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Determining Key Sustainability Indicators for Iraqi Hospitals

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ABSTRACT

Hospitals are vital facilities that play a fundamental role in protecting human health and promoting community well-being, as they contribute to improving the quality of life and delivering healthcare services at multiple levels. However, due to their high consumption of energy, water, and materials, in addition to the emissions and waste they generate, achieving hospital sustainability has become essential to ensure operational efficiency and reduce environmental, social, and economic impacts. This study aims to determine the key sustainability indicators for Iraqi hospitals, considering their critical role in supporting public health and sustainable development. Based on an extensive review of previous studies, 78 indicators were identified and classified under the environmental, social, and economic dimensions. Their significance was evaluated through a structured questionnaire distributed to engineers and specialists involved in the design and management of sustainable hospitals. A total of 102 valid responses were analyzed using the Statistical Package for the Social Sciences (SPSS-V26). The Relative Importance Index (RII) was applied to assess the relative significance of each indicator, while the Pareto principle was used to select the most influential ones. The results revealed 16 key sustainability indicators that represent the main priorities for enhancing the environmental, social, and economic sustainability of Iraqi hospitals. These findings provide valuable guidance for policymakers, designers, and healthcare managers seeking to improve hospital sustainability performance within the Iraqi context.

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1. INTRODUCTION

Hospitals represent a vital infrastructure that is one of the most consuming facilities for natural resources, such as energy, water and materials, as well as producing large amounts of waste and emissions, which makes the issue of their sustainability an urgent priority in modern health and environmental policies. In light of the increasing pressures from climate change and the commitments of the global goals for Sustainable Development, Iraqi hospitals need to adopt clear and measurable performance indicators to enhance operational efficiency and reduce environmental, social and economic impacts[1,2]. Recent studies have shown that the integration between the environmental performance management systems of hospitals on the one hand, and the new international standards of sustainability in health accreditation on the other hand, has become an indispensable necessity to ensure the quality of sustainability and its applicability. For healthcare facilities, a number of areas of particular significance have been identified which must be monitored: Energy Management, Water Management, Waste Management, gas emissions, and also infrastructure, human resources and governance. These domains are dimensions of Integrated Sustainability that allow hospital sustainability to be measured in a consistent and effective manner, and socio-economic sustainability indicators such as equity in access to service, quality of care, and cost efficiency, are no less important in the overall framework of sustainability for hospitals[3]. Recent studies indicate that the application of global sustainability evaluation systems such as ISO 14001: 2015, as adapted to be applicable in the Iraqi context, can have an effective impact on hospital environmental performance improvement. Promoting flexible leadership and institutional capacity are also the most important drivers to implement sustainable building principles and developing supporting policy and legislation [4]. Hospitals in Iraq are currently facing major challenges related to limited resources, outdated infrastructure, and the growing impacts of climate change. These conditions highlight an urgent need to identify sustainability indicators that can effectively measure the extent to which hospitals achieve sustainability within the context of local environmental and social conditions. Accordingly, this study aims to scientifically determine and analyze the key sustainability indicators of Iraqi hospitals, encompassing the environmental, social, and economic dimensions, in order to provide a reliable reference that supports the enhancement of sustainability practices and the improvement of operational efficiency in Iraq's healthcare sector.

2. Literature Review

Hospital sustainability is one of the priorities of modern building design that aims to integrate environmental performance with patient comfort and operations efficiency. Studies have shown that integrating biophilic design elements such as natural light and green spaces improves patient outcomes and their psychological well-being [5]. In Jordan, an applied study evidenced the use of sustainability-based hierarchical analysis (AHP) method in comparing the factors that affect sustainable hospital design, including natural light, energy saving and green space, for improvement in recovery outcome [6]. The 2020 "practicing green Health" report also stresses the importance of evaluating the environmental performance of the hospital based on indicators such as waste reduction, chemical use securely, and promotion of environmental leadership, which help hospitals identify opportunities for environmental improvement [7]. Besides, the Clinical Sustainability Assessment Tool (CSAT) is a viable tool for measuring the ability of hospitals to practice sustainably in healthcare, and this aids in increasing sustainability in the future [8]. The Queen's Nottingham UK hospital scheme demonstrates the part energy efficiency measures, such as the installation of double-glazed windows and the construction of an Energy Center utilizing high-efficiency heat pumps, can have in reducing carbon dioxide emissions by 10,000 tons a year, improving patient comfort, and supporting sustainability objectives [9]. Hospitals in Iraq are facing substantial challenges stemming from limited resources, aging infrastructure, and the escalating impacts of climate change. These challenges underscore the urgent need to identify sustainability indicators capable of accurately assessing the degree to which hospitals achieve sustainability within the local environmental and social context. Therefore, this study aims to scientifically determine and analyze the key sustainability indicators of Iraqi hospitals, covering the environmental, social, and economic dimensions, to provide a credible reference that can support the enhancement of sustainability practices and the improvement of operational efficiency across Iraq's healthcare sector.

3. Research methodology

This study is based on the identification of the main indicators of hospital sustainability through precise methodological steps, as follows:

1. **Collection of indicators:** the literature and previous studies were reviewed to compile sustainability indicators for hospitals, focusing on the economic, environmental, health and social dimensions.

2. **Classification of indicators:** the content Analysis method was used to classify indicators and identify their basic categories, which helped to organize the data in an organized and objective manner.

3. **Questionnaire design:** a questionnaire was developed to assess sustainability performance in hospitals based on international literature and practices, and its questions were classified according to the specified categories of indicators.

4. **Prioritization:** a survey was conducted of experts in Architecture, Civil Engineering, Mechanical and electrical engineering related to hospitals, to determine the importance of each indicator. The relative importance index (RII) was used to assess the priority of indicators.

5. **Analysis of survey data:** the survey data were coded and analyzed using the SPSS v26 software, to ensure the accuracy of the measurement and calculation of statistical parameters needed for the prioritization.

6. **Selection of key indicators:** the researchers utilized the Pareto Principle in an effort to reduce the number of indicators to relatively most important ones, which led to the identification of key indicators of sustainability performance in hospitals.

7. **Visually represent the methodology:** Figure 1 shows a summary of the steps of the methodology adopted in the study, from the collection of indicators to the selection of the main ones.

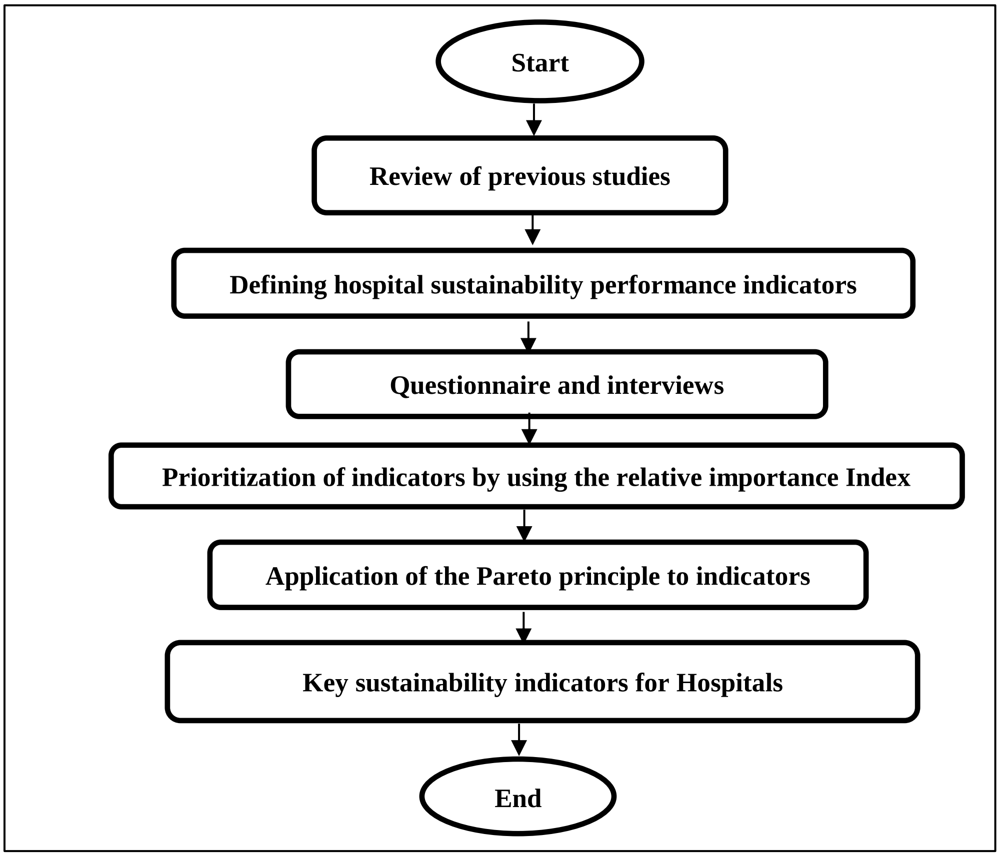

Figure 1. Research methodology

3.1 Defining Hospital Sustainability Indicators

Sustainability indicators influencing the sustainability of hospitals were identified by a literature review and a review of available existing studies. The literature review and studies resulted in the identification of 78 indicators common to three primary dimensions of sustainability, i.e.: the economic dimension, the social dimension, and the environmental dimension. Environmental dimension consists of 37 indicators grouped under three categories, which are: environmental design category, sustainable site selection category, and waste management category. The social dimension consists of 27 indicators grouped under four categories, which are: the Patient Room Features Category, Family/visitor space features category, Accessibility Category ,and Space flexibility. With regard to the economic dimension, 14 indicators have been identified, divided into two categories: life cycle cost category, and transportation cost reduction category. The details of these indicators and categories are indicated in Table No. 1, Table No. 2 and Table No. 3.

Table 1. The Specific Environmental Indicators for Hospitals

No.	Categories	Indicators	References
1	Environmental Design Category	Use natural ventilation	[10,15]
		The integrated design utilization (uniformity of interior design in respect to finishing, air conditioning, and lighting)	[10,15]
		Use of thermal insulators	[10,14]
		Utilization of the indirect solar system as a heat and light source	[10]
		Utilization of climatic comfort by the building in using color in the interfaces and high centrifugal equipment to provide heat.	[10,14]
		Flexibility design utilization and scalability	[10]
		Utilization of entries and mobility: for People with special needs	[10,14]
		Application (soundproof design-furniture-insulators) to control the noise	[10,14]
		Ventilation and smoking control usage	[10]
		Building location for tying into other buildings within the site	[11,15]
		Design of spaces in the building to respond to direct sunlight	[11]
		Greening the building means integrating green attributes in the theme of the design, i.e., green roofs and green walls	[12,11]
		Interior design appearance	[13]
		Exterior design appearance	[13]
		Quality of building architectural appearance	[12]
2	Sustainable Site Selection Category	Non-green land choice during building construction, proximity to population density	[14]
		Availability of services: Site selection accessible services such as electricity, water	[14,15]
		Accessibility to the public transport without difficulty and utilization of easily accessible land for use of environmentally friendly transport such as bicycles	[14,16,12,11,13]
		Redevelopment: Previously site selection used sites such as industrial land (habitat rehabilitation and construction in pre-invested land)	[10,16,17]
		Slowing the pace of net available land utilization, including: Layout optimization, Land utilization, and Layout and Orientation)	[16,17,12]
		Use of autochthonous vegetation (low-maintenance, low-water, and other resource-demanding vegetation)	[16,17]
		Reducing the heat island effect through the promotion of the green cover, more planting of trees, fitting green roofs to provide shade and cooling and the use of cold roofs and walkways with greater reflectance of sunlight and lower absorption of heat.	[16]
		Ecological protection of the zone	[17,15]
		Parking space (Design suitable parking spaces and cycling lanes)	[12,11]

		Environmental concern as a result of building life cycle (Building life cycle impact assessment)	[16,17]
		Visual relationship with the external landscape and Outdoor views	[17,13]
		Building a low-impact site	[16,12]
		Access to socio-economic facilities, social, and domestic	[16,12]
		Green space (Gardens and landscapes)	[10,12,11]
		Site selection high above sea level	[10,16]
		Minimizing damage to sensitive landscape	[15]
3	Waste Management Category	Use of demolition and construction waste	[10]
		Using of construction waste management includes: reducing construction waste and recycling of construction waste	[10,16,12,11]
		Reducing hazardous waste	[11]
		Using alternatives to burning waste	[11,15]
		Storage conditions of solid waste during the building's use phase (Solid waste production)	[16,10]
		Waste storage and separation	[17,15]

Table 2. The Specific Social Indicators for Hospitals

N0	Categories	Indicators	References
1	Patient Room Features Category	Washrooms	[11,13,19,20]
		Privacy	[11,13,19,20]
		Nutrition	[11,13,19,20]
		Wide space	[11,13,19,20]
		Medical utilities	[11,13,19,20]
		Overall satisfaction	[11,13,19,20]
2	Family/Visitors Space Features Category	Socialization space	[11,13,19,20]
		Community enhancement	[11,13,19,20]
		Parking space	[11,13,19,20]
		Physical activities promotion	[11,13,19,20]
		Availability of services	[11,13,19,20]
		Furniture qualities	[11,13,19,20]
		Landscape qualities	[11,13,19,20]
		Night space area	[11,13,19,20]

		Nutrition services	[11,13,19,20]
3	Accessibility Category	Accessibility to amenities (Easy access to amenities)	[11,13,19,20]
		Layout legibility	[11,13,19,20]
		Indoor signage	[11,13,19,20]
		Entrance clarity	[11,13,19,20]
		Architectural composition	[11,13,19,20]
		Outdoor signage	[11,13,19,20]
		Path distance	[11,13,19,20]
		Logistics	[11,13,19,20]
4	Space flexibility and adaptability Category	Space optimization	[11,13,19,20]
		Design Quality	[11,13,19,20]
		Flexibility and adaptability and expansion of spaces and Maximize flexibility and adaptability of indoor	[11,13,19,20]
		Spatial and volumetric organization of indoor and outdoor spaces Equipment and Furniture	[11,13,19,20]

Table 3. The Specific Economic Indicators for Hospitals

No.	Categories	Indicators	References
1	Life Cycle Cost Category	Operating expenses for energy	[14,16]
		Water operating expenses	[14]
		Supporting local economic diversity	[15,17]
		Achieving financial benefits and profits	[10,15]
		Real cost pricing and full cost accounting	[15,18]
		Financial sustainability and ensuring the financial capacity of beneficiaries by reducing excessive focus on the technical aspects of sustainability	[12,15]
		Long-term cost management through the development of long-term cost management strategies	[11,18]
		Control the costs associated with the operation and maintenance of facilities to ensure financial and operational sustainability	[11,14]
		Adopting strategies and techniques to increase the operational life of the building and improve its efficiency in the long term	[11,18]
2	Transportation cost reduction category	Enhance the presence near public transport stations and facilities to facilitate access and reduce dependence on private vehicles	[10, 11,17]
		The adoption of alternative fuels to reduce harmful emissions	[11,18]
		Adopting electric vehicles to reduce carbon emissions and promote energy efficiency in the transport sector	[10,11,16,]
		Encourage active transport (use of bicycles and walking) to reduce emissions	[11,15]

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Virtual clinics and telemedicine services to enhance telehealth delivery and reduce the need for mobility	[16,17]

3.2 Analysis of closed Questionnaire Data

The survey instrument used in this study has four major dimensions aimed at addressing various domains of sustainability in hospitals. The first dimension involves collection of individual data of respondents. The second dimension is with reference to environmental sustainability indicators for hospitals. The third dimension is with reference to social sustainability indicators for hospitals. Finally, the fourth axis deals with the economic aspects of sustainable hospitals. The Likert five-point scale was employed in order to quantify the importance of each indicator on which the responses ranged from (1) absolutely unimportant to(5) very important. The indicators were ordered after consulting a panel of specialists and engineers in different fields of engineering in order to ensure the completeness and accuracy of the rating. The questionnaire was administered to 102 participants drawn from engineers, scholars and practitioners who have in-depth expertise in the field of sustainable hospitals, and 100 responses were used after two responses were excluded due to non-adherence to requirements and research parameters. As for the data analysis, it has been divided into two main sections; the first section is intended to examine the personal and demographic information of the participants, which helps us to understand their diverse backgrounds and experiences, while the second section is focused on examining the questionnaire data regarding the environmental, social, and economic indicators of sustainable hospitals, in an attempt to detect the priorities of these indicators and the levels of their practical and applied relevance in the context of sustainable hospital design.

3.2.1 Analysis of Participant Data

This part is aimed at studying the professional and academic characteristics of the research sample, focusing on the type of labor sector, academic qualification, specialization, place of work (governorate name).,as well as the number of years of professional experience. Repetition and percentage have been utilized to summarize this basic information for the respondents of the survey as described below:

Figure (2) shows the number of academic qualifications of the respondents of the survey. It was found that most of the respondents have a bachelor's degree at 52%, and that the percentage of those who have a higher diploma was the smallest at 5%. The remaining percentages include participants with a master's degree at 29% and a doctoral degree at 14%. This distribution reflects the diversity of the sample's academic backgrounds and their suitability to contribute to the evaluation of sustainability indicators in hospitals.

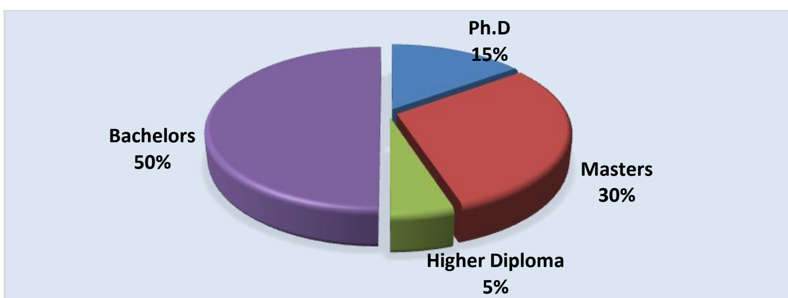

Figure 2. Percentages of participants ' academic qualifications

Figure (3) shows the distribution of participants by labor sector. It turned out that the majority of respondents work in the public sector at 76%, while the percentage of employees in the private sector was the lowest at 24%. This distribution reflects the nature of the professional background of the sample and the extent to which both sectors are represented in the assessment of sustainability indicators in hospitals.

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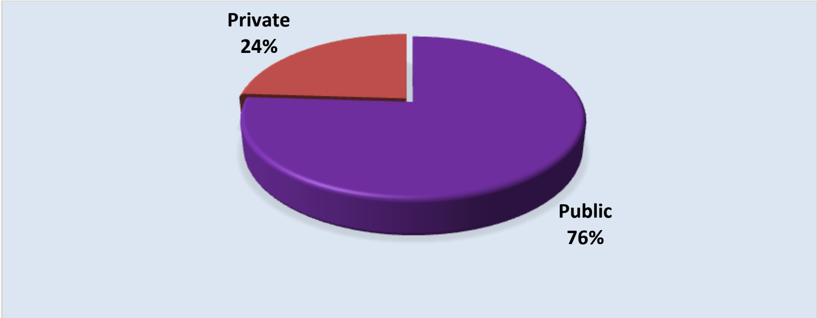

Figure 3. Percentage of participants by work sector

Figure 4 shows that the majority of participants belong to the specialty of civil engineering at 50%, while mechanical engineering recorded the lowest percentage at 5%. The remaining percentages include architecture at 36% and electrical engineering at 9%. This distribution reflects the sample's focus on specialties directly related to the structural and architectural design of hospitals, while the lower representation of mechanical and electrical engineering indicates limited expertise in technical aspects related to electrical and mechanical systems, which may affect the assessment of some environmental and technical indicators of sustainable hospitals.

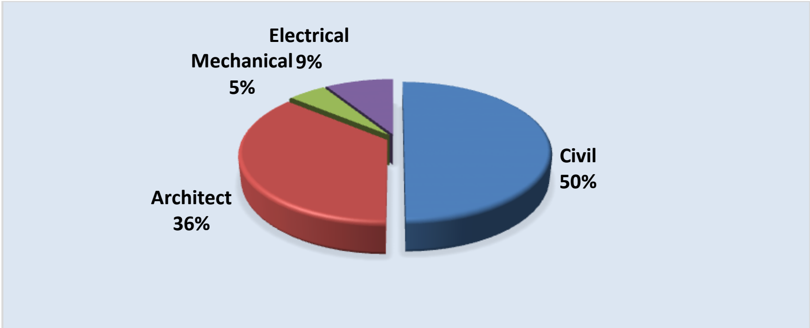

Figure 4. Percentages of participants ' academic specialties.

Figure 5 shows the percentages of years of professional experience of the participants, where most of the experiences span between 5 and 10 years at 45%, while the experiences between 16 and 20 years represent the lowest percentage (8%). The remaining percentages include participants with 11-15 years of experience at 20%, and those with more than 21 years of experience at 27%. This distribution reflects the diversity of professional experience levels of the sample, with a good representation of both medium and long-term experience, allowing a balance between modern practical experiences and deep knowledge gained over many years in assessing sustainability indicators in hospitals.

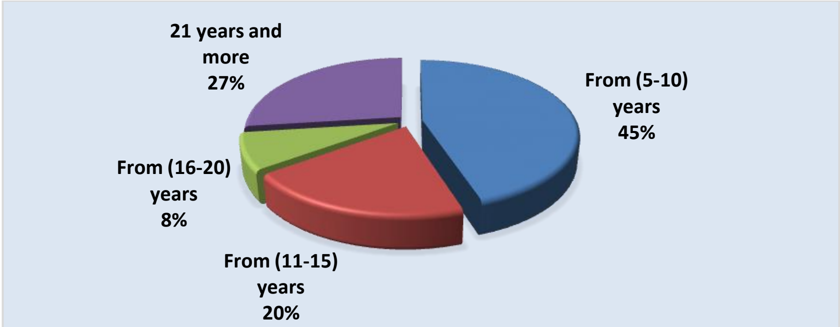

Figure 5. Percentage distribution of participants by professional experience

Figure 6 shows the distribution of participants according to their place of work, where 25% of the participants came from Baghdad, 35% from Salah al-Din governorate, while Basra represented 8%. Anbar was also represented by 15%, and Mosul by 17% of the participants. This distribution reflects the diversity and comprehensiveness of the geographical sample, enabling the collection of multiple opinions and experiences on sustainability indicators in hospitals across different Iraqi governorates.

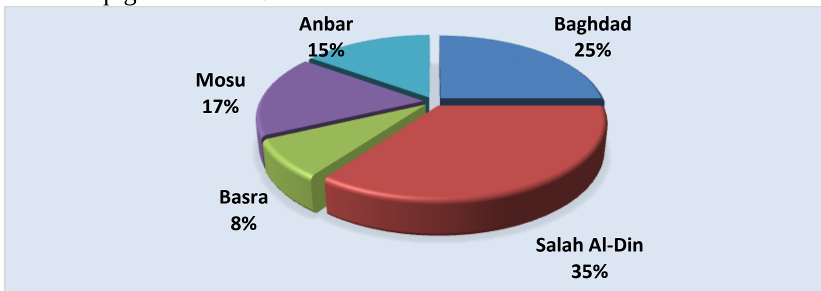

Figure 6. Percentage of participants by governorate

3.2.2 Analysis of Participants ' responses to assess Sustainability Indicators

Analysis of the data obtained from the survey was conducted using the SPSS software version 26, where the weighted average and standard deviation of indicators were computed. Using the formula of the relative importance index (RII) No. 1, the relative importance value of three indicators, namely environmental, social, and economic, was computed. The comparative weight of each indicator was classified in association with computed values and as seen in Table 5. According to the relative importance index and standard deviation, the indicators were ranked under every axis to position them in order of priority in the environmental, social and economic category.

3.3 Relative Importance Index (RII)

Relative importance index (RII) is used as a handy means of comparison and ranking of indicators based on the importance level. This indicator is mostly used in research on the basis of the five-point Likert scale, because of the fact that its value lies between 0 and 1, from which there exists precise quantitative measurement of each item of the survey's level of importance. The value of the indicator is calculated using formula No. 1, and the sign value is calculated from the resulting value as shown in Table No. 5 [21]. The mechanism is one of the most popular and reliable mechanisms of questionnaire data analysis due to its high ability to rank variables in the correct order [22]. Considering this, relative importance index calculation was used in this study to determine the relative significance of sustainability indicators in environmental, social and economic dimensions.

$$\text{RII} = \frac{\sum W}{A \times N} \times 100 \qquad (1)[21]$$

Where:
RII: Relative Important Index
W: The weight given to each indicator.
A :The highest weight (in this study it is equal to 5))
N: The total number of participants in the questionnaire

Table 4. Importance Level of Relative Important Index [21]

(RII) Values	Importance Level	
$0.8 \leq RII \leq 1$	High	H
$0.6 \leq RII \leq 0.8$	High-medium	H-M
$0.4 \leq RII \leq 0.6$	Medium	M
$0.2 \leq RII \leq 0.4$	Medium-Low	M-L
$0 \leq RII \leq 0.2$	Low	L

3.4 Pareto Principle

The Pareto Principle method is one of the statistical tools used in decision-making processes, aimed at identifying a limited set of tasks or factors that possess the greatest influence in achieving general goals. This principle is based on the idea that 20% of the effort or resources can achieve almost 80% of the results, while the remaining 80% of the effort contributes to the achievement of only 20% of the output. This principle is named after the Italian economist and sociologist Vilfredo Pareto (Vilfredo Pareto), who laid the theoretical foundation for the idea of unequal distribution between effort and results. This concept is widely used in the fields of Management, Economics, efficiency analysis, priority setting, as it reflects the imbalance in the distribution of causes and results, highlights the importance of focusing on the most influential factors to achieve the best possible results [23].

4. Results and Discussion

The results of this study are presented in two main parts; the first part deals with analyzing and calculating the relative importance index (RII) of hospital sustainability key performance indicators, to identify the level of effect of each indicator among the different dimensions of sustainability. The second part deals with the application of the Pareto Principle (20/80) to these indicators, in an attempt to choose the small proportion of indicators that will provide the greatest contribution to enhancing sustainable performance in health institutions.

4.1 Prioritization of sustainability indicators using RII

The relative importance index of the indicators was calculated within the three dimensions: environmental, social and Economic, with the aim of determining the level of importance of each indicator relative to the rest of the indicators. This indicator allows quantifying the priorities of the indicators, helping to focus on the most influential elements in promoting sustainability within hospitals. The indicators were ranked according to RII and standard deviation values to determine their order of priority, as shown in tables 5, 6 and 7.

Table 5. RII of Environmental Indicators

1.Environmental Design category	Weighted average	RII	Standard deviation	Rank	Level of importance
Use natural ventilation	3.4951	0.69902	1.21166	13	H-M
Incorporation of inbuilt design (harmony of interior design with lighting, air conditioning, and finishes)	3.9709	0.79418	1.01418	1	H-M
Utilization of thermal insulators	3.8447	0.76894	1.08246	4	H-M
Use of the indirect solar system as a heating and illumination source	3.6796	0.73592	1.22245	5	H-M
Utilization of climate comfort around the building: high centrifugal machines for heat and utilization of color in interfaces	3.4854	0.69708	1.25919	14	H-M
Flexibility design utilization and scalability	3.3592	0.67184	1.20338	15	H-M
Utilization of entries and mobility: for People with special needs	3.6117	0.72234	1.16512	10	H-M
Use (soundproof design-furniture-insulators) to reduce noise	3.5243	0.70486	1.21949	11	H-M
Use of ventilation and control of smoking	3.6602	0.73204	1.17618	8	H-M
Building location to be linked to other buildings in the site	3.6699	0.73398	1.2787	6	H-M
Interior space design to be in a position to respond to direct sunlight	3.6602	0.73204	1.08964	7	H-M
Greening of the building involves the use of green elements in the design concept such as (green roofs, and green walls)	3.6311	0.72622	1.19632	9	H-M
Visual appearance of interior design	3.5049	0.70098	1.15363	12	H-M
Visual appearance of outdoor design	3.8835	0.7767	1.05998	3	H-M
Appearance quality of building architecture	3.9417	0.78834	1.00806	2	H-M
2.Sustainable site selection category	**Weighted average**	**RII**	**Standard deviation**	**Rank**	**Level of importance**

Selection of non-green land when constructing Location near population density	3.8932	0.77864	1.08386	3	H-M
availability of services: Location selection available services such as electricity, water	3.767	0.7534	1.26184	4	H-M
Accessibility for easy use of public transport and a location fit to utilize environmentally friendly transport such as bicycles	4.0777	0.81554	1.01643	1	H
Redevelopment: Location selection former exploited areas such as industrial land (rehabilitation and Construction in pre-invested areas)	3.9223	0.78446	1.07274	2	H-M
Urban density (curb the rate of net available land use including; Land use, Layout optimization, and Layout and Orientation)	3.6117	0.72234	1.19831	13	H-M
Use autochthonous vegetation (vegetation with a tendency to thrive under minimal maintenance, water, and other inputs)	3.6893	0.73786	1.18842	8	H-M
Reduce the heat island effect by maximizing green area, planting more trees, green roofs to provide shade and cooling, and cold roofs and sidewalks that reflect more sun and less heat.	3.6214	0.72428	1.18914	12	H-M
Ecological defense of the building	3.6796	0.73592	1.19815	9	H-M
Parking capacity (Design suitable parking areas and cycles lanes)	3.6699	0.73398	1.14093	10	H-M
Environmental impact associated with building life cycle(Audit of building life cycle impacts)	3.7184	0.74368	1.17505	7	H-M
Visual relationship with surrounding landscape and Outdoor views	3.4854	0.69708	1.11903	15	H-M
Construction of low-impact site	3.5243	0.70486	1.21949	14	H-M
Access to social, domestic, and socio-economic facilities	3.4272	0.68544	1.10792	16	H-M
Green space (Gardens and landscapes)	3.7573	0.75146	1.01427	5	H-M
Site Selection High above sea level	3.7379	0.74758	1.17123	6	H-M
Low damage to sensitive landscape	3.6505	0.7301	1.13508	11	H-M
3. Waste management category	**Weighted average**	**RII**	**Standard deviation**	**Rank**	**Level of importance**
Use of demolition and construction refuse	3.699	0.7398	1.16177	2	H-M
Use of waste management system (Construction waste management include: reduction of construction waste and construction waste recycling)	3.0583	0.61166	1.27437	6	H-M
Reduction of hazardous waste	3.1845	0.6369	1.3558	5	H-M
Use of alternatives to waste incineration	3.8447	0.76894	1.23477	1	H-M
Storage conditions of solid waste during the building use period (Production of solid waste)	3.6602	0.73204	1.3325	3	H-M
Segregation and storage of waste	3.4563	0.69126	1.2507	4	H-M

Table 6. RII of Social Indicators

1.Patient Room Features Category	**Weighted average**	**RII**	**Standard deviation**	**Rank**	**Level of importance**
Washrooms	3.6796	0.73592	1.17334	6	H-M
Privacy	3.9903	0.79806	1.2641	1	H-M
Nutrition	3.9126	0.78252	1.31438	2	H-M
Wide space	3.7961	0.75922	1.23954	4	H-M
Medical utilities	3.7864	0.75728	1.20172	5	H-M
Overall satisfaction	3.8932	0.77864	1.25957	3	H-M
2.Family/visitor space features category	**Weighted average**	**RII**	**Standard deviation**	**Rank**	**Level of importance**
Socialization space	3.7476	0.74952	1.21847	3	H-M
Community enhancement	3.5825	0.7165	1.13349	6	H-M
Parking space	3.5534	0.71068	1.16087	7	H-M
Physical activities promotion	3.8447	0.76894	1.21071	2	H-M
Availability of services	3.5146	0.70292	1.16201	8	H-M
Furniture qualities	3.8447	0.76894	1.17788	1	H-M
Landscape qualities	3.6117	0.72234	1.1396	5	H-M
Night space area	3.7282	0.74564	1.13927	4	H-M
Nutrition services	3.4563	0.69126	1.19457	9	H-M
3.Accessibility Category	**Weighted average**	**RII**	**Standard deviation**	**Rank**	**Level of importance**
Accessibility to amenities (Easy access to amenities)	3.6796	0.73592	1.23839	8	H-M
Layout legibility	4.0097	0.80194	1.16733	3	H
Indoor signage	3.9515	0.7903	1.13223	5	H-M
Entrance clarity	4.068	0.8136	1.02194	2	H
Architectural composition	4.1262	0.82524	1.09973	1	H
Outdoor signage	3.8252	0.76504	1.1152	7	H-M
Path distance	3.9903	0.79806	1.02417	4	H-M
Logistics	3.835	0.767	1.02992	6	H-M
4.Space flexibility and adaptability Category	**Weighted average**	**RII**	**Standard deviation**	**Rank**	**Level of importance**
Space optimization	3.9223	0.78446	1.14352	1	H-M
Design Quality	3.8641	0.77282	1.09409	3	H-M
Flexibility and adaptability and expansion of spaces and Maximize flexibility and adaptability of indoor	3.9029	0.78058	1.08929	2	H-M
Spatial and volumetric organization of indoor and outdoor spaces Equipment and Furniture	3.8252	0.76504	1.15832	4	H-M

Table 7. RII of Economic Indicators

1. life-cycle costing category	Weighted average	RII	Standard deviation	Rank	Level of importance
Operating expenses for energy	3.8058	0.76116	1.06696	1	H-M
Water operating expenses	3.7476	0.74952	1.14377	2	H-M
Supporting local economic diversity	3.5534	0.71068	1.07309	7	H-M
Achieving financial benefits and profits	3.5922	0.71844	1.14135	5	H-M
Real cost pricing and full cost accounting	3.4804	0.69608	1.13216	9	H-M
Financial sustainability and ensuring the financial capacity of beneficiaries by reducing excessive focus on the technical aspects of sustainability	3.6311	0.72622	1.12886	3	H-M
Long-term cost management through the development of long-term cost management strategies	3.5534	0.71068	1.12658	8	H-M
Control the costs associated with the operation and maintenance of facilities to ensure financial and operational sustainability	3.6117	0.72234	1.09574	4	H-M
Adopting strategies and techniques to increase the operational life of the building and improve its efficiency in the long term	3.5825	0.7165	1.06204	6	H-M
2. Transportation Efficiency and Cost Reduction Category	**Weighted average**	**RII**	**Standard deviation**	**Rank**	**Level of importance**
Enhance the presence near public transport stations and facilities to facilitate access and reduce dependence on private vehicles	3.8252	0.76504	1.16676	2	H-M
The adoption of alternative fuels to reduce harmful emissions	3.8252	0.76504	1.14127	1	H-M
Adopting electric vehicles to reduce carbon emissions and promote energy efficiency in the transport sector	3.4854	0.69708	1.26696	3	H-M
Encourage active transport (use of bicycles and walking) to reduce emissions	3.2621	0.65242	1.37884	5	H-M
Virtual clinics and telemedicine services to enhance telehealth delivery and reduce the need for mobility	3.3981	0.67962	1.23145	4	H-M

4.2 Using the Pareto Principle (20/80) for Indicator Prioritization

After determining the ranking of each indicator and estimating its level of relative importance based on the relative importance index (RII), the total number of indicators in the three dimensions of sustainability was determined. The number of indicators reached 37 indicators in the environmental dimension distributed over three main categories, 27 indicators in the social dimension distributed over four categories, and 14 indicators in the economic dimension distributed over two categories.

In order to focus on the most impactful indicators, the Pareto Principle (20/80) was applied, which states that 20% of indicators contribute to about 80% of achieving sustainability goals, which made it possible to reduce the number of indicators in each dimension and identify the most effective ones in improving the sustainable performance of hospitals.

Pareto Principle (20/80) has been applied to all sets of indicators of the three dimensions of sustainability, namely the environmental dimension, the social dimension, and the economic dimension, with the aim of identifying the most efficient and influential indicators in achieving the overall sustainability of hospitals. The results of the analysis indicated that the application of this principle led to the extraction of seven principal indicators in the environmental dimension distributed in three main categories, as in Table 8, while

six principal indicators were extracted in the social dimension distributed in four categories as in Table 9, and the economic dimension had three principal indicators distributed in two categories as in Table 10. These results indicate the effectiveness of the Pareto Principle in reducing the number of indicators and sorting the factors with the greatest impact on hospital sustainability improvement.
After applying the Pareto Principle (20/80) over the sustainability indicators, 16 KPIs were determined and classified into 9 categories under the three dimensions: environmental, social and economic. These indicators are the most influencing factors on the sustainability of hospitals as they have a high percentage of contribution to the total impact of sustainability compared to the other indicators. This distribution reflects the importance of focusing on these high-priority indicators when planning and managing sustainable hospital projects, with the possibility of using the results as a basis for strategic decision-making and improving the environmental, social and economic performance of health institutions.

After applying the Pareto Principle (20/80) to the environmental dimension indicators, the results showed that the most influential indicators are mainly based on the Integrated Environmental Design, where it received the highest value RII = 0.79418, followed by the quality of the architectural appearance of the building with a value RII = 0.78834, and the external appearance of the design with a value RII = 0.7767. As for the sustainable site selection category, the index of accessibility to public transport and the use of environmentally friendly means of transport such as bicycles was issued with a value of RII = 0.81554, followed by the reuse of previously reclaimed land with a value of RII = 0.78446, and the selection of non-green sites near population density with a value of RII = 0.77864. In the Waste Management category, the use of alternatives for incineration of waste was the most significant with a value of RII = 0.76894.
These results indicate that hospital environmental priorities are centered on integrated design, sustainable location, and managing waste. For these indicators to be achieved on the ground, a number of pragmatic measures should be followed, including: installation of an integrated architectural design that includes natural lighting and ventilation, finishing materials and air conditioning system compatibility, selection of sites close to public transport and enabling active transport, reuse of land so that urban sprawl is limited on Natural Lands, and utilization of environmentally friendly waste management processes instead of traditional incineration. The implementation of these measures ensures that the environmental sustainability of the hospitals is enhanced and the environmental impact significantly reduced, in accordance with the Sustainable Development Goals.

The results of the analysis of the social factor using the Pareto Principle (20/80) showed that the most important drivers for hospital sustainability are based on four essential axes: features of the patient room, features of visitors' and family space, accessibility, flexibility of the spaces and their adaptability. The patient room Privacy Index was greatest with RII = 0.79806, indicating that developing an environment that preserves the privacy of the patient is one of the most critical factors in enhancing the quality of care and user satisfaction. Under the family and visitor space category, quality of furniture and the enablement of physical activities with RII = 0.76894 values were as much of an influential factor to foster the wellness of visitors and ensure maximum social interaction that results in the mental well-being of patients and families. On the accessibility category, the architectural configuration scored the highest with RII = 0.82524, followed by the entrance clarity with RII = 0.8136, which shows that effective and clear architectural design is of utmost importance in providing mobility in the hospital while also increasing safety and comfort. Under the space flexibility and adaptability category, the space optimization index reflected a very high importance with RII = 0.78446, which denotes the need to design multi-purpose spaces that can be modified as per changing hospital demands.
These results validate that focus on privacy, social comfort, accessibility, and flexibility of spaces forms a basis for enhancing the social facet of hospital sustainability, and that application of the Pareto Principle allowed the most influential indicators to be prioritized in the design and operation of sustainable hospitals.

The results of the economic dimension analysis following application of the Pareto Principle (20/80) showed that the strongest drivers for hospital sustainability are based on two general categories: life-cycle Costing, transportation efficiency and cost saving.
In the energy operating cost category, the most valuable was energy operating expenses with RII = 0.76116, and second was operating expenses for water with a value of RII = 0.74952, showing that it is a top priority to optimize energy and water consumption in order to maintain economic sustainability in hospitals. While in the transportation cost saving and efficiency category, employing alternative fuel in order to reduce

harmful emissions was most valued with RII = 0.76504, suggesting that enhancing transport efficacy and reducing associated emissions serves to largely reduce costs of operation while maximizing economic and environmental sustainability at the same time.

In order to implement these indicators into practice, it is advised to follow practical measures such as: employing efficient energy and water management systems, implementing ecologically friendly technologies in transport and equipment, and maximising the utilization of operating resources. The high priority assigned to these indicators reflects that the economic sustainability of hospitals depends on the interdependence of efficient resource utilization and minimizing running costs without prejudicing the quality of Service.

Table 8. Key Environmental Indicators according to the Pareto Principle

1.Environmental Design category	**Weighted average**	**RII**	**Standard deviation**	**Rank**	**Level of importance**
Use of integrated design (interior design consistency with lighting, air conditioning, and finishes)	3.9709	0.79418	1.01418	1	H-M
Building architectural appearance quality	3.9417	0.78834	1.00806	2	H-M
Outdoor design appearance	3.8835	0.7767	1.05998	3	H-M
2.Sustainable site selection category	**Weighted average**	**RII**	**Standard deviation**	**Rank**	**Level of importance**
Easy access to public transportation and use of a site that is suitable for the use of environmentally friendly transportation such as bicycles	4.0777	0.81554	1.01643	1	H
Redevelopment: Selection of previously exploited sites such as industrial land (rehabilitation and Construction in pre-invested areas)	3.9223	0.78446	1.07274	2	H-M
Selection of non-green land when constructing the building Location near population density	3.8932	0.77864	1.08386	3	H-M
3.Waste management category	**Weighted average**	**RII**	**Standard deviation**	**Rank**	**Level of importance**
Using alternatives to burning waste	3.8447	0.76894	1.23477	1	H-M

Table 9. Key Social Indicators according to the Pareto Principle

1.Patient Room Features Category	**Weighted average**	**RII**	**Standard deviation**	**Rank**	**Level of importance**
Privacy	3.9903	0.79806	1.2641	1	H-M
2.Family/visitor space features category	**Weighted average**	**RII**	**Standard deviation**	**Rank**	**Level of importance**
Furniture qualities	3.8447	0.76894	1.17788	1	H-M
Physical activities promotion	3.8447	0.76894	1.21071	2	H-M
3.Accessibility Category	**Weighted average**	**RII**	**Standard deviation**	**Rank**	**Level of importance**

Architectural composition	4.1262	0.82524	1.09973	1	H
Entrance clarity	4.068	0.8136	1.02194	2	H
4.Space flexibility and adaptability Category	**Weighted average**	**RII**	**Standard deviation**	**Rank**	**Level of importance**
Space optimization	3.9223	0.78446	1.14352	1	H-M

Table 10. Key Economic Indicators according to the Pareto Principle

1. life-cycle costing category	**Weighted average**	**RII**	**Standard deviation**	**Rank**	**Level of importance**
Operating expenses for energy	3.8058	0.76116	1.06696	1	H-M
Water operating expenses	3.7476	0.74952	1.14377	2	H-M
2. Transportation Efficiency and Cost Reduction Category	**Weighted average**	**RII**	**Standard deviation**	**Rank**	**Level of importance**
The adoption of alternative fuels to reduce harmful emissions	3.8252	0.76504	1.14127	1	H-M

5. Conclusions

1. As the population continues to increase, pressures on available resources are increasing, threatening their ability to meet the needs of future generations. Therefore, everyone has a responsibility for the rational use of these resources. Sustainability in this context means managing resources in a way that preserves their capacity for future use, and includes three main dimensions related to the sustainability of hospitals: environmental, social, and economic.

2. Sustainability indicators vary in number and type depending on the region and hospital conditions, preferably identified and evaluated by experts with local experience and knowledge of the operation of sustainable hospitals.

3. It was noted that the number of environmental and social indicators is greater than economic ones, this is due to several factors: environmental indicators are usually the most extensive and are focused on resource consumption and minimizing environmental impact, while social indicators are related to the development of quality of care and the well-being of patients and workers. As for economic indicators, it is difficult to collect accurate financial data related to operating and investment costs, especially in cities where financial decision-making is concentrated at the state level, as is the case in some Iraqi cities.

4. Categories of indicators can be identified using content analysis methodologies of previous research frameworks, taking into account their adaptation to the nature of local hospitals.

5. Indicators are dynamic tools that are constantly evolving, require periodic evaluation and continuous feedback, and rely on measuring results and applying improvement measures to ensure sustainable effectiveness.

6. Through the analysis, 78 key performance indicators were identified in hospitals, distributed among environmental, socio-economic categories, and ranked by the relative importance of each indicator using questionnaires and interviews with engineers and specialists in sustainable hospitals.

7. Using the Pareto Principle (20/80%), the number of indicators has been reduced to 16 key performance indicators that represent the most influential factors in enhancing the sustainability of hospitals across

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the environmental, social and economic dimensions, helping to focus efforts on the most effective priorities.

6. Recommendations

1. Adopting sustainable resource management strategies in hospitals, including rationalizing the consumption of energy, water and materials, to ensure the continuity of the availability of resources for future generations.

2. Formation of local expert teams to identify and evaluate sustainability indicators in accordance with the environmental, social and economic conditions of local hospitals.

3. Enhance the collection and analysis of accurate financial data related to operating and investment costs, and develop measurable economic indicators to support decision - making in hospitals.

4. Use content analysis methodologies to classify and adapt sustainability indicators in accordance with the nature of local hospitals and the needs of users.

5. Establish regular measurement and feedback mechanisms on sustainability indicators, with continual updating according to measurement results in order to ensure their continued effectiveness.

6. Use the classified and most important performance indicators as the basis for planning sustainability improvement programs and effectively directing resources.

7. Rank the 16 highest leverage indicators to prioritize and target practical solutions to achieve greater impact in the environmental, social and economic dimensions of hospitals.

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