implementation stages, as the mechanism proposed through the evaluation model enables the evaluation of any residential building in Egypt and then can move to assess the sustainability of residential buildings in any governorate in Egypt

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