An-Najah National University

Faculty of Graduate Studies

Sustainability Assessment of Hospitals in West Bank

By

Mohammed Saleem Amer

Supervisors

Dr. Ahmad Ramahi

Dr. Yahya Saleh

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Dedication

My deepest debt of gratitude goes to my father-in-law – Abu Ashraf and my mother-in-law Om Ashraf – who have always been models for the human ideals of honesty, sincerity, and goodness. Now as always, I am very grateful for their support, encouragement and valuable advice and constructive instructions. God bless you.

To my wife Amal, the partner of success, the symbol of love, support and determination, the candle that have burned itself to light the way for me, the pulse of the soul, and the one who, removing the thorns from my way and teaching me that the impossible does not exist, I dedicate this work.

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To all who contributed to this humble effort

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Last, but not least, I'm very grateful to anyone who has helped me in this work.

الإقرار

أنا الموقع أدناه، مقدم الرسالة التي تحمل العنوان:

Sustainability Assessment of Hospitals in West Bank

أقرّ بأنّ ما اشتملت عليه هذه الرّسالة إنما هي نتاج جهدي الخاصّ، باستثناء ما تمت الإشارة إليه حيثما ورد، وأن هذه الرسالة كاملة، أو أي جزء منها لم يقدم من قبل لنيل أي درجة علمية أو بحث علمي أو بحثي لدى أي مؤسسة تعليمية أو بحثية أخرى.

Declaration

The work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

Student's name:	**اسم الطالب:**
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List of abbreviations

AHP	Analytic Hierarchy Process
ANOVA	One - Way Analysis of Variance
ANP	Analytic Network Process
ASHRAE	American Society of Heating, Refrigeration, and Air-Conditioning Engineers
BD+C	Building Design and Construction
BEE	Built Environmental Efficiency
BRE	Building Research Establishment
BREEAM	Building Research Establishment Environmental Assessment Method
CASBEE	Comprehensive Assessment System for Built Environment Efficiency
CBA	Cost Benefits Analysis
CEN	European Committee for Standardization
CI	Consistency Index
CR	Consistency Ratio
EC	European Commission
EF	Ecological Footprint
EIA	Environmental Impact Assessment
EPI	Environmental Pressure Indicators
ESI	Environmental Sustainability Index
EQA	Environmental Quality Authority
FAHP	Fuzzy Analytic Hierarchy Process
FCA	Full Life Costing Accounting
GBCA	Green Building Council of Australia
GBTool	Green Building Tool
GDP	Gross Domestic Product
HSAtool-WB	Hospital sustainability assessment tool – west bank
IBEC	Institute for Building Environment and Energy Conservation, Japan
ICT	Information and communication technologies
ID+C	Interior Design and Construction
IF	Importance Factor
iiSBE	international initiative for a Sustainable Build Environment
ISO	International Standards Organization
LCA	Life Cycle Assessment
LCC	Life Cycle Costing
LCCA	Life Cycle Cost Assessment

LEED	Leadership in Energy and Environmental Design
MCA	Multi Criteria Analysis
MoH	Ministry of Health
NC	New Construction
ND	Neighborhood Development
NGOs	Non-Governmental Organizations
NZGBC	New Zealand Green Building Council
O+M	Building Operations and Maintenance
PCBS	Palestinian Central Bureau of Statistics
PCM	Palestinian Council of Ministers
PGPC	Palestinian General Public Council
PMMS	Palestinian Military Medical Services
PNA	Palestinian National Authority
RA	Risk Analysis
RI	Random Index
RII	Relative Importance Index
SA	Sustainability assessment
SBTool	Sustainable Building Tool
SD	Standard Deviation
SDGs	Sustainable Development Goals
SEA	Strategic Environmental Assessment
SPSS	Statistical Package for the Social Sciences
std	Standard Deviation
SWOT	Strengths Weaknesses Opportunities and Threats
UNCSD	United Nations Commission on Sustainable Development
UNRWA	United Nations Relief and Work Agency
US EPA	United States Environmental Protection Agency
USGBC	United States Green Building Council
VOC	Volatile organic compound
WB	West Bank
WHO	World Health Organization
WI	Wellbeing Index

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Sustainability Assessment of Hospitals in West Bank

By
Mohammed Saleem Amer
Supervisors
Dr. Ahmad Ramahi
Dr. Yahya Saleh

Abstract

Hospitals are the most important component of the healthcare sector which mainly aims at maintaining better health for the community and contribute to the national well-being. However, Hospitals have complex systems with social, economic and environmental impact. Palestine is a developing country that suffers from many environmental, economic, and social challenges. It is in a dire need to apply Sustainable Development (SD) concepts in all sectors including healthcare sector. Sustainability Assessment (SA) tools provide an effective framework for assessing, improving, and guiding hospital's performance in terms of environmental, economic, and social perspectives and integrating SD concept into planning, managing, and operating hospitals.

Starting from these assumptions the aim of this study is to develop a hospital SA tool to assess and improve West Bank (WB) hospitals' sustainability. To achieve this aim, the research adopted a multidimensional methodological approach which included collecting, analyzing, and interpreting many data types from many sources using various techniques. The study starts with establishing the first set of the tool's assessment items through studying the most relevant literature and exploring a number of well-known SA tools. After that, the assessment items were refined

according to their suitability for WB context. This was done through highlighting the WB local context and conducting structured interviews (to fill a questionnaire) with 60 local experts. Furthermore, when applying pairwise comparisons and the Analytic Hierarchy Process (AHP) method it was possible to develop a weighting system in which the priorities of the proposed assessment items were assigned according to WB conditions. Pairwise comparisons were performed in the form of structured interviews (to fill a questionnaire) with 30 experts.

The outcome of the research is a Hospital Sustainability Assessment tool that suits the WB context (HSAtool-WB). The HSAtool-WB is organized in a three levels hierarchal structure: fifty indicators are at the bottom of the hierarchy. Then, in the middle level the indicators are organized into 12 categories. These categories are distributed across three main areas that cover the environmental, economic, and social dimensions of sustainability. Finally, HSAtool-WB was applied to assess sustainability in 28 of the Palestinian hospitals in WB. The results show that WB hospitals do not adopt sustainable practices as they should be. As the total sustainability score of the evaluated hospitals achieved was only about 49/100 points. It is also found that the results of the environmental indicators were found to be the lowest while hospitals achieved better results in economic and social indicators. Finally, the study recommended many sustainable strategies to improve the WB hospitals sustainability based on the weaknesses that were identified during indicators' evaluations. Emphasis was placed on administrative solutions as they do not require a substantial change in the hospital structure.

Chapter One

Introduction

Chapter One

Introduction

1.1 General background

In the past few decades, humans have achieved an enormous industrial and technological revolution in various fields, but unfortunately this is accompanied by serious environmental, economic, and social ramifications. This development has caused pollution, global warming, rising ocean levels, ozone depletion, and many other serious environmental impacts, in addition to many economic and social problems such as poverty and inequality in the distribution of wealth. Based on the above-mentioned facts, the concept of sustainability or SD has emerged.

This was followed by holding many international conferences and workshops that aimed at setting guidelines and Sustainable Development Goals (SDGs). Countries from all regions of the world have begun to adopt several SDGs which will achieve the needed progress toward sustainability. In 2016, the Palestinian government recognized its commitment to achieving the SDGs. This requires integrating sustainability in all sectors at all levels (PCM, 2018).

Healthcare sector plays a major role in preserving and promoting the humans' physical and mental health. However, healthcare facilities particularly hospitals may indirectly cause harm to human health. The hospitals can cause serious environmental problems through its various operations as they consume large amounts of natural resources and power.

In addition, hospitals produce a variety of wastes types including dangerous toxic waste (Jameton & Pierce, 2001).

Organizations these days give great attention to the environmental and social impact of their operations and strive to integrate sustainability into their core business strategies. Further, firms realize that the customers and stakeholders today give social and environmental matters more attention than before (Kalender & Vayvay, 2016). Hospitals, especially the private ones, like any other corporation continually seek to achieve a competitive advantage in the health care services they offer to people. Such a competitive advantage could be realized through many strategies. Among them, are economic, social and environmental sustainability which helps companies improve their image and achieve competitive advantage and profit. SA has grown more attention from the scientific community in order to assess sustainability goals, and many SA tools were developed. To develop a good SA tool, sustainability aspects must be considered simultaneously (Ness et al., 2007). Using SA tools can result in long term benefits, environmentally friendly buildings, lower power consumption, less waste, more comfortable, more productivity, lower operating and maintenance costs (Mateus & Bragança, 2011).

Additionally, an effective SA tool must be comprehensive in evaluating the organization's building from environmental, social and economic perspectives, reflecting the local context within which it is developed and could be applied to different life cycle stages; design, construction, operating, repair, renovation, and demolition. (Ali & Al Nsairat, 2009).

1.2 Problem Statement:

Effective healthcare provision is one of the most important pillars of economic and social development of countries (Jahan & Chowdhury, 2014).The health sector in Palestine is one of the largest service sectors that serve all segments of society. It is primarily human-related and aims to preserve the health of the members of society by providing various medical services. Hospitals are the most important component of the health sector. Hospital buildings are exceptional and complex (Stevanovic et al., 2017), containing many areas with various purposes, and many types of medical equipment for various operations. Moreover, Hospitals have many users including patients, doctors, visitors, students, researchers, nurses, cleaning staff, and others are parts of hospitals, (Castro et al., 2012).

Despite the fact that hospitals' purpose is to protect the health of people, they can harm the environment and the community (Buffoli et al., 2013). Conventional hospitals buildings consume natural resources excessively and damage the environment significantly; hospitals work around the clock and consume large amounts of energy for many operations, such as lighting, ventilation, sterilization, cooling, heating and operating medical and others. (Castro et al., 2012). At the same time, they produce hazardous and non-hazardous waste liable to cause serious damage to the environment and to the health of the community.

Many SA tools are available in the market to assess the sustainability of a variety of buildings types (including hospitals) at life cycle stages, to name but a few LEED, BREEAM, CASBEE, SBTool, and Green Star. However, there is no consensus about SA tool for measuring the sustainability of hospitals that can be used globally (Buffoli et al., 2013). In fact, the above mentioned SA tools are global and have been designed to work in different regions of the world and this requires considerable efforts in adapting to local priorities and conditions in the context where the assessment will take place. Furthermore, social, economic and environmental conditions vary greatly depending on the region, as well as priorities, constraints, regulations, and legislation (Ali & Al Nsairat, 2009). In addition, the aforementioned tools and the other tools are not fully comprehensive and focus on the environment dimension, while neglecting some important economic and social aspects which considered as critical in the developing countries and hospital system (Castro et al., 2015; Buffoli et al., 2015).

Moreover, developing countries (including the WB) face many serious environmental, economic, and social challenges (Ali & Al Nsairat, 2009). From this point of view and considering the complexity of hospital system and the weakness of the available SA in the market it is necessary to develop a hospital SA tool in the local context of developing countries according to their circumstances and priorities (Alyami et al., 2015).

To this end, the current study aims at developing SA tool to assess and improve the sustainability of WB hospitals. This will help in reducing pollution, consuming less energy, and providing better healthcare services for community.

1.3 Significance of the research:

The significance of the research derives from the importance of the healthcare sector and the vital role this sector plays in society. This research aims to study and assess the sustainability in the WB hospitals which can be considered as the most important component of the health sector components.

Hospitals play a very important role in maintaining the health of the community and contribute to the national well-being. Hospital buildings are more important than any other building because they deal with human health and contribute to the nations' economics (Guenther & Vittori, 2008).

Due to the serious environmental, economic, and social problems in developing countries, developing SA tools is urgent (Ali & Al Nsairat, 2009). Palestine is one of these countries with a special particularity attributed to the exceptional conditions Palestinian hospitals have been encountering for many years. More specifically, Palestine is a developing country suffering from many economic, social and environmental problems. Economically, the Palestinian economy is a poor economy, still weak and in the process of growth, and depends mainly on external financial support from donor countries. Socially, the Palestinian society is characterized by high growth rates; according to the Palestinian Central Bureau of Statistics (PCBS), the population growth rate in the West Bank in 2016 was about 2.5 %. (PCBS, 2016b). Environmentally, there is a lack of natural resources. Moreover, the Palestinian government lacks control over available water resources in the WB and it dependents on imported energy supplies, especially electricity and petroleum products. Also, energy demand is expected to increase due to the rapid population growth rate, (EQA, Initial national communication report to the united nations framework on climate change(UNFCCC), 2016). From this point of view and considering the rapid growth, poor economy, lack of resources conditions, it is necessary to achieve sustainability in the Palestinian hospitals and to develop a SA tool in the light of Palestinian context that will guide the hospitals to achieve sustainability.

1.4 The Research Questions

This research aims at answering the following questions:

1- What type of indicators can be considered in developing an assessment tool to evaluate and improve the sustainability of hospitals in WB context?

2- How to prioritize, and weight the indicators according to the WB context?

3- How to develop a tool to be used for assessing and improving the sustainability in Palestinian hospitals?

4- To what extent do the WB hospitals adopt sustainable practices?

1.5 The Objectives of the Research

The overall purpose of this research is to develop a SA tool based on the different existing international evaluation systems. This tool is intended to be used in the local WB context, in order to guide and improve the sustainability of the WB hospitals.

To reach this aim, several research objectives have been developed:

1- To understand the concept of sustainability and SA.

2- To explore current SA tools in the healthcare context and highlight their strengths and weaknesses.

3- To highlight and analyze the Palestinian hospitals' situation (economic, social, and environmental conditions).

4- To explore and prioritize the sustainability indicators according to the WB context (available recourses, standards, regulations, and challenges).

5- To develop a hospital SA tool to be used in the local WB hospitals (HSAtool-WB).

6- To use the HSAtool-WB to reveal to what extends the sustainability is considered in the WB hospitals.

1.6 Research Hypotheses:

- **First hypothesis (H1):** There are no statistically significant differences at (α =0.05) level between hospitals' overall score, environmental, economic, and social sustainability attributed to the variable of location.

- **Second hypothesis (H2):** There are no statistically significant differences at (α =0.05) level between hospitals' overall score, environmental, economic, and social sustainability attributed to the variable of date of establishment.

- **Third hypothesis (H3):** There are no statistically significant differences at (α =0.05) level between hospitals' overall score, environmental, economic, and social sustainability attributed to the variable of specialty

- **Fourth hypothesis (H4):** There are no statistically significant differences at (α =0.05) level between hospitals' overall score, environmental, economic, and social sustainability attributed to the variable of service provider.

- **Fifth hypothesis (H5):** There are no statistically significant differences at (α =0.05) level between hospitals' overall score, environmental, economic, and social sustainability attributed to the variable of bed capacity.

- **Sixth hypothesis (H6):** There are no statistically significant differences at (α =0.05) level between hospitals' overall score, environmental, economic, and social sustainability attributed to the variable of building areas.

- **Seventh hypothesis (H7):** There are no statistically significant differences at (α =0.05) level between hospitals' overall score, environmental, economic, and social sustainability attributed to the variable of quality certificates.

- **Eighth hypothesis (H8):** There is no statistically significant correlation at (α =0.05) level between annual water consumption per bed and hospital overall score.

- **Ninth hypothesis (H9):** There is no statistically significant correlation at (α =0.05) level between annual energy consumption per bed and hospital overall score.

1.7 Deliverables:

1- A Hospital SA tool to assess and improve the WB hospitals sustainability(HSAtool-WB)

2- Descriptive analysis about environmental, economic, and social sustainability in the WB hospitals.

1.8 Thesis Structure

This thesis comprises of five chapters. The following lines present a brief discussion about these chapters:

In the first chapter ‘introduction’ the study introduces the main subject through a brief background introduction. The chapter also discusses the research problem statement, significance, and the objectives, as well as the research questions, hypotheses, and outcomes.

The second chapter ‘Literature review’ discusses literature related to the meaning of sustainability and SA concepts. In addition, the chapter deeply discusses the concept of sustainability within the healthcare sector and hospital in particular. Furthermore, the review includes highlighting the well-known SA tools and discussing many studies that customized the international SA tools to be used in a specific context to assess a specific type of buildings. Finally, the chapter explores the WB context in term of environmental, economic, and social conditions. Moreover, the Palestinian healthcare sector is highlighted.

The third chapter ‘Methodology’ presents the methodological approach followed by the researcher to conduct the study. This included presenting the research design, data types, data collection, analysis, and sampling techniques.

The fourth chapter ‘Result analysis and discussion’ is divided into three sections in which the study results are presented. This includes presenting and discussing the results that are related to establishing and weighting the assessment items, and the results of evaluating the hospitals in WB.

Finally, in chapter five ‘conclusions and recommendations’ are presented, in brief, the study conclusions, recommendations, limitations. Furthermore, suggestions for future works are also presented.

Chapter Two

Literature Review

Chapter Two

Literature Review

2.1 Overview

This chapter presents a review of the literature related to the SA in the healthcare sector in general and hospitals in particular; the chapter first discusses the concept and dimensions of sustainability. This is followed by a discussion of the concept of environmental, economic, and social sustainability in healthcare buildings and hospitals in particular. It also discusses the most important challenges hindering sustainability in hospitals.

The chapter then reviews the concept of SA and discusses the origins of SA and reveals how environmental assessment methods developed in order to assess sustainability. Furthermore, the chapter highlights the concept of indicators and their important role in evaluating the sustainability, and illustrates the main criteria for indicators development. Moreover, the chapter analyzes the most important studies in the field of development of SA tools in buildings in general and in hospitals in particular.

The chapter also reviews several topics related to SA in buildings such as, the differences between green building and sustainable building, and the green rating tools that are used to evaluate buildings sustainability.

Finally, the chapter presents a brief analysis of the Palestinian context with the focus on the WB region in which the HSAtool-WB will be applied. The analysis includes the environmental, social and economic aspects. In addition, the health sector in Palestine is explored in general with a focus on the hospitals that will be the focus of the study. Moreover, the chapter highlights some important sectors such as the energy and waste sectors, and explores the challenges facing the Palestinian society and the health sector in particular and the progress toward sustainability.

2.2 The Concept of sustainability

The concept of sustainability or SD has a growing recognition by international organizations, governments, and researchers for many decades. Pertinent literature contains many definitions of sustainability and SD. For example, according to the United States Environmental Protection Agency

(US EPA) Sustainability is to support both present and future generations to satisfy their needs by creating conditions in which the relationships between human and environment are in harmony (EPA, sustainability| US EPA, 2017). Ben-Eli(2006) in his research defined sustainability as a state of dynamic balance between human development and the environment, so that man uses environmental resources in the process of development without causing significant and irreversible damage to the environment on which his life depends.

The term SD has a wide range of meanings depending on how it is interpreted by corporations, governments, social reformers and environmental activists (Giddings et al., 2002).

In Fact, the two terms sustainability and SD have been used synonymously in previous researches, but some researchers have seen that there is a difference between the two concepts. More specifically, SD can be considered as the process through which we reach sustainability, (Diesendorf, 2000). SD as defined in Brundtland Report in 1987 the "*development that meets the needs of the present generations without compromising the ability of the future generations to meet their own needs*", (World Commission on Environment and Development, 1987). According to the previous definition, sustainability is the state in which our needs are fulfilled without compromising the other generations' needs. Moreover, sustainability is linked to long-term objectives rather than short-term ones. This depends mainly on the balance and integration of economic, environmental, and social dimensions in the decision-making process. (Emas, 2015). Within the same context, Diesendorf (2000) defines SD as" *all types of economic and social development which protect and enhance the natural environment and social equity*".

On the business side, SD means that corporations as they seek to meet their needs must use available resources rationally to ensure their continuity and availability for future generations. Moreover, organizations must not only focus on economic growth alone; the social and environmental impacts of their operations must be also considered in order to achieve healthy environmental, social, and economic systems (Pojasek, 2007). This requires organizations to formulate strategies and perform practices in a way that protect, enhance and sustain economic, environmental, and social resources (iisd, 1992).In the same context, Diesendorf (2000), discussing sustainability on the organizational level argues that corporations have an important role to play in achieving or hindering SD that's because corporations are important elements of the economy which considered as one of the main society components. In addition, when a corporation contributes to SD it should be integrated into its strategy.

In this regard, Pojasek(2007) stresses that SD must be integrated into business planning and management systems which entails that SD principles have to be incorporated into business policies and practices. Some examples of these principals are leadership commitment, stackholders needs understanding, improving business systems, and environmental and social responsibilities.

In sum, the essence of business sustainability lies in achieving long-term success while considering environmental principles and social responsibility.

It is worthy to note that, another sustainability-related term is the triple bottom line. In this paragraph, the researcher sheds light on the two concepts; sustainability and triple bottom line and how the two terms have been treated in previous studies. For instance, Alhaddi (2015) revealed that the terms triple bottom line and sustainability have been used interchangeably in literature, and the term triple bottom line is more consistent than sustainability in referring and integrating the three economic, environmental, and social dimensions simultaneously, as some researchers used the term sustainability to refer to one, two, and sometimes the three dimensions. In the same context, Pope et al. (2004) pointed out that the triple bottom line concept can be considered as an interpretation of the sustainability concept that gives equal importance to the environmental, social, and economic dimensions.

2.3 Dimensions of sustainability:

Sustainability is no longer referring to environmental issues alone. (Buffoli at el., 2014a), but rather it is an integrative concept that considers the three dimensions known as the three pillars of sustainability (economic, social, environmental). These dimensions must be regarded as equally important and integrative because each of these dimensions has an effect on the other two dimensions. The connections and the way each dimension affects the other dimensions are important to understand SD, (Stevens, 2005).Vallance et al.(2011) reveals that environmental sustainability cannot be achieved in difficult economic or social conditions, and the same goes for other dimensions.

Sustainability can usually be represented by three overlapping episodes that show the relationships between the three dimensions, where the three-loop overlap area represents sustainability as depicted in Figure 2.1.

With regard to the environmental dimension, it refers to what extent the business is using the natural resources wisely such as using renewable energy resources and work as much as possible to mitigate the environmental damage caused by various business operations, in order to preserve natural resources for future generations. Economic sustainability refers to the economic performance of the enterprises and to what extents contribute to the economy and refers also to the responsible use of resources to achieve long-term profitability and survival. Social sustainability refers to the impact of the organizations on society equal opportunities, social justice, health, education, etc. (Alhaddi, 2015).

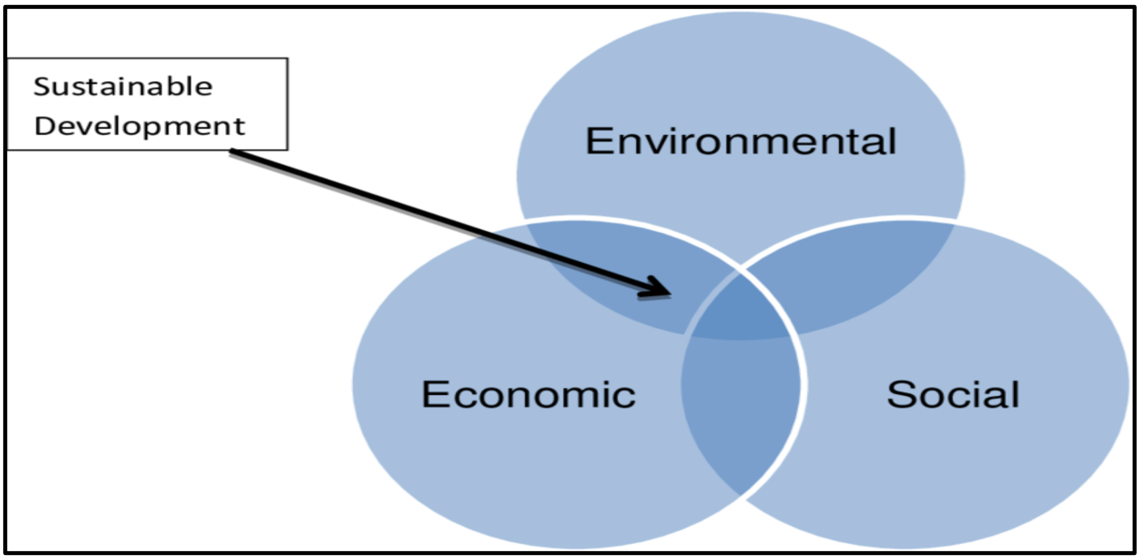

Figure 2.1: Sustainability dimensions (Eadie et al., 2011)

From the Stevens(2005)'s point of view, there are relationships between dimensions of sustainability, which are called the reciprocal influences as illustrated in Figure 2.2

In this regard, Teodorescu. (2015) discussed the relationships between the three sustainability dimensions as follow:

1- *Economy - Environment*: Economic activities can significantly affect the environment in terms of depletion of natural resources and increasing the demand for energy and through the emission of gases and waste disposal from different industries and services. Investing in environmental technologies is important to protect the environment and keep it clean.

2- *Environment – Economy:* as the environment provides the natural resources needed for the economy, imposing the economic activities to environmental policies; environmental taxes can be used to encourage environmentally-friendly economic development and reduce the negative effects on the environment.

3- *Environment – Social:* the environment provides society with air, water, and other important factors. The quality of these factors depends on the amount of pressure the environment is subjected to by the community. Therefore, environmental protection policies must be employed in order to preserve the continuity of these resources and protect them from contamination. The relationship here lies in the process of pollution protection and waste management in order to maintain good health.

4- *Social – Environment:* consumption growth due to the population growth and higher incomes mostly accompanied by greater consumption of natural resources and energy. This, in turn, will negatively affect the health of the community and quality of life.

5- *Economy-Social:* the economy plays a major role in providing jobs, income and living a decent life for the members of society.

6- *Social-Economy:* The success of any economy and its development depends on the human factor. The productivity and good health of individuals contribute significantly to the wheel of economic development.

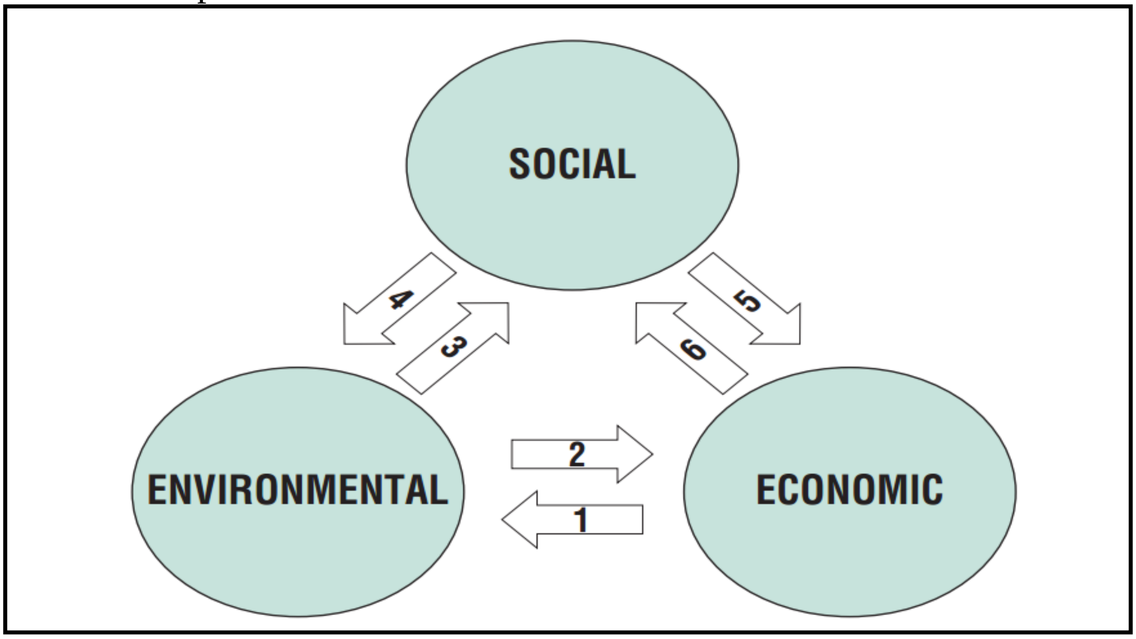

Figure 2.2: Interaction between economic, social and environmental, (Stevens, 2005)

At the organizational level, a firm must focus on all the sustainability dimensions in order to achieve sustainability, (Ramirez et al., 2013). According to Emas. (2015) sustainability can be achieved by integrating economic, environmental, and social dimensions in the decision-making process. In the same context, Giovannoni& Fabietti.(2013) emphasized the importance of considering the three sustainability dimensions at every organizational level using an integrated approach in which governance, management, measurement and reporting systems, and business models, effectively designed and practiced.

Finally, it is important to highlight that the institutional dimension has been added as a fourth pillar with the other three environmental, social, and economic dimensions. The institutional dimension was introduced by the Commission on Sustainable Development in 1995 and it is related to gender equality, equality of education, participation of the political system and others. The possibility of increasing the number of these dimensions in the future would always be available. (Doan et al., 2017).

2.4 Sustainable building versus green building:

In the present time, many of the stakeholders still consider the two concepts (green building and sustainable building) as synonyms. However, green building or sustainable building is not the same. In this context, Castro et al .(2015), stressed that the concept of sustainable building is broader than the concept of green building and includes more criteria that are relating to social and economic dimensions. Figure2.3 illustrates the additional criteria that could be taken into consideration in a sustainable building, which are often neglected in green buildings, especially in hospital buildings where social dimensions such as comfort, safety, and well-being are very important factors.

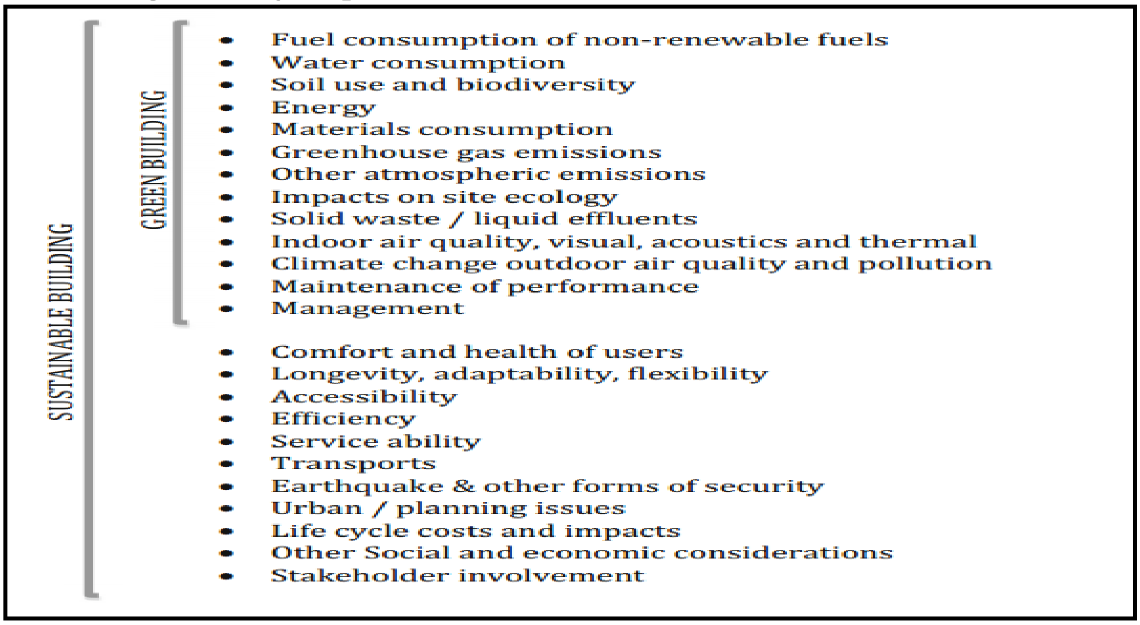

Figure 2.3: sustainable building versus green building (Castro et al., 2015).

In a recent study, Doan et al. (2017) highlighted many of the definitions of the green building in literature. The authors pointed out that green building is design strategies and techniques aimed at providing people with a healthy building while reducing the environmental impact of the building in terms of rational use of renewable and non-renewable natural resources and minimizing the environmental pollution throughout its life cycle.

Overall, the term sustainable is broader than green. Green is an environmental term while sustainability encompasses all the environmental, social, and economic dimensions. For example, a building can be green in term of energy efficiency and resources utilization but at the same time not socially sustainable if not designed well.

2.5 Sustainability in healthcare sector:

The healthcare sector is one of the most important service sectors in the community because its main task is to preserve and promote the health of members in the society, in addition to its vital role in the economy. Moreover, SD and healthcare are interrelated; SD promotes health and quality of life, and at the same time it is difficult to proceed to SD without good health, Weisz et al. (2011).

At the global level, health and well-being have been recognized as important components of sustainable development. In this context, WHO.(2017b) has defined sustainable development from a health perspective as managing natural and non-natural resources in a fair manner so as to ensure health and well-being for all present and future generations.

Moreover, of the 17 SDGs adopted by United Nations (UN) in the 2030 agenda for SD, the third goal emphasizes the essential role of good health and well-being for societies in all ages. In addition, there are some other goals that include the health of good individuals indirectly.

Over the past few decades, sustainability has expanded to include the healthcare sector components. Within this context, many studies have been conducted (Castro et al., 2015). However, most of these carried out studies focused on improving energy efficiency, and waste management, (Stevanovic et al., 2017). According to Jameton & McGuire. (2002) sustainability in healthcare is the balancing of patient needs, economic concerns, and environmental damage. This could be achieved by providing high-quality services considering the institution’s financial ability to keep alive on the long-run. Keeping in mind the consequences of the imminent environmental damage caused by the various operations in hospitals.

With regard to the definition of sustainability within healthcare, many definitions have been formulated by several studies such as the study of Weisz et al. (2011) who Defined sustainability in hospital as the conditions under which the hospital's health care service is provided according to the healthcare criteria and also considering economic efficiency, environmental and social compatibility. However, in a recent study for Moore et al. (2017), the researchers identified 24 different definitions from 209 various studies carried out in the field of sustainability of healthcare. Based on the analysis the study revealed that most of the sustainability studies lack a consistent definition for sustainability makes it challenging for researchers to study the previous literature. Additionally, the researchers defined five constructs to formulate a comprehensive sustainability definition, the constructs are Time, continued delivery, behavior change, evolution/adaptation, and continued benefits.

As is evident from several studies conducted within the field of sustainability in healthcare there are many factors and practices contribute to healthcare sustainability. One of these studies is the work of Jamaludin et al. (2013) who examined the relationship between sustainable healthcare services and sustainable healthcare performance in the Malaysian healthcare industry. The study revealed that providing sustainable healthcare services such as using natural resources wisely, reducing the waste and emissions, and providing good work conditions and many other sustainable services will improve sustainable healthcare performance.

Finally, it should be noted that the human factor and its important role in sustainability cannot be ignored and in this context, many studies have been conducted such as the research of Goh& Marimuthu. (2016) who investigated the role of organizational commitment to healthcare sustainability. The researches reviewed several studies that focused on human resources management and employees' satisfaction. The study concluded that employee’s organizational commitment toward sustainable development plays an important role in improving the performance on the long-run and guiding the healthcare facilities toward sustainability.

2.5.1 Environmental sustainability in hospitals:

Long ago, the greatest interest was concentrated on the durability of construction regardless of environmental damage (Buffoli et al., 2014b), nowadays communities seemed to be more aware of environmental issues. This, in turn, has shed more light on environmental sustainability (Capolongo, et al., 2015b). As a result, institutions and hospitals have recently become more interested in measuring their environmental performance in order to comply with legislation, laws, and standards and to meet stakeholders needs (Blass et al., 2017). Thus the establishment of green environmentally friendly hospitals has received considerable attention recently (Bilec et al., 2010).

Morelli. (2011), defines environmental sustainability as the condition in which the relationships between man and the environment are in a state of balance and harmony, so that societies can satisfy their needs by using renewable and non-renewable environmental resources in a manner that does not exceed the capacity of the environment to regenerate these resource, as well as to minimize the pollution resulting from different activities of life.

It is agreed that hospitals are considered to be amongst the biggest polluters of the environment by dumping all types of waste. Other important factors are the large consumption of energy sources, especially electricity and water, and the large use of toxic chemicals in the in therapy, cleaning, and disinfection. (Kaplan & Forst. 2017). Moreover, the health sector is considered to be one of the most producers of air pollution emissions. A study of the impact of the health care sector on the public health in United States (US) resulted in that the health care sector has a considerable fraction of the national air pollution emissions including acid rain (12%), greenhouse gas emissions (10%), smog formation (10%) criteria air pollutants (9%), stratospheric ozone depletion (1%), and carcinogenic and non-carcinogenic air toxics (1–2%) (Eckelman & Sherman, 2016).

In addition to the large amount of energy consumed by hospitals within the construction, there are large indirect parts caused by the production of the power itself, the use of pharmaceuticals and medical devices which also consume large amounts of energy to be manufactured, and other supply chain activities. (Eckelman & Sherman, 2016)

According to Nascimento et al.(2017) many factors are crucial for successful environmental sustainability in hospitals : linking SD to the strategic planning, resources optimization and waste reduction, leadership commitment, compensate achievements related to achieving sustainable goals, transparency and open channels of continuous dialogue with all stakeholders, sustainable procurement and replacement of products with other environmentally friendly ones, energy efficiency and waste management programs to cut cost and increase profit, dedicated sustainable development area with a team responsible for planning, implementation, monitoring, and evaluation of sustainable practices.

Successful environmental sustainability initiatives provide hospitals with many benefits in term of performance efficiency and effectiveness, outcome improvement (clinical, and hospital users experiences), increase productivity, decrease resources consumption and waste generation. Finally, those initiatives will ensure positive perception by society (Bilec et al., 2010; Nascimento et al., 2017)

Comparative studies have been conducted to highlight the benefits of green hospitals over the traditional ones such as those by Thiel et al., (2014) who conducted a comparative study between a green LEED-certified hospital and a traditional one using the expenses, productivity, quality of care, staff satisfaction, and utilities metrics. The results reveal that the green LEED-certified hospital decreased resources (energy and water) consumption by approximately 50% per square meter, and improved staff satisfaction, productivity, and quality of care.

Another comparative study conducted at a hospital unit level was for Campion et al., (2016) who made a comparison between traditional hospital Oncology unit replaced with new green one in order to identify the effect of green building design (GBD) features and Evidence-based design (EBD) on patient outcomes, employee performance, satisfaction, and overall utilities. Six categories were analyzed (quality of care, productivity, utilities, Expenses, staff satisfaction, and patient satisfaction). Results of the study showed that: quality of care, productivity, utilities metrics have not changed between green and traditional unit, whereas the other three metrics; expenses, staff satisfaction, and patient satisfaction enhanced after moving to the new green unit.

2.5.2 Social sustainability in hospitals:

Quality of life is one of the most important pillars of SD, (Weisz et al., 2011). Since 1946 World Health Organization (WHO) Emphasizes that health does not only mean the absence of diseases but also include mental, psychological and social well-being (WHO, 1946).

Moreover, the treatment in hospitals has changed from the concept of treatment of diseases to the treatment of people. Hence, the interest should be imposed in all aspects of improving the patient's perceptions and emotions inside the hospital, especially the quality of the hospital's environment and interior design. However, Social dimension was not addressed adequately in most of the previous studies particularly those which are related to healthcare systems (Capolongo, et al., 2015b). Moreover, most of the sustainability initiatives in hospitals emphasised environmental and economic dimensions. However, the social dimension was almost neglected. (Weisz et al., 2011)

In a very sensitive environment such as a hospital, where people spend most of their delicate times whether they are patients, visitors, or staff (Capolongo et al., 2014) great attention should be paid to the social aspects that play a major role in patients healing process, supporting staff performance (Buffoli et al., 2014a), and improving competitive advantage (Capolongo et al., 2014). Hospitals are argued to integrate social aspects in their policies and design and provide a participatory and collaborative environment that meets health and well-being (Capolongo et al., 2016b).

According to Capolongo et al. (2016b) socially sustainable hospital is a hospital in which the patient feels comfortable and welcoming, and provides an environment with a great focus on users’ psycho-physical well-being. Moreover, the researchers reveal that social sustainability in the hospital is determined by three criteria namely the humanization, comfort, and distribution. First one is humanization which is the most qualitative criterion and refers to which extend the hospital environment is safe, secured and well designed in term of spaces, rooms, and soft qualities. In addition, the concept of humanity is largely related to the extent to which users feel safe and protected in a well-being environment. Comfort; the second criterion, refers to the quality of the interior environment represented by providing a high interior air quality, integrated natural and artificial lighting system, and high efficiency thermal system. Comfort is achieved in supporting the psycho-physical state of the users. Finally, the distribution criterion refers to the way in which the hospital departments, paths, routes, and other wards are organized to meet different hospital functions, optimize resources, cope with continuous change, allow users to access hospital facilities with minimal time and effort, and to support the physical and mental states of the users.

2.5.3 Economic sustainability in hospitals:

The health sector and hospitals in particular play a significant role in the country's economy. Countries spend a large part of their Gross Domestic Product (GDP) on hospitals (Capolongo, et al., 2015b).

According to Bottero, et al. (2015) economic sustainability is the hospital's capability to provide high-quality, effective and continuous healthcare services to current and future communities. This capability must be supported by decision-makers at all organizational levels in the hospital. Moreover, the researchers revealed that this capability is determined by managerial, technological and clinical factors. With regard to the managerial factor, adoption of management strategies in order to maximize the service efficiency, minimize waste, and optimize resources allocation is recommended. Clinical factors can be determined by the ability and readiness of the hospital and its procedures to deal with adverse events and risk control. Finally, technological factors are the adoption of new technologies and information systems that improve the service delivery process and optimize resources.

Finally, it was proven that economic sustainability is an indirect benefit of achieving environmental and social sustainability, a sustainable hospital in term of environmental and social aspects has an improved productivity, collaborated, safe and comfortable environment, more satisfied staff and patients, reduced resources consumption, improved outcomes, and environmentally friendly products. All aforementioned benefits play a major role in the hospital’s survival particularly the private ones (Bilec et al., 2010; Carnero, 2015).

2.5.4 Hospital sustainability challenges:

The concept of sustainability in itself is a challenge; it is a broad interdisciplinary concept that has been defined and interpreted differently by many researchers and practitioners. Indeed, despite the large number of definitions of sustainability in literature there is still a lack of a clear and specific definition of sustainability, this makes it difficult to determine what is to be sustained (Moore et al, 2017). This in turn will make the development of a SA tool a difficult process that involves many indicators systems and requires management of information flows between enormous numbers of stakeholders (Mateus & Bragança, 2011).

In healthcare context and particularly within hospitals system there are a large number of stakeholders (patients, employees, visitors, students, researchers public administration, governments, NGOs, and others) with diverse and sometimes conflicting interest and needs (Capolongo et al., 2015a; Djukic & Marić, 2017).For instance, the investor is interested in the economic aspect while the end user cares about health and comfort (Haapio & Viitaniemi, 2008).

Hospital buildings are exceptional and complex (Stevanovic et al., 2017), containing many areas with various purposes, and many types of medical equipment for different operations. As well as many users including patients, doctors, visitors, students, researchers, nurses, cleaning staff and others are parts of hospitals (Castro et al., 2012). Furthermore, hospitals are also different according to the medical specialties, the type of services they provide, the target group of the community, the location, funding and the ownership including the private, governmental, public and specialized. (Castro et al., 2015). In addition, hospitals have a dangerous work environment, which runs counter to its basic function of maintaining the health of individuals. Hospitals are considered among the most dangerous places of work where users can get infected, in addition to exposure to other hazards such as wounds, slippage, etc. (Kaplan & Forst, 2017).

In general, progress towards sustainability requires a change at all levels within institutions. However, humans by nature reject the change. This may lead to resist sustainable practices that in conflict with their usual ways of livings, so counterproductive results will be expected. It could bring new bad habits more damaging to the environment (Vallance et al ., 2011).

From an environmental point of view, sustainability requires reducing resources consumption especially water and energy. However, this reduction would be a challenge in hospital buildings which can consume three times of the same size residential building (Capolongo, et al., 2015b).

Healthcare sector, in general, is a rapidly developing field that witnessing a tremendous and accelerating development in all respects which accompanied with an increasing demand for high-quality services from the society. However, the planning, construction, and operation of the hospital take a relatively long time, which can make the hospital after operation unable to provide sustainable services (Capolongo, et al., 2015b).

2.6 Sustainability Assessment (SA)

SA had a growing recognition over the past decades because sustainability has become one of the fundamental goals that institutions seek to achieve at the local and global levels, regardless of the nature of the organization's profitability or non-profit, (Boër et al., 2013). Many tools and frameworks have been developed in order to direct and guide the decision-making process toward sustainability, (Pope et al., 2017). However, SA is a complex evaluation methodology (Sala et al., 2015) through which decision-making process can be guided to achieve sustainability (Bond et al., 2012).

According to Capolongo et al.(2015a) SA tool should be designed in a way that enables nonexperts to use it easily. The use of such a tool should not require much time and resources. In addition, SA tools should produce understandable and specific results, and contribute to the process of guiding policy formulation to support sustainability. Within the same context,Castro et al. (2017) stressed that an effective SA framework has to be aligned with the sustainability aspects of the context in which the assessment will be made. Further, Mateus & Bragança. (2011) argued that SA systems should be transparent, have some flexibility in order to accommodate more than one type of building and adaptable with technological development.

2.6.1 SA origins

SA can be considered as a new field that has been evolved from impact assessment tools such as Environmental Impact Assessment (EIA)and Strategic Environmental Assessment (SEA)(Waas et al., 2014). Pope et al. (2004), emphasized that environmental assessment tools represent a good foundation to develop a SA method by extending these tools to include economic and social dimensions with the environmental dimension. According to this view, many SA methods can be considered as an extended integrated assessment that include the environmental, economic, and social sustainability dimensions (Sala et al., 2015).

It is important to highlight that in the literature many evaluation tools have been presented under the heading SA. However there is consensus from many researchers about the fact that SA differs from integrated assessment and can be considered as the following generation of integrated assessment (Pope et al., 2004; Ness et al., 2007; Waas et al., 2014; Sala et al., 2015).In this light, many researchers carried out studies to distinguish and compare these tools in terms of their contextual and methodological aspects.

In this context, Pope et al. (2004), proposed a conceptual framework discussing three models for SA:

1- EIA-driven integrated assessment: it is an extension of the EIA that considers social and economic with environmental issues, this approach considered as reactive (ex-post process). Moreover, environmental, social, and economic impacts of a project are evaluated and compared with predefined values/thresholds to accept the impacts or reject them. The main aim is to minimize impacts.

2- Objectives-led integrated assessment: which is an extension of SEA to include triple bottom line concept, this approach is characterized as proactive (ex-ante process), it aims to evaluate sustainability objectives before the implementation of a project in order to determine the most positive objectives that will contribute to sustainability.

3- Assessment for sustainability: the main idea in this approach is to define the term sustainability from a societal point of view in order to get a sustained society. This approach is based upon having a clear vision based on that definition. After that, the vision is translated to criteria which will be used to compare the initiatives with it.

In a very similar manner, Ness et al. (2007) presented a framework for categorization of the common sustainability tools based on the focus area, purpose, and temporal dimensions for providing a short description and application examples. In addition, these tools were categorized into three main groups, each of which has subgroups:

1- Indicators and Indices: which include integrated (for example Environmental Sustainability Index (ESI), Wellbeing Index (WI), Ecological Footprint (EF), etc), and Non-integrated, for example, Environmental Pressure Indicators (EPI).

2- Product related assessments: The tools of this group are used to assess the environmental impact of products and services from a comprehensive life cycle perspective from cradle to grave, such as Life Cycle Assessment (LCA), Life Cycle Costing (LCC), product energy analysis, and product material flow. It is worth mentioning that Life Cycle Assessment has been used widely to assess the environmental impact of products and services through their entire life cycle including the acquisition of raw material, production, use, and disposal. Moreover, the traditional LCC tools do not consider the environmental costs in evaluation except some tools such as Life Cycle Cost Assessment (LCCA) and Full Life Costing Accounting (FCA).

3- Integrated assessments: includes many tools that are used mainly as forecasting tools such as Multi Criteria Analysis (MCA), Risk Analysis (RA), Cost Benefits Analysis (CBA), and impact assessment tools. These tools guide and support the decision-making process regarding projects and policies.

2.6.2 SA indicators:

SA depends on indicators (Nascimento., 2017), where indicators can be defined as *"signs or signals that relay a complex message, from potentially numerous sources in simple and useful manner*" (Kurtz et al., 2001). By indicators, it is possible to determine the extent to which the goal has been achieved and whether you are moving on the right path, symptoms can be determined before they become a problem that is difficult to solve, (Sustainable Measures, 2017). Moreover, most of the administrative decisions depend on the indicators through which we can assess the past, current conditions, predict future change, and identify risks, (Kurtz et al., 2001). In this context, Mateus & Bragança. (2011) summarized the role of indicators in the process of assessing sustainability in which we identify, analyze and evaluate different phenomena.

In fact, sustainability indicators are different from other traditional social, environmental, and economic indicators. These traditional indicators reflect the extent to which one dimension can be achieved while sustainability indicators can directly or indirectly address more than one sustainability dimension (SustainableMeasures, 2017). For example, the indicators of “transport” category relates to the environmental issues such as pollution, social issues such as access to the transportation, and have an economic meaning in terms of the cost of fuel used in transportation (Castro et al., 2015). It is also important to highlight that sustainability indicators are different from traditional variables as the indicators must relate to a reference value (goal, target, or threshold), and without a reference value the indicator has no meaning and cannot reflect the system status (Waas et al., 2014). Moreover, indicators may differ from organization to another because an indicator depends on the organization goals and strategies. (Kalender & Vayvay, 2016).

Based on the definition of The Brundtland Report published in 1987 by the World Commission on Environment and Development (WCED), “*meeting the needs of the present generation without compromising the ability of future generations to meet their own needs*” (WCED, 1987), it is obvious that there is a need for indicators to measure the long-term progress toward sustainability (Nascimento et al., 2017). Using indicators is important for the process of evaluating, trading-off between the social, environmental, and economic area of sustainability, and measuring progress towards sustainability.

As stated in the action plan for the 21th century (Agenda 21) which proposed by the UN in the Conference on Environment and Development held in Rio de Janeiro, Brazil, in 1992, countries are argued to develop indicators of SD in order to progress toward sustainable integration between the ecosystem and other development systems (UN, 1992). As a consequence, many sustainability indicators have been developed by various stakeholders at various levels within different contexts for different purpose. In addition, many international organizations such as The UN Commission on Sustainable Development (UNCSD), and the European Commission (EC) developed a list of indicators to track SD. Moreover, countries and groups also adopted a set of indicators to monitor the SD process, (Stevens, 2005).

Finally, there are many researchers who have recommended that the selection of sustainability indicators must be according to certain criteria. Some of these important criteria are summarized in Table 2.1

Table 2.1 criteria for sustainability indicators selection

Indicator criteria	References
Clear and easy to understand	Diesendorf (2000), Reed et al. (2006), Blass et al. (2017), SustainableMeasures. (2017), Carnero (2015), and Stevens. (2005).
Measurable	Blass et al. (2017), Carnero (2015), Bottero et al. (2015), and Diesendorf (2000).
Reliable	SustainableMeasures. (2017), Blass et al.,(2017), and Diesendorf (2000).
Relevant	SustainableMeasures. (2017), Blass et al. (2017), Bottero et al. (2015), and Diesendorf (2000).
Upgradable	Reed et al. (2006), Carnero (2015), Bottero et al. (2015).
Data accessibility	Blass et al. (2017).
Specific	Bottero et al. (2015).
Comparability	Carnero (2015),

2.6.3 SA indicators frameworks:

Regarding the methodologies used to design and arrange sustainability indicators, there are many frameworks that have been developed. In their analysis of indicator development frameworks, Reed et al. (2006) revealed that indicator frameworks fall under two main paradigms; top-down (expert-led) and bottom-up (community-based), with each paradigm has advantages and disadvantages. The top-down approach can generate objective indicators. However, this will be at the expense of simplicity and make the indicators difficult to understand. The bottom-up approach generates a comprehensive list of indicators that can be more relevant to the context of the problem and characterized as easy to understand and use, but at the same time, these indicators are less objective. In addition, the large number of indicators would make the processes of validating and application difficult and getting a consensus from all involved stockholders will be challenging. Additionally, the researchers pointed out that most of indicators frameworks share the steps: Defining the context so as to take the priorities and conditions into account in accordance to the local context, then setting SDGs and strategies, and the last step consists of developing and evaluating indicators. Finally, the researchers argue that to develop local SA indicators it is better to integrate the bottom-up and top- bottom into one approach that includes the best practices of each one of them.

2.6.4 International SA tools:

In the construction field there are many SA systems have been developed by organizations and authorities in order to assess buildings sustainability at different life cycles phases; design, construction, operating, maintenance, and rehabilitation.

At this level, it is possible to highlight that the use of these tools is of great benefits which are represented in developing the required connections between build environment and SD, translating SD aims into objectives goals, establishing references for sustainable practices at local, national, and global levels, and providing the decision making process with the required information to progress toward SD (Castro et al., 2015).

In the market it is possible to enumerate many of SA methods for various types of buildings such as the Building Research Establishment Assessment Method (BREAM), which has been developed in 1990 in United Kingdom (UK) (BREEAM,2018), Sustainable Building Tool (SBTool) which has been developed by the non-profit organization international initiative for a Sustainable Built Environment (iiSBE) (iiSBE, 2016), The Leadership in Energy and Environmental Design (LEED) that has been developed in USA (LEED, 2017), the Comprehensive Assessment System for Built Environment Efficiency (CASBEE) was founded in Japan (IBEC, 2017), and the Australian Green star tool (GBCA, 2018).

In this thesis, the focus will be only on rating systems that are relevant to assessing sustainability in health care buildings. The researcher is going to explore the most well-known and widely used rating systems. BREEAM, LEED, and CASBEE, Green Star. To be precise, these tools can be used to assess healthcare building sustainability (Castro et al., 2017).

2.6.4.1 BREEAM

BREEAM (Building Research Establishment Environmental Assessment Method) was the first developed green rating system by Building Research Establishment (BRE) in 1990 in the UK. It is considered the first commercially released green rating system at that time. BREEAM is a widely used rating system that is adopted by more than 80 countries and with more than 567,600 issued certificates (BREEAM, BREEAM home page, 2018), which represent roughly 80% of the European market share (Doan et al., 2017).

Moreover, BREEAM provides a number of schemes to assess different types of buildings at various life cycle stages in the UK and internationally; BREEAM Infrastructure, BREEAM Communities, BREEAM New Construction (NC) (international only), Home Quality Mark (UK only), BREEAM In-Use, and BREEAM Refurbishment (UK only). (BREEAM, BREEAM home page, 2018).

Within the scheme BREEAM NC many buildings types can be assessed during design, construction, and major refurbishment stages including healthcare buildings. However, this method does not evaluate well an operative hospital because it depends heavily on quantitative data which does not consider users' perceptions in the evaluation process (Buffoli et al., 2015). Furthermore, BREEAM uses the bespoke scheme to assess non- standard building types including healthcare buildings that do not fall under BREEAM NC healthcare buildings scope (BREEAM, 2016).

BREEAM NC evaluates the buildings according to ten categories with a predefined weight for each category (as shown in Table 2.2). Each category includes a number of criteria relate to specific sustainability aspects.

Table 2.2: BREEAM assessment Categories and weighting (BREEAM, 2016).

Category	Weighting
Management	12
Health and Well being	15
Energy	19
Transport	8
Water	6
Materials	12.5
Waste	7.5
Land use and Ecology	10
Pollution	10
Total	100%
Innovation (Additional)	10%

Highlighting the abovementioned categories it is possible to reveal that the focus of the evaluation is on environmental factor with eight main categories that assess the environmental impact of the building. In addition, some social aspects are evaluated through the category ‘Health and wellbeing’. Furthermore, the category ‘innovation’ recognizes any new innovation in the building in term of new features and performance that contribute to sustainable benefits (Buffoli et al., 2015).

Regarding the rating approach, the final score is obtained by adding the weighted credit for each assessment category to obtain a single overall score (Refer to Table 2.3).

Table 2.3: BREEAM rating benchmarks (BREEAM, 2016).

BREEAM rating	%score
Outstanding	>=85
Excellent	>=70
Very good	>=55
Good	>=45
Pass	>=30
Unclassified	<30

2.6.4.2 LEED

LEED (The Leadership in Energy and Environmental Design) has been developed by USGBC (US Green Building Council) and released in 1998. Since then, many versions of the tool have been released, and the last version was in 2013 which has been updated recently in 2019 (LEED, 2017).

Geographically, LEED is the most widely used SA tool. The number of countries using this tool has increased dramatically as it was 135 countries in 2012, and jumped up to reach150 countries and territories in 2014. Currently, the number is over 165 countries and territories around the world with more than 92,000 projects using LEED (Doan et al., 2017).

LEED offers a number of schemes to assess different types of buildings including LEED BD+C (Building Design and Construction), ID+C (Interior Design and Construction), O+M (Building Operations and Maintenance), ND (Neighbourhood Development), and Homes. Within the scheme LEED BD+C (Building Design and Construction). Through the scheme LEED BD+C many types of buildings can be evaluated by a specific methodology with particular manual and tool. This includes new construction, core & shell, retail, schools, data centers, warehouses and distribution centers hospitality, and healthcare buildings that are being newly constructed or going through a major renovation (LEED, 2017).

Table 2.4 illustrates the LEED categories and available credits for each category. In fact, there is no weighing system adopted by LEED, but a simple additive approach (points system) in which all assessment criteria have the same weight.

Table 2.4: LEED assessment Categories and possible credits (Doan et al., 2017).

Category	Possible Credits
Location and Transportation	9
Sustainable Sites	9
Water Efficiency	11
Energy and Atmosphere	35
Materials and Resources	19
Indoor Environmental Quality	16
Innovation	6
Regional Priority	4
Total	110

Table 2.4 shows that LEED focuses more on building's environmental performance by including five categories relate to water, energy, materials, and site. It is worth noting that, LEED offers the innovation category with six points extra credits that can be obtained by adopting innovative strategies toward sustainable design. In addition, LEED includes the category (Regional priority) which provides an

incentive to obtain more credits for respecting specific environmental priorities in a particular geographical region. This made the LEED more flexible than other well-known tools such as BREEAM.

LEED considers five levels of performance according to the final aggregated score. These levels are presented in Table 2.5

Table 2.5: LEED rating benchmarks (Doan et al., 2017).

LEED rating	%score
Platinum	80+
Gold	60-79
Silver	50-59
Certified	40-49

2.6.4.3 CASBEE

CASBEE (Comprehensive Assessment System for Built Environment Efficiency) has been developed as a co-operative project between academia, industry, and the local governments in 2001 in Japan. Like other rating systems CASBEE evolved over time, the first released tool was CASBEE for offices in 2002. Shortly thereafter CASBEE for NC completed in 2003, CASBEE for Existing Buildings in 2004 and CASBEE for Renovation in 2005. It should be noted that CASBEE has been designed to be used only in Japan which limits its flexibility. However, in 2015 a pilot version has been developed to be used in countries other than Japan (Doan et al., 2017).

CASBEE comprises of many tools known as CASBEE family, these tools developed to be applied at different scales: CASBEE-Housing and CASBEE-Building tools developed to evaluate the environmental performance of houses and buildings, while CASBEE-Urban Development and CASBEE-City are used to assess a group of buildings and applied on the urban blocks and local governments respectively. (IBEC, 2017).

At building level, CASBEE provides tools to evaluate the environmental performance of the buildings at various life cycle stages including pre-design, new construction, existing, and renovation. (IBEC, 2017).

CASBEE has about 80 assessment criteria that divided into two main categories: Q (environmental quality of the building) which includes Q1: indoor environment, Q2: quality of service, and Q3: outdoor environment (on site). The other main category is L (environmental loading of the building) and includes L1: energy, L2: resources and materials, and L3:off-site environment. (Doan et al., 2017)

CASBEE has a different approach to calculate the final score of the evaluation. This approach is based on calculating the value of BEE (Building Environmental Efficiency). BEE is the ratio between building environmental quality and building environmental loading, BEE is illustrated in the following equation (Alyami et al., 2015)

$$BEE = \frac{(Building Environmental Quality)}{(Building Environmental Loadings)} \quad (2.1)$$

Also, it should be noted that each criterion within the main L and Q categories is multiplied with a weight coefficient. Then all weighted criteria in each of L and Q categories are aggregated to obtain a score from 0 to 100 for each of the Q and L categories. After that, BEE value is calculated using the equation 2.1. Then, the gradient graph illustrated in Figure 2.4 is used to translate the BEE value into a qualitative scale of five levels from C to A. (See Table 2.6)

Table 2.6: CASBEE rating benchmarks (Doan et al., 2017).

CASBEE rating	BEE Value
Excellent (S)	BEE = 3.0
Very good (A)	BEE = 1.5
Good (B+)	BEE = 1.0
Fairly poor (B-)	BEE = 0.5
Poor (C)	BEE = < 0.5

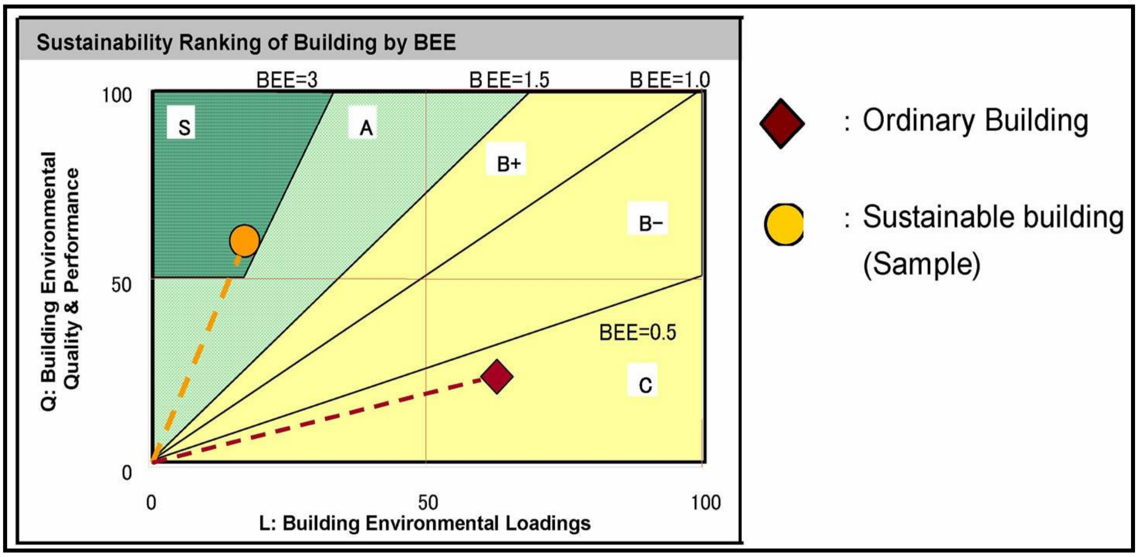

Figure 2.4: Environmental labelling based on Built Environmental Efficiency (BEE) (IBEC, 2017).

2.6.4.4 Green Star

Green Star is the Australian national voluntary SA system for buildings. It was established by the Green Building Council of Australia (GBCA) in 2003 to improve buildings' environmental efficiency, increase productivity, and promote health and wellbeing. Green Star provides tools to assess buildings at different scales including Green Star –Communities, Green Star –Design & As Built, Green Star – Interiors, and Green Star – Performance. The Green Star – Healthcare v1 was first released in 2009 in order to evaluate healthcare buildings during planning, designing, construction, fit-out, and operation phases. However, the registration under this version has been stopped in December 2015. (GBCA, 2018).

Green Star –Design &As Built is the available tool for the new healthcare buildings which assesses buildings according to nine impact categories, with each assessment category includes a number of credits (Table 2.7), (GBCA, 2018). Moreover, the total number of credits for all categories equal to 110 including the innovation category by which Green star encourages the improvement of building's sustainable performance innovations (Banani et al., 2016). Furthermore, the overall building performance is assigned a label according to one of Green star's four rating levels which are presented in Table 2.8.

Table 2.7: Green Star assessment categories and possible credits

Category	Possible credits
Management	14
Indoor Environment Quality	17
Energy	22
Transport	10
Water	12
Material	14
Land Use & Ecology	6
Emissions	5
Total	100
Innovation (Additional)	10

(Banani et al., 2016).

Highlighting Table 2.8, it could be noted that the aim of the green star tool is to assess the healthcare building in term of environmental impact and quality of building's interior environment.

Table 2.8: CASBEE rating benchmarks (Banani et al., 2016).

Green Star rating	%score
6 Stars	75 +
5 Stars	60 – 74
4 Stars	45 – 59
1-3 Stars	10 – 44

2.6.4.5 BREEAM, LEED, CASBEE, and Green Star comparison.

In the previous sub-sections, the four most well-known SA tools (BREEAM, LEED, CASBEE, and Green Star) were briefly reviewed. In fact, the comparison between building SA tools is challenging as they emphasize differently to the economic, environmental, social sustainability dimensions. Moreover, each of these approaches uses different criteria and weighing systems according to the local context in which they have been developed (Haapio & Viitaniemi., 2008; Castro et al., 2015).

However, many studies have been conducted to characterize, analyze and compare these tools. One of these comparative studies is the work of Haapio & Viitaniemi (2008) who discussed and analyzed sixteen environmental assessment tools.The study categorized the tools according to their characteristics, types of buildings they assess, users of the tools, covered building's life cycle stages, the format of the results, and errors and uncertainties. In a similar manner Castro et al. (2015) studied BREEAM, LEED, CASBEE, and Green Star tools in term of their goals, users, used criteria, structure, weighting system, life cycle phase of the application, and communication format of the results. Additionally, the study highlighted the strengths and weakness of these tools, identified the similarities and differences between these tools, and analyzed how these tools meet the International Standards Organization (ISO) and European Committee for Standardization (CEN) standards. Within the same context, Stevanovic et al.(2017) used a Strengths Weaknesses Opportunities and Threats (SWOT) analysis based on architects' experiences to compare between BREEAM NC and DuuzaamheidsmeterZorg which considered as the most common tool in assessing the sustainability of hospital projects in the Flanders Region. The comparison was made in term of their weighing systems and coverage of building life cycle phases.

Another important recent study was the work of Doan et al. (2017) who compared between the tools BREEAM, LEED, CASBEE, and the

New Zealand version of Green Star (Green star NZ). The researchers gave a brief overview of each tool. Then they deeply discussed the features and structure for each tool in term of incorporated sustainability aspects and categories and weighting systems

Based on the brief overview of BREEAM, LEED, CASBEE, and Green Star, and analyzing many comparative studies including the above-highlighted ones, the researcher concluded the following:

1- BREEAM is the first developed tool and LEED is the most flexible one. Moreover, LEED, CASBEE, Green Star and many other tools are under the direct or indirect influence of BREEAM. Furthermore, LEED, BREEAM, Green Star developed by non-profit organizations while CASBEE developed by a research project between industry, academia and government of Japan. (Doan et al., 2017, Banani et al.,2016).

2-The tools are similar in aspects and different in others. For example, BREEAM, LEED, and Green Star have similar structure, weighting system, and the following categories: 1- management; 2- indoor environmental quality/well-being; 3- service quality; 4- energy; 5- transport; 6- water; 7- materials; 8- waste; 9- sustainable sites; and 10- pollution. Moreover, All the four tools have the same way of results presentation includes certifications and reports. (Castro et al., 2015).

However, some pitfalls can be noted regarding these studied tools, these pitfalls are summarized in the following lines:

1- All the four tools have unbalanced criteria for the environmental, social, economic dimensions, with the main focus on environmental concerns, while neglecting some important economic and social aspects which considered as critical in hospital system (Castro et al., 2015; Buffoli et al., 2015).

2- These tools often are quantitative in nature, neglect the local context of the region to be applied in, and need experts' opinions in most cases which require more time and raise the cost of application (Buffoli et al., 2013).

3- These tools evaluate the building from the assessor point of view without taking into account the perceptions the other building users, particularly in the hospital system where the occupants' perceptions are very important (Buffoli et al., 2015).

4- These tools can be considered as design tools rather than performance measurement systems; they evaluate the building from a structural and technical point of view. Thus they cannot be used to evaluate and improve performance of operative hospitals (Buffoli et al., 2015).

Finally, Table 2.8 presents the main features of the compared tools including country, organization, flexibility, main categories, and many other features.

Table 2.9: Main features of BREEAM, LEED, CASBEE, and Green Star (Doan et al., 2017; BREEAM, 2018; LEED, 2017; Banani et al.,2016; IBEC, 2017 ;GBCA, 2018).

	BREEAM	LEED	CASBEE	Green Star
Country	UK	USA	Japan	Australia
Organization	BRE	USGBC	JSBC	GBCA
Flexibility	81 countries	167 countries	1 country	1 country
First version	1990	1998	2002	2003
Latest version	2016	2019	2014	2017
Building types	−Office −Housing –Healthcare −Courts −Industrial Units –Retail −Schools −Multi-residential −Schools −Neighbourhoods	−Offices −Homes −Neighbourhoods Development −Retail −Healthcare −Schools	−Residential –Office −Schools −Retail −Health care −Urban development −Cities	−Education −Healthcare −Industrial −Multi-residential –Office −Office Interiors −Retail Centre
Types of projects	-New construction −Refurbishment −Existing buildings	-New construction −Refurbishment −Existing buildings	-New construction −Refurbishment −Existing buildings	-New construction −Refurbishment −Existing buildings
Main categories	Management Health and Wellbeing Energy Transport Water Material Waste Land use and Ecology Pollution Innovation	Integrative process Indoor Environment Quality Energy & Atmosphere Location & Transportation Water Efficiency Material & Resources Sustainable Sites Regional Priority Innovation	Indoor Environment Quality of Service On-site Environment Energy Resources & Materials Off-site Environment	Management Indoor Environment Quality Energy Transport Water Material Land Use & Ecology Emissions Innovation
Rating approach	Pre-weighted categories	Additive credits	BEE ranking chart	Pre-weighted categories except for Innovation
Total Maximum Possible Points	110	110	BEE=3	110
Rating level	Pass >=30 Good >=45	Certified 40 Silver 50	Poor: BEE <0.5 Fairy Poor: BEE = 0.5-1.0	1-3 Stars (10 – 44) 4 Stars (45 – 59)

	Very good >=55	Gold 60	Good: BEE = 1-1.5	5 Stars (60 – 74)
	Excellent >=70	Platinum 80	Very good: BEE = 1.5-3; or BEE >=3 and Q < 50	6 stars (+75)
	Outstanding >=85		Excellent: BEE >=3 and Q<=50 ,,,,,,, ,,,,,,,	
Update interval	Annual	As required	As required	Annual
Number of certified buildings	568,025	80000	541	2000

2.6.5 Customized SA tools for a specific type of buildings and according to local context.

In fact, the above highlighted SA tools are global and have been designed to work in different regions of the world and this requires considerable efforts in adapting to local priorities and conditions in the context where the assessment will take place. Furthermore, social, economic and environmental conditions vary greatly depending on the region, as well as priorities, constraints, regulations, and legislation (Ali & Al Nsairat, 2009). As a result, many efforts have been made and many studies have been carried out to customize the SA tools so that they are intended for a specific type of buildings, and according to a specific local context and conditions. These efforts are discussed in the following lines.

Many countries customized the international SBTool assessment tool to be applied on the national level and to fit into their local context. For instance, the SBToolCZ version developed in the Czech Republic, SBToolPT adaptation is to be used in the Portuguese context, Protocol ITACA founded within the Italian reality, and Verde came up in Spain.

Moreover, the NZGBC (New Zealand Green Building Council) developed the Green Star NZ rating system based on the Australian Green Star tool.

In a similar manner, many researchers customized international SA tools in order to assess specific types of buildings or to be used for SA in a particular context.

For instant, Mateus & Bragança.(2011) developed a SA tool (SBToolPT-H) to assess sustainability of existing, new and renovated residential buildings in the Portuguese context. The developed system was based on the above mentioned Portuguese version of SBTool – (SBToolPT) which has been developed by the Portuguese chapter of iiSBE to be applied in the Portuguese context. The developed tool with the hierarchical structure comprises of (main dimensions, categories, and indicators) twenty-five indicators grouped in nine categories that cover the environmental, social, and economic sustainability dimensions. The study used the AHP methodology to weight the categories and the indicators.

AHP is a mathematical multi-criteria decision-making technique was developed by Thomas Saaty in 1980 and has been extensively studied and reviewed since then. It has been used around the world in a variety of decision situations in many fields such as governmental, business, industry, healthcare, and many other fields (Saaty T. L., 2008). This technique involves two basic steps in the decision-making process; the first step is to design the problem or decision in a hierarchal structure consisting of goals, criteria, and alternatives. Then comes the evaluation step based on a paired comparison between the hierarchy structure elements is made in order to prioritize and weight all the factors (Vargas , 1990). AHP will be discussed in detail in the methodology chapter.

It should be noted that some studies have been conducted in developing countries that aimed at developing tools to assess buildings' sustainability. The first study to be reviewed is the work of Ali & Al Nsairat.(2009) who developed a green building assessment tool for residential units. This tool was supposed to be used in the Jordanian context. The researchers adopted a methodology comprises of an analysis of the international green building rating systems such as LEED, CASBEE, BREEAM, and the Green Building tool (GBTool) and highlighting the Jordanian local context (economic, social, and environmental conditions). Moreover, by interviews (structured and unstructured), and observations, the researchers were able to develop a hierarchal structure that comprises the main sustainability aspects (economic, social, environmental) on the top. At the second level are the main categories, each category was identified by a set of indicators. The assessment items at each level of the tool were weighted using AHP.

Regarding the weighting of the assessment categories in the proposed tool, it was noted that almost half of the weights were given to the water and energy efficiencies groups. This, in the researchers' point of view, is consistent with the fact that Jordan is suffering from a severe shortage of natural resources, especially water.

Within the same context and with a start of analyzing and comparing the most well-known international tools (BREAM, LEED, SBTool, and

CASBEE), and using the Delphi technique and AHP method through a consensus-based approach, Alyami (2015), adapted a rating system to assess buildings' sustainability in the Saudi Arabia context, which is called the Saudi Environmental Assessment Method (SEAM). The study proposed 11 weighted assessment criteria: Indoor environment quality (12.7%), water efficiency (25.8 %), energy efficiency (18.4%), waste management (6.8%), pollution (8.3%), management (4.9 %), site quality (5.4%), and materials (6.4%), quality of service (4.5 %), economic aspects (4.3%), and cultural aspects (2.5 %).

In a very similar manner and within the same region, Banani et al (2016), defined a sustainability assessment framework to measure the performance non-residential buildings in Saudi Arabia. This study explored and compared a number of international rating systems -such as LEED, BREEAM, Green star, and CASBEE - to establish a set of variables to assess sustainability for non-residential buildings. The established variables were refined according to the Saudi Arabia context by conducting semi-structured interviews. In addition, the researchers used survey questionnaires and AHP method to develop a weighting system for the assessment items which included nine criteria and 36 sub-criteria. The established criteria with weight are Energy efficiency (24%), water efficiency (27%), materials selection (10%), indoor environment quality (10%), land and waste (7%), effective management (7%), whole-life cost (7%), quality of service (5%), and cultural aspects (3%).

In a more recent study, Zarghami et al (2018), proposed a set of categories and criteria to be used for assessing the sustainability of residential building in the Iranian context. The proposed categories and indicators were proposed Based on an investigation of the common indicators of the well-known SA tools (LEED, BREEAM, CASBEE and SBTool). In addition, the indicators and categories were weighted according to the Iranian context using pairwise comparisons questionnaire conducted by local residential buildings experts. Furthermore, the Fuzzy AHP (FAHP) method was implemented to generate the final priorities of the categories and indicators. The proposed weighted categories are Energy efficiency (30.1), water efficiency (28.1), sustainable site (17.5%), materials and resources (15%), and indoor environmental quality (9.3%).

2.6.6 Customized SA tools for healthcare buildings:

It's evident that healthcare organizations and hospitals, in particular, are considered as one of the major pollutants because they consume resources and energy excessively and releases all types of waste and toxins to the environment. Therefore, achieving sustainability in these buildings is an urgent necessity. In this sense, many efforts by both researchers and practitioners have been made to assess sustainability in health care buildings. However, to present, there is no holistic SA method for healthcare facilities (Stevanovic et al., 2017).

LEED, BREEAM, Green star and many other SA tools have been developed in order to evaluate the sustainability of the healthcare buildings from the early design phase. Despite of the widespread use of these tools, because of their simplicity and subjectivity, it was proven that these tools still have many weaknesses, (Stevanovic et al., 2017).

Additionally, within the scholars' community many studies have been conducted in the context of SA in healthcare buildings, some (e.g Capolongo et al., 2016; Carnero. 2015)developed SA that evaluate the healthcare buildings sustainability focusing only on environmental or social dimensions. Other more comprehensive studies (e.g: Buffoli et al., 2013; Castro et al., 2017) included the three sustainability dimensions in the developed tools. These studies and others will be deeply discussed below.

Buffoli et al. (2013) proposed a SA tool which was developed depending on the well-known assessment tools such as LEED, BREEAM, and ITACA, in order to be used in the European context. The tool was designed for evaluating the sustainability of a hospital that already exists or in the design phase. In addition, the developed tool provides guidelines and strategies so as to support sustainability in the future.

The researchers stress that the importance or weight and the application of each indicator differ according to the hospital status whether its an operative or in design hospital. For example, the indicators related to the environmental impact of the hospital have more weight in the design phase because environmental impact depends heavily on the materials and techniques used to establish the hospital. However, in the case of an operating hospital it is very difficult to change these things because they have become existing and changing process of these things will be costly in term of money and time. Furthermore, the application of the criteria is also different according to hospital status. For example, users comfort can be measured by questionnaire for an operative hospital but in the case of a hospital in the design phase, these criteria can be evaluated by how the experts or designers can guarantee users comfort.

The hierarchical structure of the developed system includes the three dimensions of sustainability environmental, social, and economic. These dimensions are broken into criteria, which are evaluated by a set of indicators

Regarding the weighting technique, the system components were structured in network hierarchical structure taking into account the interdependicnes between the components. The Analytic Network Process (ANP) method was used to define a weighting system at every hierarchal level.

ANP is a mathematical technique that has been used in complex decision making analysis and was developed by Saaty in 1996. Moreover, ANP is considered as generalization of AHP which assumes that upper levels of the hierarchal structure are independent of the lower level as well as the elements in a level is also assumed to be independent of each other, while ANP considers the interdependences between the structure's elements which are grouped into clusters of related factors rather than into hierarchical levels (Saaty T. L., 2008).

It worth to be mentioned that the abovementioned developed system has been tested by Buffoli et al. (2014b) who used the tool to analyze and compare the sustainability aspects (environmental, social, and economic) of two hospitals with approximately 600 beds capacity in Italy (in Lombardy region). An old operative hospital has been compared with another new in-design one. The necessary information was collected from both hospitals using field visits, interviews, questionnaires, and documentations. Sustainability was assessed in both cases. The researchers came up with a set of recommendations and strategies to improve weaknesses and shortcomings in the critical areas. Of the results achieved, the economic aspect of sustainability recorded the most satisfactory scores in both cases and the researchers attributed the reason for this to the fact that economic performance is affected by management policies more than the hospital structure.

In a more recent study by Castro et al.(2017), a healthcare building SA method in the Portuguese context was developed, namely (HBSAtool-PT).A method that can be used in new and refurbished healthcare buildings. In this study, the methodology researchers followed is very similar to the one in the study of Ali & Al Nsairat. (2009). Specifically, the similarity is in term of studying the international SA tools in healthcare such as LEED BD+C, BREEAM UK NC, Green Star - Design & As Built, and CASBEE - NC, and analyzing the local Portuguese context. In addition, the study explored the ongoing standards work such as ISO TC59 and CEN TC350 work related to sustainable construction.

Furthermore, the researchers compared the developed approach with other well- known existing methods (BREEAM UK NC, LEED BD+C, Green Star - Design & As Built) used in healthcare SA in the light of the core categories of ISO and CEN standards. Further, comparisons were also made with other studies in the same field.

The hierarchal structure proposed model consists of indicators, categories, and areas. A list of fifty-two sustainability indicator was developed and grouped in twenty-two categories which in turn were aggregated to measure the five main dimensions of sustainability; environmental, socio-cultural and functional, economy, technical, and site. In addition, AHP has been used in weighting the indicators and categories by converting the subjective interviews' results into quantitative numbers.

Sahamir et al (2017), conducted a study to identify criteria for green hospital assessment system according to the Malaysian context. The researchers explained that the evaluation of the green hospital building should consider the environmental, economic and social factors. The assessment items were proposed to be within two levels the first upper level included the main assessment items which include 10 criteria: energy efficiency, indoor environmental quality, sustainable site planning and management, materials and resources, water, innovation, transport, land use and ecology, pollution, and waste. In addition, the study proposed many sub-criteria for each of the main criteria depending on the analysis of the main international SA systems such as LEED, BREEAM, and Green Star. Table 2-10 presents a brief comparison between the three above discussed studies.

Table 2.10: comparison of (Buffoli et al., 2013; Castro et al., 2017; Sahamir et al. 2017) studies.

The study	Buffoli et al.(2013)	Castro et al. (2017)	Sahamir et al (2017)
System structure	The assessment items arranged into a three level hierarchal structure(Areas, Criteria, Sub-criteria)	The assessment items arranged into a three level hierarchal structure (Areas, Categories, and Indicators)	The assessment items arranged into a two level hierarchal structure (Criteria, and Sub-criteria)
Weighting technique	Analytic Network Process (ANP)	Analytic Hierarchy Process(AHP)	No weighting system
Phase of application	Two set of criteria to assess operative or in design	One list of criteria to assess new or refurbished building	One list of criteria to assess hospital's building in general
Healthcare building type	Hospitals building	Healthcare buildings in general	Hospitals building
Context	Italian context	Portuguese context	Malaysian context

Finally, there are many other frameworks which have been developed in field of SA of healthcare structures. However, these frameworks cannot be considered holistic as they had not addressed all sustainability dimensions, but the focus mainly was to assess the healthcare buildings from social or environmental point of view. Some of these studies are summarized in Table 2.11

Table 2.11: Some environmental and social sustainability assessment frameworks for healthcare buildings.

Author(s)	Sustainability Dimensions	Brief Description
Buffoli et al. (2014a)	Social	Developed an assessment system named LpCp - tool (Listening to people to Cure people) aims at evaluating the humanization and comfort of an operative hospital in the Italian context. The assessment tool consists of a questionnaire and processing software (excel spreadsheet). The questionnaire has been used for collecting the data of user's perception about the social aspects, and the software to analyze the collected data in order to determine the areas of deficiencies and provide management with information to formulate strategies to improve performance in these areas.
Capolongo et al. (2014)	Social	Starting from the question "does the result of a design meet users' expectations?" the researches proposed a new design process to improve the hospital interior environment. The proposed methodology comprises three steps: Definition of the soft qualities criteria using focus group, then trading-off between proposed design criteria, and finally adjustments and finalizations to identify the characteristics of furniture and decorations.
Carnero. (2015)	Environmental	Proposed a multi-criteria approach for environmental SA in healthcare organizations using FAHP. The researcher claims that this technique will make it possible to handle the uncertainty, vagueness or ambiguity in decision makers' judgments. Moreover, the study revealed that using the proposed model makes it possible to compare environmental sustainability over time and make comparisons between different healthcare organizations. environmental sustainability has been assessed based on water consumption, energy efficiency, waste production, greenhouse gas emissions, and consumption of materials, recycling, environmental accidents, and biodiversity criteria.
Capolongo et al. (2016)	social	Developed a rating tool for in design or operative hospital that evaluates the social aspect of sustainability. The proposed rating tool consists of

		three hierarchical levels comprises of three main criteria (Humanization, Comfort, Distribution) and each criterion is evaluated by four indicators. Humanization is evaluated by the indicators of safety and security, social aspects, well-being, and health promotion. Comfort is evaluated by day lighting, social thermal comfort, interior air quality (IAQ), and acoustic indicators. The final criterion is the distribution which is evaluated by the access and paths, hospitalization blocks, space flexibility, and departments' offices indicators. Regarding the results of the study, the researchers revealed that the environmental dimension impact is significant in the design phase of the hospital, while for an operative hospital the social dimension followed by the economic dimension is more influential than the environmental dimension.
Buffoli et al. (2016)	Social	Developed a tool to improve the social aspects in emergency rooms. Milan hospital with 600 beds has been selected to collect the data. Humanization and comfort aspects were explored using a questionnaire with closed format questions and a worksheet to process the data about user's experiences and perceptions, two copies of the questionnaire one for the adults and the other for children. Emergency rooms have been selected due to the presence of patients in a difficult psychological situation and stress for them and their relatives.
Blass. (2017)	Environmental	Proposed a framework to measure hospital environmental performance in Brazil. The development process comprises three consecutive and repeated stages: conception, implementation and analysis. Conception stage includes evaluation of the initial environmental status to determine environment-related goals, and deployment of goals into strategic, tactical, and operational measures. The implementation phase comprises of the determination of indicators to monitor goals achievements, and implementation of measures at strategic, tactical, and operational levels. The last stage is the analysis stage and includes monitoring goals achievements, checking and analysis of organizational performance, as well as preparing and communicating environmental reports.

2.7 West Bank Context

2.7.1 Environment and natural resources

2.7.1.1 Water

Water is one of the most important natural resources that is used in all fields and sectors of life. Rainfall is the main source of water in Palestine, ranging from 100-650 mm per year; water resources in Palestine are fed by rainwater. These sources include (EQA, 2017):

1- Surface water: Surface water is scarce in WB, and flows for a limited time of year so that they cannot be exploited. The main source of surface water sources in the WB is the Jordan River. However, this river is controlled by the Israeli authorities and exploited in irrigation and houses.

2- Groundwater: The groundwater layers in the Palestine are usually located in three main basins (the western basin, the eastern basin, and the north-eastern basin). WB relies mainly on groundwater through water springs and wells. Groundwater is fed by rainfall of 8-814 million cubic meters per year in the WB (EQA, 2017).

3- Non-traditional water sources: The Palestinian government has developed non-conventional sources of water. This includes sources such as water desalination projects and some pilot projects to reuse wastewater.

It should be emphasized that water sources in WB suffer from many challenges including the Israeli authorities control of almost 80% of the available water resources in Palestine, undernourishment of groundwater basins due to climate change, lack of access to some sources due to the wall, pollution of groundwater as a result of untreated wastewater, the non-utilization of non-traditional water sources such as the exploitation of wastewater. Additionally, water losses in the WB range between 24% and 36%, which are higher than international standards (EQA, 2017).

2.7.1.2 Energy

The sources of energy in Palestine are limited, depends on the purchase of energy in all its forms from external sources.

1- Electricity: Electricity is the primary source of energy on which Palestine relies on for various home and industrial uses. However, Palestine depends on the purchase of electricity from external sources such as the Israeli companies, where the proportion of imported electricity in 2014 was 88% from Israel, 4% from Jordan and Egypt, and 7.3% was generated by Gaza Power Plant (EQA, 2017)..

The electricity purchased is distributed to the population centers in the Palestinian territories through six distribution companies, five of them are located in in the WB in addition to some local bodies. However the rate of electricity loss is high and is about 24% of the purchases because of technical matters related to the efficiency of transport networks and other non-technical due to theft of electricity by some consumers, this loss ratio is high if compared to the loses in neighboring countries, where the percentage of losses in Jordan was 14% and 6.5% in Israel. (MAS, 2014)

Because of reliance on external sources to supply electricity, the prices of electricity purchased in Palestine are the most expensive compared to European countries and neighboring countries (EQA, 2017).

2- Oil derivatives: The Palestinian authorities buy the oil derivatives from Israel; this includes gasoline, diesel, kerosene and liquefied gas. It should be noted that demand for petroleum products is increasing due to population density (EQA, 2017).

3- Renewable energy: Renewable energy resources are the inexhaustible resources of energy that are the least polluting of the environment when compared to other types of energy. In addition, renewable energy generation reduces dependence on others to supply energy

Renewable energy resources include solar energy, wind power and solid and organic waste. However, renewable energy accounts for 18% of total energy consumed in Palestine. Palestine's use of renewable energy is limited to using solar energy to heat water as well as burning of wood, coal, and peat in addition to some small projects that aim to generate electricity by exploiting the sun light (EQA, 2017).

It is important to highlight that The Palestinian energy sector suffers from many difficulties and obstacles (EQA, 2017):

1. The biggest challenge is that the energy in Palestine in its various forms is purchased from external sources, which makes the provider controls many things and most importantly the price and quantities of purchased energy.

2. Renewable energy sources are not getting enough attention and exploitation, and there are limited investments initiatives in renewable energy limited to some small projects.

3. Weak awareness programs in the field of energy conservation, and decreasing the consumption

4. Palestine lacks a national electricity network, where electricity considered as the main energy resource that is used in Palestine.

5. Overlap in responsibilities between the relevant authorities.

2.7.1.3 Climate change

Climate change is one of the most serious problems threatening humanity's future on earth. Like other countries, Palestine suffers from the effects of climate change. It affects the temperature of the air, the amount of rain and its distribution, in addition to desertification, floods, heat waves and many other serious economic, social, health, and environmental consequences.

It is worthy to note that the Palestinian government is striving to avoid the damage of climate change by preparing strategies to avoid the damage of climate change, in addition to participating in relevant conferences and concluding agreements with concerned parties (EQA, 2017).

2.7.1.4 Waste

- **Waste water / sanitation**

In Palestine, waste water and sanitation threaten public health. Approximately 70 million cubic meters of wastewater is discharged annually, in addition to 40 million cubic meters of wastewater from illegal Israeli settlements.

Wastewater and sanitation infrastructure is inadequate and suffers many problems including the lack of wastewater treatment plants and inefficient existing stations as there are only 10 wastewater treatment plants, of which five are in the WB. Furthermore, wastewater collection networks in major cities are inefficient and incomprehensive, and the wastewater collection and treatment services in rural areas are not sufficient.

Finally, it is important to note that there is a great threat to the Palestinian environment, which is the wastewater that the Israeli settlements pump into the Palestinian land, in the absence of a system for examining its type and quantity of this wastewater. (EQA, 2017).

- **Solid waste**

In Palestine, there is no approved system for solid waste management. Moreover, the solid waste management sector faces many financial and managerial difficulties and obstacles including the conflicts of laws and regulations in this field while there is an absence of a unified national solid waste database. Furthermore, there is a lack of sanitary landfills, a spread of many open dumps of solid waste in different areas of Palestine. Additionally, Palestine lacks control over trans boundary wastes.

Finally, with regard to medical waste, there is no system of separation and treatment of solid medical waste except for some efforts by some hospitals such as the Palestine Medical Complex in Ramallah. (EQA, 2017).

- **Hazardous waste**

Hazardous wastes are wastes that may cause harmful accumulative effects that harm the environment or pose a risk to human health and other organisms. They can be found in liquid, solid or gaseous states. Moreover, Hazardous wastes Fall under four categories: Ignitability, corrosivity, reactivity, and toxicity (EPA, 2019).

Medical waste contains a large percentage of hazardous waste that can cause serious damage to the environment and humans' health.

There is a lack of information about this type of waste; the most available information is about waste from the health sector. According to data available in the Palestinian Central Bureau of Statistics (PCBS) for 2017, the health sector produced 13.4 thousand tons of solid waste per month (EQA, 2017).

As with solid waste management, hazardous waste management system also faces many challenges which include the lack of special hazardous waste dumps except for some pilot projects (incinerators and treatment units) in some hospitals in Ramallah, Hebron, and Gaza. In addition, there is an absence of treatment and separation system for hazardous wastes except for some efforts by some hospitals (EQA, 2017).

- **Chemicals and hazardous materials:**

Chemicals are used in Palestine in many fields, including agriculture, industry, health, research, and others. However, it should be noted that there is a lack of a precise inventory of the types and quantities of chemicals that enter the land of Palestine in a legal or illegal manner, especially the dangerous chemicals caused by Israeli settlement plants inside the Palestinian territories. These dangerous chemicals are highly polluting to the environment and harmful to public health.

The Palestinian government faces many challenges in the management of chemicals and hazardous materials, including the lack of expertise and equipment required to examine materials, as well as the weak coordination between the concerned authorities in the government (EQA, 2017).

2.7.2 Demographic and social characteristics:

At the end of the year 2016, the estimated population was 4,816,503, distributed as 60.9% in WB and 39.1% in Gaza strip, with 50.8% males and 49.2% females. The population density in Palestine was 800 people/km^2, and in the WB specifically the population density was 519 people/km^{2}With a difference in the density between the WB governorates, where the highest density was in Jerusalem, where it reached 1236 people/km^2, and the lowest was in Jericho, where it was 90 people/km^2

The Palestinian society is a young society where 54.1% of the population are children; 14.9% under five years, 39.2% in the 0-14 age group, while the population over the age 65 constitute only 2.9% of the population (PCBS,2016b).

2.7.3 Economic characteristics:

Palestine is a developing country with a weak economy that relies heavily on foreign aid. Moreover, the economic situation in Palestine depends on the unstable political situation making the investment difficult in such circumstances. Furthermore, the final decision on everything related to economic development in Palestine is linked to the Israeli approval where exports, imports, taxes, etc. are all under Israeli control. According to the latest estimates issued by the PCBS in Palestine, the unemployment rate in Palestine was 25.9% in the year 2015, 22.5% for males and 39.2% for females. (PCBS,2016b)

The poverty rate among the Palestinian populations is high. During 2011 it was estimated at about 25.8% according to real consumption patterns, 17.8% in the WB and 38.8% in the Gaza Strip. Moreover, the estimates indicate that 12.9% of citizens in Palestine suffer from extreme poverty (PCBS,2016a).

2.7.4 Palestinian Healthcare sector:

2.7.4.1 General overview

Since 1994 and after signing of the Oslo Accords, the Palestinian National Authority (PNA) which began its work in 1994 has been responsible for the management of the health sector in the WB and Gaza Strip. Since then, despite the obstacles imposed by the Israeli authorities and the difficult political and economic conditions, the Palestinian health sector has witnessed remarkable development over many years, for example the number of primary health care centers in the Palestinian governorates has increased dramatically over the past few decades, as it was 454 in 1994 and increased to reach 739 in 2016 (MOH, 2016).

The Palestinian healthcare sector is one of the most important sectors in Palestine, Where the latest statistical data indicate that the total expenditure on health in Palestine in 2015 was about 1,321.3 million US dollars which represent 10.1% of GDP which is a relatively high figure, and higher than the expenditure on health in 2014, which was 9.8 of GDP (PCBS, 2016b).

The Palestinian health sector comprises three main components: primary health care, secondary health care, and tertiary care. These three levels of services are provided by five main providers: Ministry of Health (MOH), UN Relief and Work Agency (UNRWA), non-governmental organizations (NGOs), Palestinian Military Medical Services (PMMS) and

Private sector. MOH bears the heaviest burden, due to the fact that it is the main health provider (MOH, 2016).

Admittedly, since the time the PNA assumed responsibility for managing the health sector in 1994 to this day the health sector in Palestine suffers from many difficulties. This hinders the Palestinian healthcare ability to cope with the rapid development of the medical field, as well as limits its ability to provide services to the Palestinian society effectively. Finally, it should be noted that Israeli restrictions constitute the major challenge to the Palestinian health sector. (MOH, 2016)

In addition to the economic blockade imposed by the Israeli authorities on the Palestinians which limits the ability of the healthcare institutions to buy medicines and equipment, there are also a network of barriers (fixed barriers, unexpected movable barriers), physical obstacles (lumps of earth, concrete cubes, iron gates), prohibited streets, and many checkpoints that hinder access to healthcare facilities. Furthermore, the annexation, expansion and apartheid wall which makes the Palestinian territories isolated areas from each other and from other countries of the world, making it difficult for people to access healthcare facilities. (WHO, 2016).

As a result of the aforementioned obstacles, MOH doesn’t have the ability to deal with all medical cases within its institutions. Accordingly, MOH is purchasing medical services from private hospitals in Palestine, hospitals in Egypt and Jordan, hospitals inside Jerusalem, and hospitals in the Green Line region. The total number of all medical referrals in 2016 was 91,927 which cost 566,720,980 New Israeli Shekels (NIS). However, transfers for treatment also involves great suffering especially when the medical referrals are transferred to the Israeli hospitals occupied Jerusalem or the Green Line region, where the Israeli authorities impose restrictions on the movement of ambulances and patients, as well as obstructing the issuance of permits to patients and their relatives, and interrogate the patients. (MOH, 2016).

2.7.4.2 Health services delivery system:

The Palestinian health care system provides health care services at three main levels (MOH, 2016) :

1- Primary health care: These are preliminary tests and comprehensive health care that do not necessarily require complex equipment or specialized resources. This includes initial diagnosis and treatment, health, supervision, management of chronic conditions and preventive health services.

2- Secondary health care: Care that is provided by institutions specialists, care provided for referrals from primary health centers or in emergency situations.

3- Tertiary health care: This type of care is provided by the centers that provide specialized consultative care, examination, and treatment for patients who are transferred from primary and secondary care centers.

2.7.4.3 Hospitals:

Hospitals are institutions that deliver diagnostic and curative services around the clock. A hospital system consists of professional medical and non-medical staff as well as patient facilities (WHO, 2017).

According to the last report issued by MOH in Palestine in October 2016; the number of hospitals in Palestine is 81 operating in Palestine including East Jerusalem. 51 hospitals in WB, and 30 in Gaza Strip. The total number of hospitals' beds (including psychiatric and neurological hospitals) is 6,146 beds distributed in governmental, non-governmental, private and UNRWA hospitals, 61% in West Bank and 39% in Gaza Strip, 72.5% of them are general beds, 19.6% specialized beds, 3.1% rehabilitation beds and 4.8% maternity beds, with a population of 780 per bed, including East Jerusalem hospital beds, 759 per bed in the Gaza Strip and 794 per bed in the WB. Table 2.12 includes the Palestinians hospitals in WB distribution according to total beds and governorate in 2016. (MOH, 2016).

In fact, MOH is the main provider of secondary health care services (hospitals) in Palestine, where it owns and manages 27 hospitals out of 81 distributed in all governorates of Palestine, where the total bed capacity of these hospitals is 3,325 beds, NGOs have 34 hospitals with a bed capacity of 2,061 beds, the private sector has 16 hospitals with a capacity of 536 beds. UNRWA has one hospital in Qalqiliya with a capacity of 63 beds. PMMS have three hospitals in Gaza Strip with a capacity of 161 beds.

Table E-1 in Appendix E presents the distribution of the Palestinian hospitals and total beds by governorate and specialty.

Table 2.12: Distribution of Hospitals and Total Beds for WB Governorates (MOH, 2016).

Governorate	Number of hospitals	Number of beds
West Bank	**51**	**3,747**
Jenin	3	246
Tubas	1	44
Tulkarm	3	173
Nablus	7	640
Qalqiliya	2	125
Salfit	1	50
Ramallah & Al Bireh	8	480
Jericho & Al Aghwar	1	56
Jerusalem	7	698
Bethlehem	8	588
Hebron	9	629

2.7.4.4 Classification of hospitals

Hospitals can be classified according to many criteria such as size, ownership, specialty, types of provided services, Clinical capacity. In the following lines, the distribution of Palestinian hospitals according to specialty is discussed

1- General Hospitals:

These hospitals provide secondary diagnostic and medical treatment and some of these hospitals have the capacity to provide secondary and some tertiary health care. In 2016, the number of general hospitals in Palestine was 43 with a bed capacity of 4,455. These hospitals include many specialties such as emergency, internal medicine, general surgery, cardiology, obstetrics & gynecology, dermatology, ear, nose and throat, and orthopedics. Furthermore, general hospitals may provide other services such as anatomical pathology services, clinical laboratory services, diagnostic X-ray services, and outpatient services. However, these hospitals usually do not provide a service for infectious diseases, although there are hospitals include sections to treat these diseases.

2- Specialized Hospitals: these hospitals provide specialized, advanced and comprehensive diagnostic and medical treatment in secondary and tertiary care. Also, these hospitals provide monitoring services for inpatients with a specific type of disease. The number of these hospitals in 2016 was 21 hospitals with a total capacity of 1206 beds.

3- Maternity Hospitals: these hospitals are specialized in the field of obstetrics and gynecology as they provide services for women during pregnancy and childbirth as well as services for newborn infants and midwifery training services. In Palestine there were 13 hospitals with a capacity of 296 beds.

4- Rehabilitation & Physiotherapy Centers: these centers provide rehabilitation and physiotherapy services which include diagnosis and treatment services for patients with Dysfunction in musculoskeletal, neurological and muscular functions. In 2016, there were four centers in Palestine with a total capacity of 189 beds.

The distribution of different hospital beds according to their specialty and service providers illustrated in Table 2.13. Table E-1 in Appendix E presents the distribution of the Palestinian hospitals and total beds by governorate and specialty.

Table 2.13: Distribution of hospital beds by service provider and specialty, Palestine in 2016 (MOH, 2016)

Service provider	general		specialized		Rehabilitation		Maternity	
	No of beds	% of beds	No of beds	% of beds	No of beds	% of beds	No of beds	% of beds
MoH	2,809	63.1%	473	39.2%			43	
NGOs	1,206	27.1%	487	40.4%	189	100%	179	
Private	216	4.8%	246	20.4%			74	
UNRWA	63	1.4%						
PMMS	161	3.6%						
Palestine	**4455**	**100%**	**1,206**	**100%**	**189**	**100%**	**296**	**100%**

2.7.5 SD in the Palestinian context

In 2016, the Palestinian government recognized its commitment to achieving the SDGs. This was followed by establishing a national team which is headed by the Prime Minister's Office. This team includes members from many relevant fields. Moreover, the team is responsible for implementing and monitoring the SDGs in Palestine. Within the Palestinian national voluntary review on the implementation of the 2030 agenda, the Palestinian government emphasised that the Israeli occupation is the main obstacle that impedes the achievement of SDGs in Palestine. Moreover, it stresses the achievement of SDGs requires the participation of all stakeholders from all sectors including the health sector, (PCM, 2018). In other words, all the sectors in Palestine are required to progress toward sustainability including healthcare institutions.

2.8 Summary

Sustainability is a broad old new concept that has received great attention over the past few decades because of the serious environmental and social consequences that accompanied the development achieved by man in all fields. Moreover, Sustainability has been formulated in many definitions according to many factors, including the body or level or priorities, circumstances and many other factors.

By striving for sustainability by various stakeholders at the global, national and institutional levels, many SA methods have emerged. However, SA is not an easy process because it involves many factors with interrelationships.

In the past, the focus of the assessment was on the environmental impacts, as in the impact assessment tools. After that, SA methods have emerged to be the following generation of environmental impact assessment methods such as EIA and SEA, where these tools have been extended to include social and economic aspects with the environmental ones.

Many SA tools are available in the market to assess the sustainability of a variety of buildings types (including hospitals) at life cycle stages, to name but a few LEED, BREEAM, CASBEE, and Green

Star. However, the aforementioned tools and the other tools are not fully comprehensive and have many weaknesses including the great focus on the environment dimension, do not fit all contexts, and time-consuming. As a consequence, many efforts have been made and studies have been carried out to develop tools and frameworks for evaluating the sustainability of certain types of buildings and within a given context according to specific conditions and priorities.

In addition, several research work has been done to develop SA methods to evaluate the sustainability of healthcare buildings, especially hospitals which characterized by the complexity, excessive use for natural resources, and dumping all types of waste. However, these studies had been conducted in developed countries where the priorities and conditions are different from developing countries.

Palestine is a developing country that lacks control over its natural resources and borders. Moreover, it is characterized by a weak economy that depends on foreign aid in a fundamental way and is controlled by the Israeli economy in all its activities. As a consequence, all sectors, including the health sector are suffering from these difficult conditions which hinder development and sustainable service delivery. Moreover, Palestine is witnessing a rise in population density, especially in the areas of major cities and refugee camps, in addition to the high rate of unemployment and poverty.

The Palestinian health sector comprises three main areas: primary health care, secondary health care, and tertiary care. These three levels of services are provided by MOH, UNRWA, NGOs, PMMS and Private sector. There are 81 hospitals in Palestine, 51 in the West Bank and 30 in the Gaza Strip, including general, specialist, maternity and rehabilitation centers. However, many of these hospitals have been working for many decades and became obsolete buildings.

In fact, very important sectors, such as energy and waste management, face many challenges that can negatively affect sustainability and threaten the Palestinian environment and community health.

To this end, this study aims at developing SA tool that is customized to assess hospitals' sustainability in the developing countries context particularly in WB.

Chapter Three

Research Methodology

Chapter Three

Research Methodology

3.1 Overview

This chapter describes the characteristics methodological approach adopted by the study to achieve the study objectives. This includes the research overall approach, methodology steps, sampling, data types, collection, and analysis.

3.2 Research strategy:

According to Creswell (2014), the research approach “are plans and procedures for research that span the steps from broad assumptions to detailed methods of data collection, analysis, and interpretation”. The three research approaches are qualitative, quantitative, and mixed methods. Choosing any of the aforementioned approaches to address the research problem depends mainly on the research problem nature and the researcher experiences.

The qualitative approach aims to explore the meaning of peoples, experiences, cultures by collecting and analyzing qualitative data through observations and interviews. The quantitative approach aims to analyze the relationships between variables which can be measured by instrument such experiment and survey. After that, the data can be statistically analyzed. The mixed method approach integrates qualitative and quantitative data in the same study (Creswell, 2014).

The main objective of this research is to develop a hospital sustainability assessment tool, then to use this tool to assess and improve the hospitals' sustainability in Palestine, specifically in the West Bank. To achieve this purpose a multidimensional research strategy was adopted. This strategy adopted the mixed methods approach in which qualitative and quantitative data are utilized. Many data collections methods were used including interviews (structured and unstructured), focus groups, observations, and surveys.

The study approach integrates between the quantitative survey design and the Ethnography qualitative design which requires the researcher to go down to the field and spend considerable time in observing and interviewing different stakeholders.

3.3 Stages of the methodology:

Figure 3.1 illustrates the flow chart of the methodology adopted by the researcher in order to achieve the research objectives. The methodology comprises mainly of five steps. These steps are discussed in the following lines

Stage one: Establishing assessment items

The beginning of this study was to establish an initial set of assessment items (categories and indicators) for assessing hospital sustainability in the WB context. This was performed through exploring the most well-known SA tools (BREEAM, LEED, CASBEE, and Green Star), as well as an extensive review of the literature of SA.

Stage two: Refining assessment items

The main aim of this stage was to refine the established set of assessment items so as to consider the most relevant items that were suitable for the WB context. This was conducted by discussing the environmental, economic, and social conditions of the WB context. In addition, the Palestinian healthcare sector was also highlighted. Additionally, structured interviews (in the form of a questionnaire) with many experts from different fields were also conducted.

Stage three: Weighting assessment items:

This stage aims to assign weights for the assessment items according to their priorities to the WB context. This was performed through conducting a structured interview (pairwise comparisons in the form of a questionnaire). After that, the AHP method was used to generate the final weights for all the assessment items.

Stage four: Building the sustainability assessment tool for assessing WB hospitals sustainability (HSAtool-WB):

Formulating the assessment items in the final form was the aim of the fourth research stage. The results of stage two and stage three were used to formulate the tool in its final form.

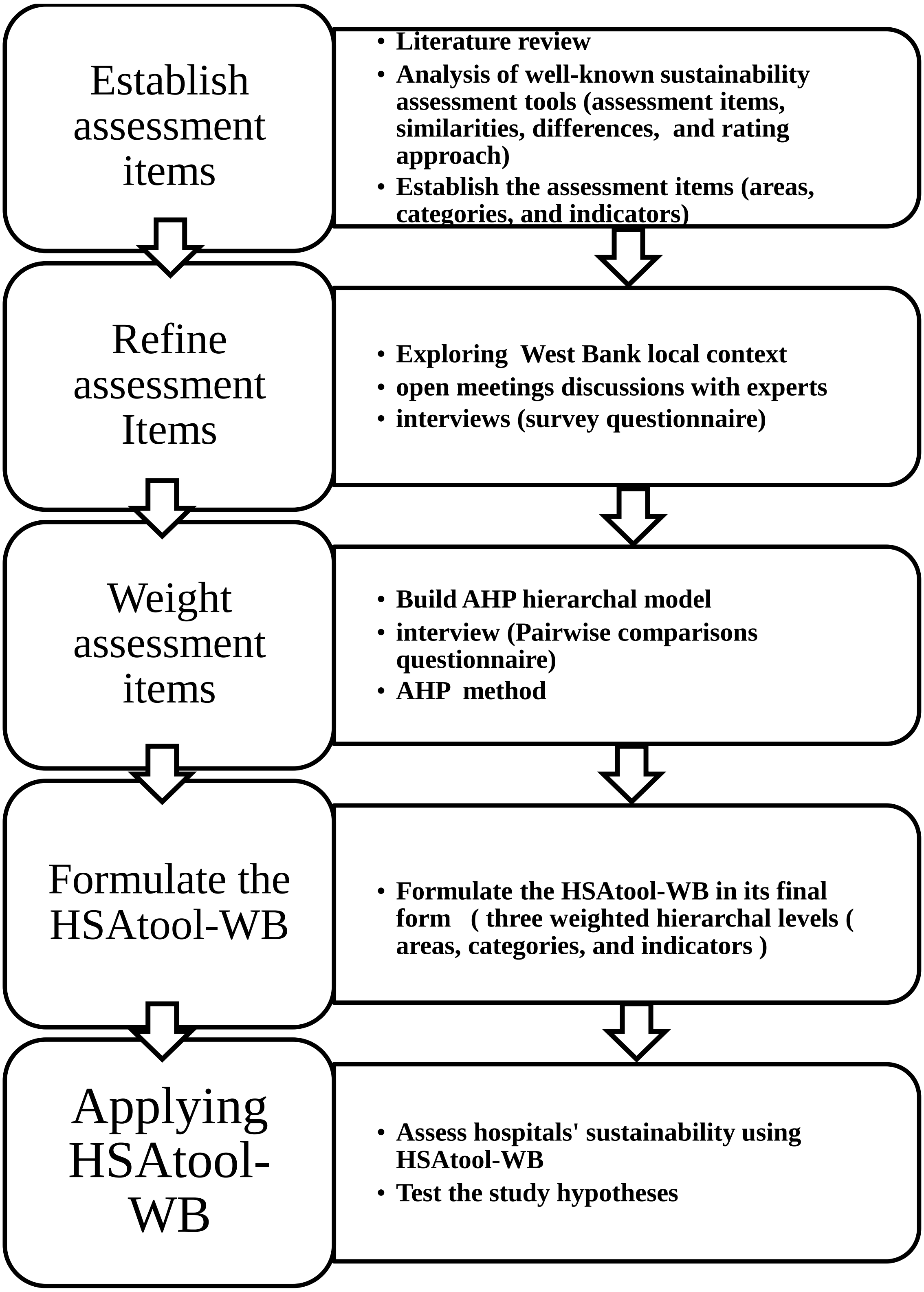

Figure 3.1: Research methodology stages.

Stage five: Applying the HSAtool-WB to assess the hospitals' sustainability in the WB.

The aim of the final stage of this study was to use the developed tool (HSAtool-WB) to evaluate and improve the sustainability of WB hospitals. In addition, in this stage, the research hypotheses were also tested.

3.4 Data collection:

In this study, many data types (quantitative and qualitative) were gathered to achieve the research objectives. These data types and sources are discussed according to each research stages in the following lines.

3.4.1 Establishment of the first set of assessment items

The data for the establishment of the first set of indicators was drawn from two main sources. The first source was from reviewing the literature, where the focus of the literature review was on studies that were conducted to customize the international SA tools to be used in a specific local context. The other source of data was obtained through exploring the well-known international tool (LEED, BREEAM, Green star, CASBEE), this included highlighting the tools technical manuals to identify their assessment criteria, and rating approach.

It should be noted that the aforementioned SA tools were selected in this study because they can be used to assess healthcare buildings (Castro et al., 2017). Moreover, these tools are the most widespread, well-known, and successful tools in the market. (Banani., 2016; Castro et al ., 2015;

Sahamir., 2017; and many others). In addition, they have been launched through cridible orgnizations (Alyami , 2015).

3.4.2 Refinement of the assessment items

Regarding the second research stage which included refining the initial set of indicators so as to include the most relevant assessment items, the data was obtained from the following two sources:

3.4.2.1 Reviewing official reports :

This included analysing some relevant public documents, specifically Palestinian MoH, PCBS, and EQA reports. This was done to have a deeper understanding of the current Palestinian situation in term of priorities, regulations, and challenges.

3.4.2.2 Discussions with experts

Many open-meetings Discussions with experts were conducted. The experts were selected from various fields including water, energy, renewable energy, mechanics, waste management, architectural design, green buildings, health, SD and urban planning. Through these discussions, it was possible to highlight important issues regarding assessment items and to decide the applicable assessment items in WB. This included adding, modifying, and deleting some assessment items.

3.4.2.3 Structured interview (questionnaire)

The structured individual and group interviews were the main data collection tool used in this stage. The interviews were designed in the form of a questionnaire. This tool was used by several researchers such as (Ali & Al Nsairat, 2009; Castro et al., 2017). These interviews were conducted to identify the most important assessment items which must be included as well as the un releavent assessment items which should be excluded.

It is worthy to mention that, conducting questionnaire in an interview where the researcher facing the participant will give the respondent opportunity to understand the subject more deeply and will give the interviewer the ability to clarify any question that may be raised by the respondent (Ali & Al Nsairat, 2009).

3.4.2.3.1 Questionnaire design

The questionnaire design was informed by the work of many researchers in similar studies such as the work of Ali & Al Nsairat. (2009), Alyami (2015), Castro et al . (2017). In addition, the questionnaire design was discussed with many local experts, revised and modified according to their recommendations. Furthermore, the design served the goal of this stage which aimed to improve and refine the list of indicators as the questionnaire gave the respondent the ability to add new assessment items (category or indicators) or suggest removing others by giving them low rating value. A 5 points Likert-type scale (ranked from 1 Not important to 5 Very important) was used to rate various assessment items (Refer to Appendix B). The questionnaire comprised of three parts:

1- Part one: this part was designed to gather general information about the respondents including gender, profession, work organization's type, years of experiences, and the highest level of education.

2- Part two: in this part, the respondents were asked to rate the assessment areas (environmental, economic, and social) according to their importance for assessing and improving hospital’s sustainbility in WB using the abovementioned Likert scale.

3- Part three: this part asked the respondents to rate the assessment indicators and categories according to their importance for assessing and improving the hospital’s sustainability in WB. In this part, the respondents had the ability to suggest new indicators or categories. The rating process used also the abovementioned Likert scale.

The questionnaire was translated to Arabic language before it was used to gather the data as the mother language in Palestine is the Arabic language. Two months was given to data collection. The interviews were conducted at any time and place suitable for the respondent after obtaining his/her approval to do the interview.

3.4.2.3.2 Questionnaire pilot study:

Before using the questionnaire to collect data through the structured Interviews it was reviewed by 7 experts and arbitrators to make sure it was valid and easy to understand and answer. The questionnaire was refined based on experts’ recommendations. After that, a pilot study was conducted by filling the questionnaire by 10 experts from various fields including engineering, architecture, design, urban planning, healthcare, and green buildings. This was performed to ensure the questionnaire questions were simple and clear.

Finally, the questionnaire items were modified and adjusted based on the comments of experts, arbitrators, and participants. It should be noted that the participants who filled the questionnaire in the pilot study were excluded from the study sample.

3.4.2.3.3 Questionaire reliability

A questionnaire reliability test was performed to ensure the internal consistency of the Likert scale of the questionnaire. Cronbach's alpha measure was used to determine questionnaire reliability. Internal consistency was measured between each indicator and the overall mean of the category for which the indicator belongs. The results of the questionnaire items' reliability test which shows that all Cronbach's alpha values for all elements were over 70%, and the total reliability of the questionnaire was 0.896. Thus, the proposed questionnaire was consistent (Gliem & Gliem, 2003).

3.4.3 Weighting the assessment items:

After defining the most appropriate assessment items in the previous stage and structuring the assessment items in a hierarchal level (assessment areas at the top level, categories in the second level and the indicators in the lowest level), the next step was to assign weights for all assessment items in all hierarchal levels. To do so, pairwise comparisons were performed. These comparisons were conducted using square reciprocal matrices. Moreover, the comparisons were conducted through individual and group interviews. The matrices were arranged in a questionnaire. This questionnaire was designed so as to define a weight for each indicator according to its importance with respect to the group which it belongs to. In the same way, each assessment category was assigned a weight according to its importance with respect to the main area which it belongs to. Finally, the three assessment areas were also assigned weights according to their importance to the overall hospital's sustainability score.

The questionnaire with the cover letter and detailed explanations of how to fill it are presented in Appendix C.

3.4.4 Hospitals evaluation:

The final research stage aim was to apply the developed tool in the local WB context to assess and improve hospitals' sustainability. To achieve this, an evaluation form (Illustrated in Appendix D) was developed based on the developed tool's indicators. Each indicator can be assigned a score ranging from 1 (very poor level) to 10 (best practice). The evaluation form included two parts:

1. The first part collects general demographic information about the hospital including the location in WB, date of establishment, number of beds, Specialty, service provider, and quality certificates. Regarding the location variable, it is divided into three options. The first option is 'North' and includes the provinces of Jenin, Tubas, Tulkarm, and Nablus. The second option is the 'Center' and includes the provinces of Qalqiliya, Salfit, Jerusalem, and Ramallah and Al Bireh. Finally, the 'South' option includes the provinces of Bethlehem, Hebron, and Jericho.

2. The second part of the form includes all the assessment indicators which can be rated from 1 to 10 according to the actual performance. It should be noted that three indicators were added to the form. The first indicator was annual water consumption which was measured in cubic meters per bed. The second one is the annual energy consumption which was measured in dollars per bed. The energy indicator value includes the electricity, fuel, and cooking gas consumptions which are converted to a single value represented in dollars. The third indicator was the bed capacity indicator and was measured by the number of beds. These indicators were not included in calculating the final sustainability score, rather they were used in the analysis to make a clearer image of the hospitals status.

Four months were spent in data collections. This included field visits to all hospitals. Through these visits, it was possible to rate the assessment indicators for all the sample hospitals. This was conducted through observations, investigations, interviewing management, engineers, staff, patients, and visitors. In addition, water, and energy bills were verified to determine the annual water and energy consumption.

3.4.5 Research sample size:

The study included three different samples. The size and type of these samples were selected according to the objective of each stage of the research. In the following lines these samples will be discussed:

1- The first sample comprised of a group of experts from various fields; SD, architecture, urban planning, water efficiency, energy efficiency, renewable energy, and healthcare. A purposive sampling technique was used to select 60 participants. It should be noted that this technique was used by several researchers such as Ali & Al Nsairat. (2009) and Castro et al. (2017). However, other researchers selected a smaller sample size, as the case with Banani et al. (2016) who choosed a sample size of 22 experts. Participants were interviewed as individuals or a group of two, three, or four. This was done to allow some interaction. During these interviews, the participants filled the questionnaire which aimed at determining the most applicable assessment criteria for the WB context (See Appendix B).

2- The second sample of participants was selected in order to fill the questionnaire of the pairwise comparisons (See Appendix C). The experts were selected based on their qualifications and experiences toward sustainable construction from local construction and design consultancy companies, universities, and healthcare orgnizations. Regarding the recommended sample size, it was argued that a sample size between 10 and 50 is sufficient because in such type of complex decisions problems the respondents' qualifications and experiences are more important than the size of the sample (Alyami, 2015). Within this context, Zarghami et al . (2018) selected a group of 32 experts to do the required pairwise comparisons in their study.

In light of this, a sample of 30 experts was selected to perform the pairwise comparisons.

3- The third sample differs from its predecessors in that it includes institutions (hospitals) rather than individuals. In order to select a representative sample size, Thompson formula was used (Thompson, 2012).

$$n = \frac{N * P(1-P)}{\left[\left(N-1\right) * \left(\frac{d^2}{z^2}\right)\right] + P(1-P)} \qquad (3.1)$$

Where n is the sample size, N is the population size, d equals the percentage error (0.5), P is the proportion of the property offers and neutral (0.5), and z is z value is the upper α/2 of the normal distribution (1.96 for 95% confidence level).

Using the above equation (3.1) with 51 hospitals as population size. The result sample size is 45 hospitals. However, only 31 hospitals were assessed. This is because of many reasons including time and money constraints and a need to forge a head with the study. As the evaluation process required many visits to each hospital for coordination, approval, and evaluation. The evaluation of the 31 hospitals took about four months. In fact , other three hospitals were excluded from the sample due to the lack of some important data for the assessment process. Therefore, the final sample size was 28 hospitals.

3.4.6 Data analysis:

All the data analysis should be inspired with the fact that hospital SA tool offers a mean to assess and improve hospital's sustainability according to an expected level of performance against a number of predefined criteria regardless of how old the hospital is. In addition, the tool has to be able to suggest and foster reasonable solutions that could improve the hospitals' sustainability while they are operating.

In the light of this, the developed SA tool should assess the hospital's performance comprehensively including environmental, economic and social aspects, in addition to acknowledging the local context by considering cultural, climatic, and economic conditions. Moreover, the tool should be simple, easy to use and not time-consuming. In the following lines, data analysis is presented for each of the study stages.

3.4.6.1 Establishing assessment items

To establish the first set of assessment items many data analyses were performed including a deep and critical analysis of a large amount of literature on SD, sustainability in buildings, and SA in buildings and hospitals in particular. Indeed, the analysis of the literature was mainly focused on the studies that aimed at customizing the international SA tools to assess a particular type of buildings in a specific local context.

Additionally, a critical analysis of the well-known sustainability assessment tools (LEED, BREEAM, Green stare, CASBEE) was conducted. The analysis focused on tools strengths and weakness, assessment criteria, and rating approach.

3.4.6.2 Refining assessment items

Two types of data were analyzed to refine the first draft of the assessment items. The first data analysis was focused on the qualitative data relating to the context in which the tool will be applied. Therefore, all the factors that influence hospital performance such as experiences, technologies, and local regulations were analyzed. Moreover, Palestinian priorities, climatic conditions, natural resources, economic status, the local community were also analyzed. Furthermore, the analysis included key stakeholders needs and expectations.

The second type of analysis was performed for the quantitative data which were gathered through the questionnaire which aimed to determine the most important indicators relevant to the assessment of hospitals in WB context. (Refer to Appendix B). Firstly, using the Statistical Package for Social Sciences (SPSS V.23) program, descriptive statistical analysis was performed and included the followings:

- The reliability of the questionnaire was tested by measuring the Cronbach alpha.
- Frequencies, percentages, means, and standard deviations analysis to summarize the respondent's demographic data and to identify the importance of the assessment items.

Secondly, Microsoft Excel spreadsheet V. 2007 program was used to calculate the Relative Importance Index (RII), in order to determine if any of the proposed assessment items have to be excluded from the tool.

RII was calculated using the following formula (Johnson & LeBreton, 2004):

$$\text{RII} = \frac{\sum W}{AN} = \frac{5n_5+4n_4+3n_3+2n_2+1n_1}{5N} \qquad (3.2)$$

Where W is the weight that is given to each assessment item by the respondent ranging from 1 to 5. The value of W is obtained by adding the multiplication of each weight with the number of respondents who assigned it for the specified item. For example, $5n_5$ represents the highest weight (5) multiplied by n_5 which represent the number of respondents who rated the assessment item as very important. A is the highest weight (in this study 5), and N is the number of respondents.

Finally, it is necessary to emphasize that, RII value ranges from 0 to 1, any assessment item obtained a value of less than 60% will not be included in the tool.

3.4.6.3 Weighting assessment items

It is difficult for any SA tool to be suitable for all the world regions (Alyami et al., 2015). Every region in the world has its own characteristics, environmental conditions, economic state, and cultural values. In addition, there is a consensus that certain weights must be set for all the assessment items with any SA tool according to the local context in the area in which the tool is applied (Ali & Al Nsairat, 2009; Buffoli et al., 2013;Alyami et al., 2015;Banani et al., 2016; Castro et al., 2017; Zarghami et al., 2018).

The AHP method was used to generate the weights for all the assessment items in all the hierarchal levels (areas, categories, and indicators). AHP, implemented using the software Expert Choice V.11 to analyze the results of the pairwise comparisons which were performed by the experts using the questionnaire which illustrated in Appendix C.

3.4.6.3.1 Analytical Hierarchy Process (AHP)

3.4.6.3.1.1 Background

The Analytic Hierarchy Process (AHP) is a mathematical multi-criteria decision-making technique that has been developed by Thomas Saaty in the 1970s. This method has been used around the world in a variety of decision problems in many fields such as governmental, business, industry, healthcare, and many other fields (Saaty, 2008). AHP offers comprehensive approach to decision-making in which the decision-making problem is organized in a hierarchical structure which includes both qualitative and quantitative and sometimes contrasting factors. After that, all the decision factors of the hierarchy are prioritized and weighted using judgments of experts through pairwise comparisons in order to trade-off between different decisions alternatives.

3.4.6.3.1.2 AHP methodology

AHP methodology comprises mainly three specific steps begins with decomposition of the problem into a hierarchy of manageable elements (e.g. goal, criteria, sub-criteria and alternatives), then utilizing experts' judgments in order to set weights for the hierarchy elements. Finally, an overall rating is generated by synthesizing priorities of the decision alternatives. AHP Methodology steps can be explained as the following:

Step one: Develop a hierarchal structure of the problem (problem modeling):

The first step of AHP is to arrange the decision-making problem components based on their important in hierarchical structure descending from the general to the more specific where the overall goal of the decision at the top of the hierarchy, the criteria or sub-criteria in the intermediate levels, and the options or alternatives in the lowest level (Saaty 2008), Figure 3.2 illustrates a simple hierarchical problem structure.

This step is the most creative part of the decision-making process as it requires identifying the important decision factors to be included such as goals, stakeholders, issues, and attributes and where to include them. Arranging these factors in a hierarchy will provide an overall view of the complex decision and relationships embedded in the situation (Saaty 1994)

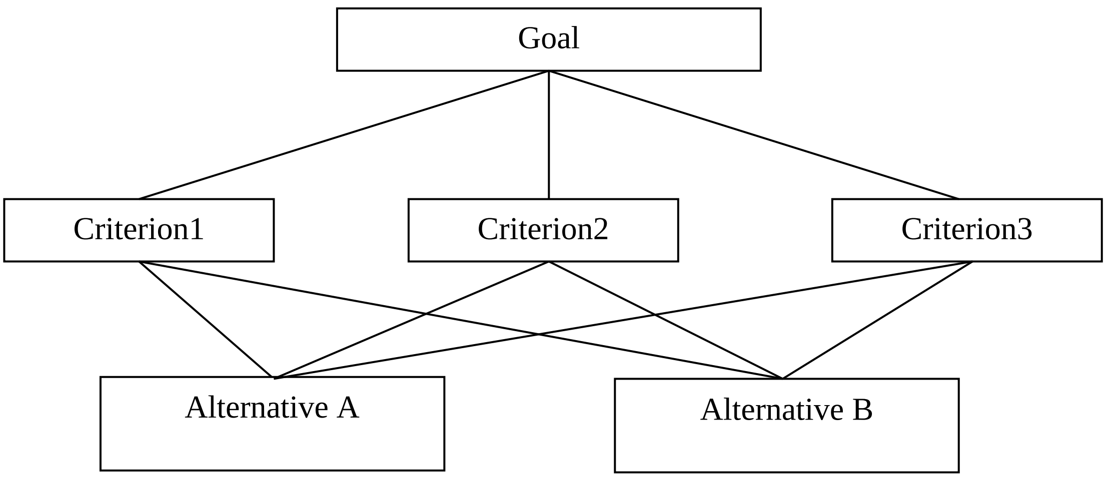

Figure 3.2: AHP simple hierarchal structure of a problem

Step two: Pair-wise Comparison

After the problem is hierarchically structured, a series of one-on-one pairwise comparisons are established to determine the relative importance (relative weight) for each element in the hierarchy, this is done by comparing elements of a particular level of a hierarchy with respect to their impact on their parent element in the next higher level. The pairwise comparisons can be obtained from actual measurements such as price, weight, …etc. or subjective experts' opinions such as satisfaction, feeling, and preferences. Saaty (2008) recommended a nine-point fundamental scale to compile verbal experts' judgments to numerical judgments (shown in Table 3.1).

Table 3.1: Saaty's fundamental scale for absolute numbers

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance of one over another	Experience and judgment slightly favor one activity over another
5	Essential or strong importance	Experience and judgment strongly favor one activity over another
7	Very strong importance	An activity is strongly favored and its dominance demonstrated in practice
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between the two adjacent judgments	
Reciprocals	If activity i has one of the above numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i	
Rationals	Ratios arising from the scale	If consistency were to be forced by obtaining n numerical values to span the matrix

The pair wise comparisons between the elements/criteria in each level of the hierarchy are organized in a square matrix called pairwise comparison matrix (e.g. A) and takes the following notation:

A=

Goal	C_1	C_2	C_3	..	C_n
C_1	W_1/W_1	W_1/W_2	W_1/W_3	..	W_1/W_n
C_2	W_2/W_1	W_2/W_2	W_2/W_3	..	W_2/W_n
C_3	W_3/W_1	W_3/W_2	W_3/W_3	..	W_3/W_n
:	:	:	:	:	:
C_n	W_n/W_1	W_n/W_2	W_n/W_3	..	W_1/W_n

Each element in the matrix ($a_{ij}=w_i/w_j$) represents the ratio between the weight of the element in the left of the matrix i to the element j which located on the top. The pairwise comparisons are governed by three rules: $a_{ij}>0$, $a_{ij=1/}$ $a_{ji,}$ $a_{ij}=1$ for all i, j =1, 2,... n, where n is the number of elements. As a result, the diagonal elements in the matrix equal one, and ratios below the diagonals are the reciprocals of the ratios above the diagonals. Therefore, As well as the number of comparisons for the matrix of n^2 elements will be only $\frac{n(n-1)}{2}$.

After completing the pairwise comparison matrices for all levels of the hierarchy, ratio scales are derived in the form of priority vectors. In this operation, firstly the matrix A is normalized by adding each column and dividing each element by the summation value of the same column, then averaging across the rows to obtain the normalized principal eigenvector which is called the priority vector. The sum of all priority vector elements is equal to 1 because it is a normalized vector.

The calculated normalized eigenvector *w* is a solution for the equation $Aw = \lambda max w$, where A is the matrix that contains the original set of pairwise comparisons before normalization and λ max is the largest eigenvalue of the matrix A. For pairwise comparison matrices λ max must be approximately equal to the number of matrix elements (n), and the deviation of λ max from n is a measure of the consistency of experts' comparative judgments.

To measure the consistency AHP offers the Consistency Index (CI) which can be calculated by the subsequent formula.

$$CI= \frac{\lambda\,\max - n}{n-1} \qquad (3.3)$$

The Consistency Ratio (CR) can be found by the following equation:

$$CR=CI/RI \qquad (3.4)$$

Where RI is the Random Consistency Index (See Table 3.2). In general, it's argued that a CR of less than 0.01 is acceptable. Otherwise, the evaluations should be improved

Table 3.2: Average Random Consistency Index (RI) (Saaty, 1994).

Number of elements (n)	1	2	3	4	5	6	7	8	9
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45

Step three: synthesizing priorities

After making the pairwise comparisons and performing the consistency check for all comparison matrices, the next step is to find the global or overall priority of the decision alternatives. Each criterion and sub-criteria in the hierarchy has both local (immediate) and global (final) priority. The global priority of sub-criteria can be found by multiplying the local weights of sub-criteria with their parent criteria weight. As well as, the global priorities of the decision alternatives are obtained by adding the results of multiplying each criterion weight with respect to the overall goal (Saaty,2008).

3.4.6.4 Hospitals evaluation

A total number of 28 hospitals were evaluated using the evaluation form (Refer to Appendix D), the data in the form which considered as quantitative were analyzed using the SPSS V.23 program. Descriptive statistical analysis was performed and included the followings:

- Frequencies, percentages, means, and standard deviations analysis to summarize the hospitals' demographic data.
- Means, and standard deviations analysis for all the assessment indicators, categories, and areas scores.
- Calculation for deriving the weighted score for indicators, categories, areas and overall sustainability score.
- Calculations to derive the hospitals' overall score.

- The study proposed the Importance Factor (IF), and can be calculated by dividing each indicator weight by its score by the following equation.

$$\text{Importance Factor (IF)} = \frac{Indicator\ Weight\ (IW)}{Indicator\ Score\ (IS)} \qquad (3.5)$$

The IF value reflects the priority of the sustainable strategies that hospitals have to adopt so as to improve their sustainability. The lower the indicator score and the higher the weight, the higher the IF value will receive. That is, the improvement starts for the indicators with the higher IF values.

- One- way ANOVA test, Independent – Samples T-Test, and Pearson correlation test were performed to test the study hypotheses.

3.5 Summary:

The study adopted the mixed methods approach in which qualitative and quantitative data were collected, analyzed, and interpreted. The methodology adopted to achieve the study's objectives comprised of five steps to achieve the study objectives. These steps started in establishing the first draft of the assessment items. Then, the assessment items were refined and weighted based on experts' experiences according to their relevance to assess and improve hospital's sustainability in the WB. After that, the tool (which is called HSAtool-WB) was formulated in its final form. The final step of this study was applying HSAtool-WB to assess and improve the hospitals' sustainability in WB.

Chapter Four

Results Analysis and Discussion

Chapter Four

Results Analysis and Discussion

4.1 Overview

This chapter analyzes and discusses the results of the qualitative and quantitative collected data. It comprises of three sections; the first section presents the results of establishing comprehensive SA items to assess hospitals in the WB region. In the second section, the chapter presents the results of weighting the assessment items according to their importance to the local WB context. In addition, the formulation of the HSAtool-WB in its final form was also presented.

In the third section, the chapter deeply discusses the results of applying the HSAtool-WB tool in WB context. This included discussing the descriptive statistics tests which were performed on the collected hospitals' data. Moreover, the results of the study hypotheses tests are also presented.

4.2 HSAtool-WB assessment items:

4.2.1 The first set of HSAtool-WB assessment items:

The first set of the HSAtool-WB items were established. It consists of three assessment areas at the top level, 11 categories at the middle level, and 59 indicators at the lowest level. This was conducted based on reviewing the well-known SA tools, studying the literature which is most relevant to the subject of this study; the first set of HSAtool-WB assessment items is illustrated in Appendix A. After that, the initial list was initially refined based on the expert recommendations through open-meeting discussions. For example, the category (Materials and Waste) was split into two categories (Waste management and Materials). Moreover, some indicator were excluded because either they were not relevant to the WB context such as Cycling routes , or they are hard to be applied in operative hospitals system such as Recycled materials indicator. After that, the resulted HSAtool-WB comprised of three organized assessment areas. These areas are subdivided into 12 categories, which in turn included a number of 50 assessment indicators.

4.2.1.1 HSAtool-WB areas

Sustainability has three dimensions; environmental, economic, and social. These dimensions must be included in any SA tool. Therefore, the proposed set of assessment items covered the abovementioned dimensions. The environmental area relates mainly to energy, water, waste, site, and other issues. Managerial, clinical, and technological factors are addressed by the economic area. Finally, the social area deals with themes like comfort, space flexibility, and health and wellbeing.

4.2.1.2 HSAtool-WB categories

HSAtool-WB includes 12 categories. These categories cover the three sustainability areas. Water efficiency, energy efficiency, waste management, site and location quality, materials, and pollution and risks define hospital environmental sustainability. The economic sustainability of the hospital can be addressed by including management performance, clinical performance, and technological performance. The social areas defined by health and wellbeing, space flexibility and adaptability, and comfort.

The following lines discuss the definitions of all HSAtool-WB categories:

- **Water efficiency:**

Water issues are important in WB as it lacks water resources. This category evaluates the hospital water performance in term of strategies and procedures used to rationalize water consumption.

- **Energy efficiency :**

Energy efficiency is considered as one of the main assessment categories that should be included in all SA tools. The hospital energy performance will be evaluated in this category. It is done by evaluating the installation of effective energy systems, exploitation of renewable energy sources, and the adoption of energy monitoring and management strategies.

- **Site and location quality:**

The hospital building is not separated from its surrounding site. A sustainable hospital plays a vital environmental role in the site through minimizing the ecological impact which might happen when applying various operations and maximizing the quality of its outdoor spaces. In addition, this category considers important issues such as the hospital's accessibility, using hybrid cars, and recharge of groundwater.

- **Waste management:**

This category considers issues related to how hospitals manage different waste types (hazardous and non-hazardous).

- **Materials:**

Hospitals use a variety of material that may negatively affect human health and environment. Materials category aims to evaluate how hospitals select, purchase, and use all materials.

- **Pollution and risks:**

Emissions reduction strategies are a major characteristic of a sustainable hospital. This category considers issues related to pollution management, greenhouse, refrigerant, and night light time pollutions.

- **Management :**

A core assessment category is the management category which evaluates the strategies and actions adopted by hospitals to manage staff issues, processes, and technologies.

- **Clinical performance :**

This category evaluates hospital performance in term of adopted strategies to prevent clinical risks. This includes infection control procedures and drugs management systems.

- **Technological performance**

Medical technologies are accelerating dramatically, and information systems play major roles in managing hospital matters. This category evaluates the hospital medical technologies and how the hospital harness information technology in management.

- **Health and well-being:**

It is important to provide an internal hospitals environment in which users feel safe and healthy. This category evaluates issues related to these issues such as safety, security, well-being, and social aspects.

- **Space flexibility and adaptability:**

This category evaluates the hospital ability to extend horizontally or vertically, and whether the internal paths, offices, departments are distributed in a way that enhances resources optimization and allows the users to move easily inside the hospital wards.

- **Comfort :**

The hospital's internal environment must provide the users with an acceptable level of thermal, lighting, visual, and acoustic comfort. The comfort category evaluates the hospital's adopted strategies to keep the internal environment comfortable.

4.2.1.3 HSAtool-WB indicators:

HSAtool-WB includes 50 indicators. As noted above, these 50 indicators belong to 12 categories. These indicators and their definitions are presented in Table 4.1.

Table 4.1: HSAtool-WB indicators and definitions.

Environmental Area	
Water efficiency	
Indicator	**Definition**
1- Gray water recycling	Identifies recycling of gray water (water of showers, washing machines, and hand washing basins) for irrigation the plants and flushing in WC's.
2- Rain water harvesting	Inspects whether the hospital is collecting rain water or not
3- Efficient water appliances and plumbing fixtures	Identifies installing efficient water equipment such as (Low flush WC's, flow control and self closing hand washing basins, and water saving shower heads)
4 -Water monitoring system	Evaluates water monitoring system in term of water consumption monitoring system, leak detection, quality control, and isolation valves.
5- Water strategy	Evaluates the adoption of a documented water strategy
6- Landscape Irrigation system	Evaluates the Effectiveness of Landscape Irrigation system (using drip irrigation and moisture sensors systems)
Energy efficiency	
7- Building Envelop Performance	Evaluates the building envelop performance in term of adequate insulation, low air leakage, and moisture penetration
8- Energy consumption monitoring and management system	Evaluates the effectiveness of the energy management system in term of energy consumption monitoring, and energy consumption data use
9- Energy sub-metering system	Identifies the use of sub-metering for main energy sources
10- Renewable energy sources	Evaluates the effectiveness of the adopted strategies to exploit renewable energy sources (converting solar and wind energy to electricity)
11-Efficient Heating, ventilation and air conditioning (HVAC) system	Evaluates the HVAC system in term of type, design, and efficiency.
12- Lighting system	Evaluates the efficiency lighting system in term of type, integrated lighting concept, and auto-sensored lighting system
13-Hot water distribution system	Evaluates the status of the hot water distribution system with respect to generation, distribution, and fuel type.
14-Green appliances	Identifies the use of green refrigerators, washing machines, dryers, etc
Site and location quality	
15- Ecological protection of the site	Expresses the level of protection of the natural environment surrounding the hospital
16-Heat island effect	Evaluates hospital's attention toward Heat island effect decrease through installing green roofs and cool pavement technologies such as grasp paving

17- Recharge of groundwater	Identify the hospital's adopted strategies to recharge of groundwater through permeable paving or landscaping
18- Transportation and accessibility	Evaluates hospital's accessibility in term of access to public transportation, distance to amenities, paths to access the hospital
19- high quality outdoor spaces	Expresses the quality level of outdoor spaces (gardens, paths, plants, setting places, etc)
20-Hybrid cars and sharing	Identifies the use of hybrid cars (electric cars), and the adoption car sharing strategy
Waste management	
21-Waste management system	Evaluates how waste management strategies are aligned with waste hierarchy (3R's: reduce, reuse, and recycle)
22-Waste separation and storage	Evaluates the procedures that are adopted to separate and storage hazardous medical waste
Materials	
23-Low environment impact materials	Expresses the attention toward reducing environmental impact by the use of low impact materials in (paints, roofing, walls and floors, detergents ...etc)
24-durable Materials	Identifies the use of high strength materials that require less maintenance
25-Materials Reuse	Identifies if the hospital reuses of components and materials
Pollution and risks	
26-Greenhouse gas emissions	Identify the adopted strategies to mitigate green house gas emissions from all energy sources used in hospital operations and in transports (CO2 mitigation strategy...)
27-Night time light pollution	Evaluate the procedures token to reduce internal and external night time light pollution.
28-Pollution management	Evaluates the Adoption of pollution response plan
29-Refrigerant	Identifies if the hospital adopt strategies to reduce refrigerants environmental impact
Management	
30-Process efficiency	Evaluates the management of the processes to increase process added values (increasing the service efficiency and effectiveness).
31-Staff qualification and education	Evaluate the adopting a clear staffing plan to recruit, develop, and sustain the staff. And encourage opportunities to learn and exchange experiences
32Technology assessment	Evaluates the presence of multidisciplinary team to evaluate medical technology to improve service quality, and optimize resources allocations
Clinical performance	
33- Infection control	Evaluates the presence of infection prevention protocols, and Risk assessment
34- Drugs administration system	Looks at the adoption of an effective drugs administration system to prevent risks related drugs misuse
Technological performance	
35- Information and communication technologies (ICT)	Evaluates the level of Using Electronic Health Record (EHR),and online access to clinical tests' results

36-Medical technology obsolescence	Evaluates the medical equipment age and replacement process
Health and well-being	
37- Hazardous materials	Expresses the level of attention toward hazardous substances in adhesives and sealants, Paints and coatings, Formaldehyde reduction, Carpet and hard flooring, Ceiling systems
38-Security/Safety	Evaluates the level of security control (perceived security with regards to theft, perceived personal safety), and trust in hospital services
39-Health promotion	Evaluates the presence of health promotion actions such as prevention and promotion campaigns, and using of natural and non-toxic materials
40-Well-being	Expresses the level of well-being (colors, materials, artificial and natural lighting, furniture quality , clear signals and paths , activities/facilities for staff and patients/ visitors: sport, culture, restaurant areas, WI-FI areas, etc., quality of green areas and outside views)
41- Social aspects	Evaluate the presence of discriminatory behaviour, spaces for meetings, hospitality to patients' relatives, collaboration between hospital staff
Space flexibility and adaptability	
42- Space flexibility	Evaluates the ability of Horizontal or vertical expansion. The presence of free spaces(soft spaces), rooms for future use, and modular furniture
43- Blocks Distribution	Evaluates the internal distribution in term blocks typology, and distance between the patients rooms and main vertical connections
44-Departments	Looks at how the departments are distributed , and the presence of relax areas
45-Paths	Evaluates the efficiency of paths in term of suitable width, separation to enhance access of hospital wards
Comfort	
46- Thermal comfort	Evaluates the users' thermal comfort in term of indoor temperature, relative humidity, room temperature control, humidity control
47-Indoor air quality	Evaluates the strategies that are adopted to CO_2,CO,NO monitoring, low or zero gassing interior finishing materials, Smoking control, Volatile organic compounds(VOCs)
48- Lighting comfort	Evaluates the quality of lighting in term of good daylight distribution, lighting controllability, glare control, illuminance levels.
49-Visual comfort	Evaluate the level of aesthetic impact, access to views, visual privacy from the exterior, and access to sunlight
50- Acoustic comfort	Evaluates the internal noise levels and provide appropriate acoustic comfort

4.2.2 HSAtool-WB applicable items

The structured interviews (questionnaire) aimed at determining the applicable and the most relevant assessment items with respect to the local context of the WB. This was done by calculating mean and RII for all HSAtool-WB items. The equation (3.2) was used to calculate the RII for all the assessment items. The results show that all the assessment items scored an RII value above 60%. This means that all the proposed items are important to assess the sustainability of the Palestinian hospitals in the WB. The following lines include detailed discussions of these results.

4.2.2.1 Demographic characteristics of the respondents

Table 4.2 summarizes the demographic characteristics of the respondents who filled the questionnaire that aimed to determine the most relevant assessment items with respect to the local context of the WB, (See Appendix B).

Table 4.2: Demographic characteristics of respondents.

variable	number	Percent (%)
Gender		
Male	35	58.3
Female	25	41.7
Profession		
Architect	14	23.3
Engineer	21	35.0
Designer	5	8.3
Manager	17	28.3
Planner	3	5.0
Type of orgnization		
Construction company	12	20.0
Hospital	23	38.3
Government Agency	6	10.0
Education	13	21.7
Design Consultancy	6	10.0
Years of experience		
Less than 5	4	6.7
5-10 years	21	35.0
More than 10 years	35	58.3
Highest Level of education		
Bsc	25	41.7
Msc	14	23.3
PhD	21	35.0

4.2.2.2 Questionnaire reliability test

Table 4.3 presents the Cronbach's alpha test's results. The results indicate that the questionnaire was reliable as the values for all the paragraphs of the questionnaire were above 70% and the overall Cronbach's alpha was .896 which is also above 70%.

Table 4.3: Cronbach's alpha coefficient for the reliability of Questionnaire A.

Category	Number of items	Cronbach's Alpha
Water efficiency	6	.821
Energy efficiency	8	.713
Site and Location quality	6	.790
Waste management	2	.738
Materials	3	.715
Pollution and Risks	4	.777
Management	3	.730
Clinical performance	2	.759
Technological performance	2	.786
Health and well-being	5	.733
Space flexibility and adaptability	4	.812
Comfort	5	.743
All items	**51**	**.896**

4.2.2.3 HSAtool-WB applicable areas

It is clear that all of the three assessment areas are important and should be included in the assessment tool. Results showed that the environmental area is the most important area. The economic area comes in second place with a slight difference. Finally, the social area is the least important area, (See Table 4.4).

Table 4.4: Mean and RII of assessment areas

Assessment area	Mean	RII
Environmental	4.87	0.97
Economic	4.82	0.96
Social	4.47	0.89

4.2.2.4 HSAtool-WB applicable categories

Results reveal that with respect to the environmental area the energy efficiency and water efficiency are the most important categories which seem rational according to the Palestinian context. Subsequently, waste management and risk and pollution are almost at the same level. Finally, the site and location quality category has the least importance among other environmental categories. Regarding economic area, management, clinical performance, and technological performance categories must be included in the assessment items. Concerning social area categories, the health and well-being and comfort are more important than space flexibility and adaptability indicator. (As illustrated in Table 4.5)

Table 4.5: Mean and RII of assessment categories

Assessment categories	Mean	RII
Water efficiency	4.62	0.92
Energy efficiency	4.88	0.98
Site and Location quality	3.92	0.78
Waste management	4.30	0.86
Materials	4.05	0.81
Pollution and Risks	4.27	0.85
Management	4.65	0.93
Clinical performance	4.60	0.92
Technological performance	4.57	0.91
Health and well-being	4.35	0.87
Space flexibility and adaptability	3.95	0.79
Comfort	4.20	0.84

4.2.2.5 HSAtool-WB applicable indicators

- **Water efficiency**

It is clear from (Table 4.6) that using efficient water appliances, adopting a water conservation strategy and water monitoring system are extremely important for hospital sustainability in WB. Moreover, rain water harvesting, recycling of gray water, and using effective land irrigation system are viable ways to reduce potable water consumption.

Table 4.6: Mean and RII of water efficiency indicators

Water efficiency	Mean	RII
Gray water recycling	3.45	.69
Rain water harvesting	3.60	.72
Efficient water appliances and plumbing fixtures	4.45	.89
Water monitoring	4.38	.88
Water conservation strategy	4.15	.83
Landscape Irrigation system	3.32	.66

- **Energy efficiency**

The energy efficiency includes 8 indicators (as shown in Table 4.7). Using renewable energy sources is the most important factor, while energy sub-metering is the least important one.

Table 4.7: Mean and RII of energy efficiency indicators

Energy efficiency	Mean	RII
Building Envelop Performance	4.48	.90
Energy monitoring and management	4.47	.89
Energy sub-metering system	3.45	.69
Renewable energy	4.70	.94
HVAC system	4.62	.92
Lighting efficiency	4.37	.87
Hot water distribution system	4.53	.91
Green appliances	4.40	.88

- **Site and location quality**

A total of 7 indicators (Table 4.8) for site and location quality were revised and rated. Transportation and accessibility to the hospital was the most important consideration. In addition, ecological protection of the site, high quality outdoor spaces, and car sharing methods were also considered as important for evaluating hospital sustainability. Finally, heat island effect and recharge of ground water were given almost the same level of importance

Table 4.8: Mean and RII of Site and location Quality indicators

Site and location Quality	Mean	RII
Ecological protection of the site	3.57	.71
Heat island effect	3.32	.66
Recharge of groundwater	3.30	.66
Transportation and accessibility	4.10	.82
Outdoor Spaces quality	3.62	.72
Hybrid cars and sharing	3.50	.70

- **Waste management**

Hospitals produce many types of waste including hazardous and non- hazardous waste. Waste separation and storage was rated as the most important indicator, and then came the waste management system (See table 4.9)

Table 4.9: Mean and RII of waste management indicators

Waste Management	Mean	RII
Waste management system	4.40	.88
Waste separation and storage	4.52	.90

- **Materials**

Respondents argued that the three proposed indicators of materials category are all important (Table 4.10). The most important one was using durable materials. In addition, low environmental impact materials and materials reuse were also considered important for evaluating hospital sustainability.

Table 4.10: Mean and RII of waste management indicators

Materials	Mean	RII
Low environment impact materials	4.55	.91
Materials durability	4.60	.92
Materials Reuse	3.32	.66

- **Pollution and risks**

It is clear that the 4 indicators related to pollution and risks (Table 4.11) were all rated as being moderately important while pollution management is a core consideration.

Table 4.11: Mean and RII of pollution and risks indicators.

Pollution and Risks	Mean	RII
Greenhouse Gas Emissions	3.90	.78
Night time light pollution	3.90	.78
Pollution management	4.12	.82
Refrigerant	3.83	.77

- **Management**

Table 4.12 shows that all the management indicators process efficiency, staff qualification and education, technology assessment were rated as very important in order to provide sustainable high quality effective and efficient healthcare services in WB hospitals

Table 4.12: Mean and RII of management indicators.

Management	Mean	RII
Process efficiency	4.38	.88
Staff qualification and education	4.58	.92
Technology assessment	4.63	.93

- **Clinical performance**

The clinical performance requires the evaluation of protocols adopted by the hospital to reduce and prevent the clinical risks and adverse drugs events which have a strong impact on patients' health and hospital's reputation (See Table 4.13).

Table 4.13: Mean and RII of clinical performance indicators.

Clinical performance	Mean	RII
Infection control	4.73	.95
Drugs administration system	4.67	.93

- **Technological performance**

The medical sector is witnessing a rapid acceleration in the field of technology, especially in the field of medical equipment and ICT. The medical technology obsolescence and ICT indicators are both important to evaluate the hospital's biomedical technologies and to what extent the hospital uses ICT respectively. (See Table 4.14)

Table 4.14: Mean and RII of technological performance indicators.

Technological performance	Mean	RII
Information systems	4.37	.87
Medical technology obsolescence	4.48	.90

- **Health and well-being**

Table 4.15 shows that all health and well-being indicators are important. The most important two indicators are hazardous materials and security/safety indicators.

Table 4.15: Mean and RII of Health and well-being indicators

Health and well-being	Mean	RII
Hazardous materials	4.67	.93
Security/Safety	4.33	.87
Health promotion	3.70	.74
Well-being	3.78	.76
Social aspects	3.83	.77

- **Space flexibility and adaptability**

A total of 4 indicators (Table 4.16) for Space flexibility and adaptability category were rated by respondents, the most important indicator was the one which evaluates the hospital to change its functions with the lowest possible resources, as well as the possibility of horizontal and vertical expansion in the structure. Subsequently, paths, departments, block distribution are almost at the same level.

Table 4.16: Mean and RII of Space flexibility and adaptability indicators

Space flexibility and adaptability	Mean	RII
Space flexibility	4.42	.88
Blocks Distribution	3.83	.77
Departments	3.77	.75
Paths	3.9	.78

- **Comfort**

Comfort is an important consideration in the hospital environment. Therefore a total of 5 indicators shown in (Table 4.17) were proposed by this study. These indicators will evaluate to which extent the hospital's users are feeling comfortable in terms of interior building temperature, lighting, acoustic and aesthetic comfort, as well as the indoor air quality.

Table 4.17: Mean and RII of comfort indicators

Comfort	Mean	RII
Thermal comfort	4.33	.87
Indoor air quality	4.28	.86
Lighting comfort	4.17	.83
Visual comfort	3.8	.76
Acoustic comfort	3.9	.78

4.2.3 Summary

After reviewing the literature, exploring the international SA tool, highlighting the local Palestinian context, conducting open meeting discussions with experts, and conducting interviews; it is possible to suggest a comprehensive set of assessment items for HSAtool-WB. This tool with the hierarchic structure includes three assessment areas which include 12 categories. Each category includes many indicators. Table 4.18 presents HSAtool-WB areas, categories, and indicators.

Table 4.18: HSAtool-WB applicable areas, categories, and indicators

Areas	Categories	indicators
A1 Environmental Area	**C1** Water efficiency	**I1** Gray water recycling
		I2 Rain water harvesting
		I3 Efficient Water appliances and plumbing fixtures
		I4 Water monitoring system
		I5 Water strategy
		I6 Landscape Irrigation system
	C2 Energy efficiency	**I7** Building Envelop Performance
		I8 Energy consumption monitoring and management system
		I9 Energy sub-metering system
		I10 Renewable energy sources
		I11 Efficient Heating, ventilation and air conditioning (HVAC) system
		I12 Lighting system
		I13 Hot water distribution system
		I14 Green appliances
	C3 Site and location Quality	**I15** Ecological protection of the site
		I16 Heat island effect
		I17 Recharge of groundwater
		I18 Transportation and accessibility
		I19 high quality Outdoor Spaces
		I20 Hybrid cars and sharing
	C4 Waste Management	**I21** Waste management system
		I22 Waste separation and storage
	C5 Materials	**I23** Low environment impact materials
		I24 durable Materials
		I25 Materials Reuse
	C6 Pollution and Risks	**I26** Greenhouse Gas Emissions
		I27 Night time light pollution
		I28 Pollution management
		I29 Refrigerant
A2 Economic area	**C7** Management	**I30**Process efficiency
		I31 Staff qualification and education
		I32 Technology assessment
	C8 Clinical performance	**I33** Infection control
		I34 Drugs administration system

	C9 Technological performance	**I35**Information and communication technologies (ICT)
		I36 Medical technology obsolescence
A3 Social area	**C10** Health and well-being	**I37**Hazardous materials
		I38 Security/Safety
		I39 Health promotion
		I40 Well-being
		I41 Social aspects
	C11 Space flexibility and adaptability	**I42** Space flexibility
		I43 Blocks Distribution
		I44 Departments
		I45 Paths
	C12 Comfort	**I46** Thermal comfort
		I47 Indoor air quality
		I48 Lighting comfort
		I49 Visual comfort
		I50 Acoustic comfort

4.3 Weighting of HSAtool-WB Items:

A pairwise comparison approach was adopted to develop a weighting system for the HSAtool-WB. Moreover, the AHP method was used to identify the HSAtool-WB items weights. It used a hierarchical structure under the headline of hospital sustainability. It consists of assessment

areas at the top level, categories of each area at the middle level, and indicators of each category at the lowest level (Figure 4.1). This method was applied using the computer by Expert Choice Software. (Ali and Al Nsairat, 2009; Alyami 2015).

Thirty experts from government, academia, industry, and healthcare were interviewed and asked to conduct the pairwise comparisons using the AHP questionnaire (See Appendix C). The results of weighting are introduced in figures for each level of the hierarchy in the following parts.

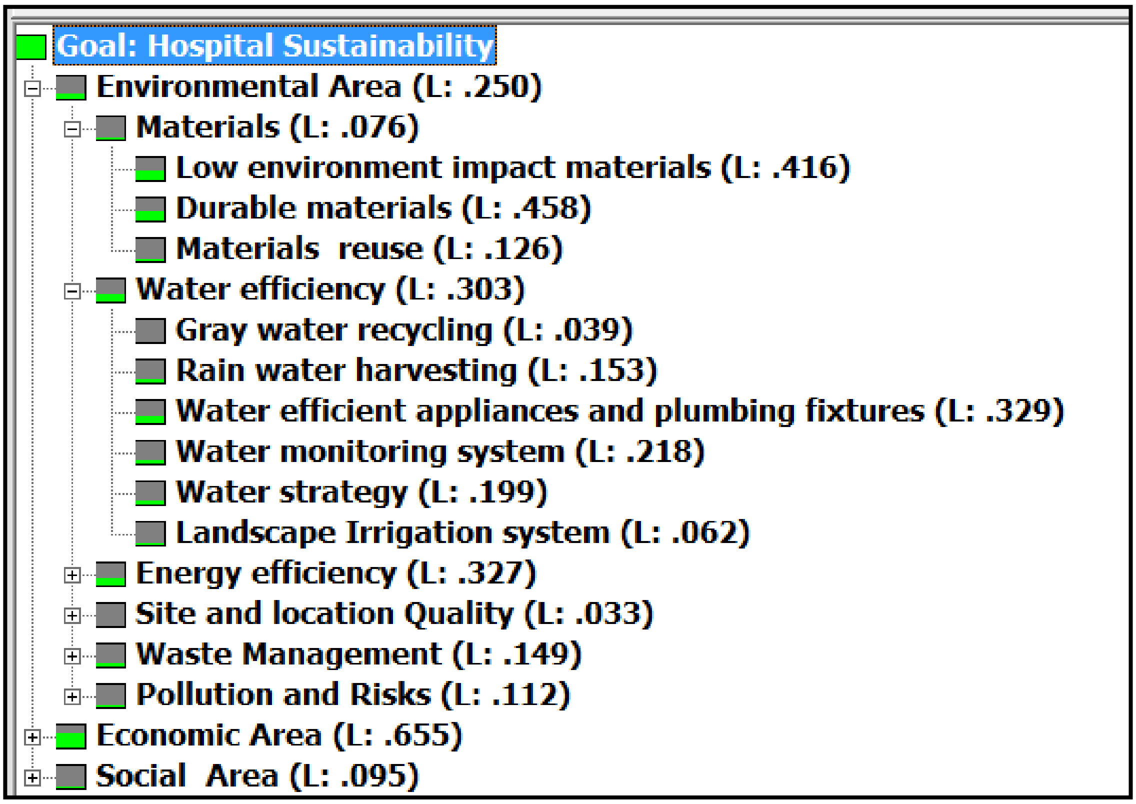

Figure 4.1: Weighting of HSAtool-WB Items using the expert choice software

4.3.1 Weightings of HSAtool-WB areas– 1st Level

Regarding the results of the interviews and by using the Expert Choice Software to calculate the weightings of the assessment items (As illustrated in Figure 4.2), the economic area ranked as the most important assessment area and represents about 49% of the total certification. Then environmental area came in second place with about 31%. Finally, the social area received the lowest importance with about 20%, (As shown in Figure 4.3).

It should be emphasized that economic issues are more important than environmental concerns in developing countries. (Ali & Al Nsairat, 2009; Alyami et al., 2015), In addition, an operative hospital particularly, economic issues is more crucial than social and environmental issues.(Blotter et al., 2015)

	Environmental Area	Economic Area	Social Area
Environmental Area		2.0	2.0
Economic Area			2.0
Social Area	Incon: 0.05		

Figure 4.2: Pairwise Comparison of HSAtool-WB areas with respect to the goal Hospital Sustainability

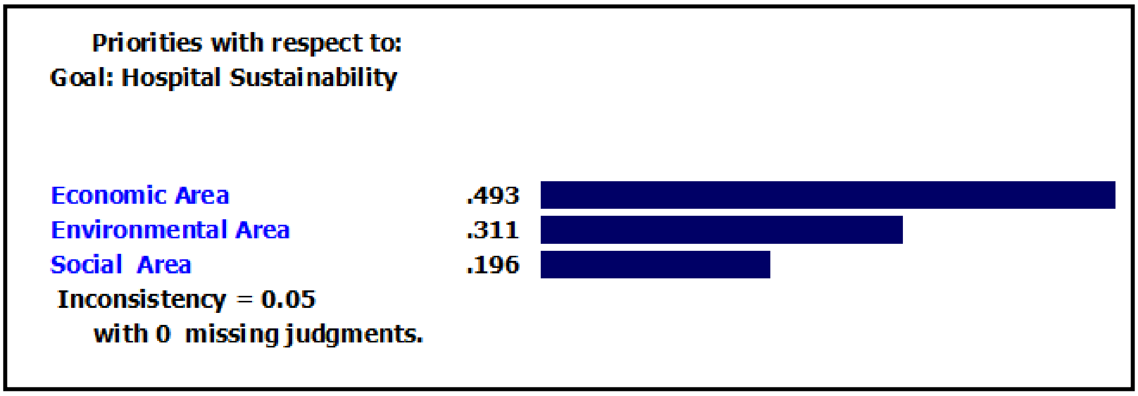

Figure 4.3: Priorities of HSAtool-WB areas with respect to the goal- Hospital Sustainability

4.3.2 Weightings of HSAtool-WB categories – 2nd Level

- **Environmental area categories:**

When analyzing Figure 4.4; it is possible to conclude that the energy efficiency and water efficiency categories represent the highest priority categories for Palestinian sustainable hospital assessment at 33% and 30%, respectively. It is worth mentioning that the results show a great similarity with previous studies conducted in developing countries in the field of sustainability assessment, as these studies gave the water category and energy category the highest weight (Ali & Al Nsairat, 2009; Alyami et al., 2015; Banani et al.,2016).

Then, the waste management came in second place with 15%, followed by pollution and risks, and materials with 11%, and 8%, respectively. Finally, the site and location quality came with the lowest priority of 3%.

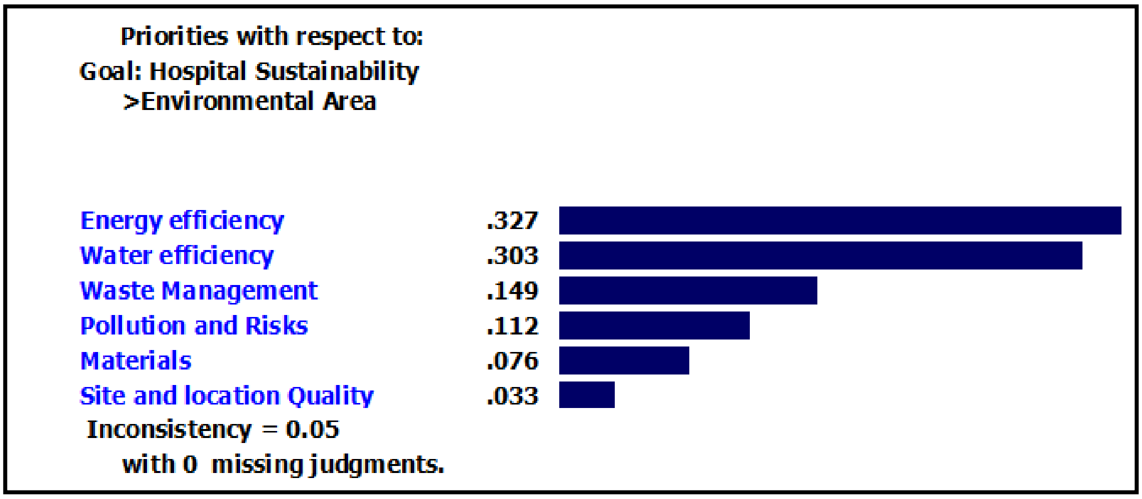

Figure 4.4: Priorities of HSAtool-WB environmental categories

- **Economic area categories:**

From the analysis of Figure 4.5, it is obvious that the management category received the highest importance among other categories with 44%. Then Clinical performance came in second place with 39%, followed by Technological performance with 17%.

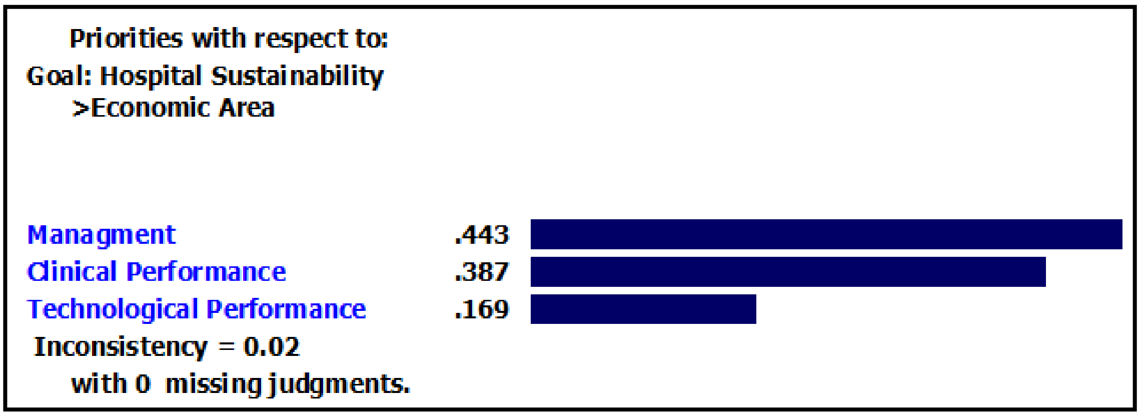

Figure 4.5: Priorities of HSAtool-WB economic categories

- **social area categories:**

In Figure 4.6, Health and well-being and space flexibility and adaptability have similar weights, with a slight difference between them (about 3%). Meanwhile, Comfort received the lowest weight.

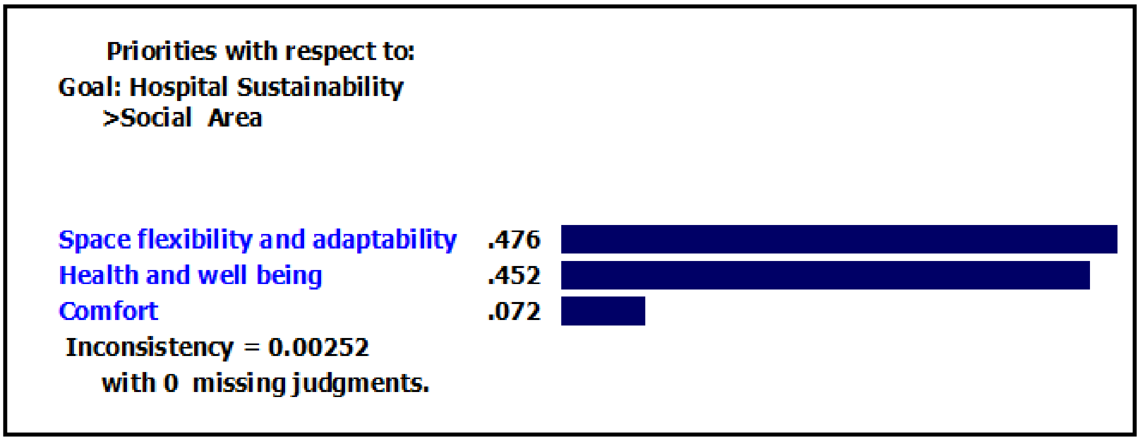

Figure 4.6: Priorities of HSAtool-WB social categories

4.3.3 Weightings of HSAtool-WB indicators – 3rd Level

In this part the weights of each category indicators are presented in details.

- **Water efficiency indicators weighting:**

It is clear according to Figure 4.7, that the results of the pairwise comparison between water efficiency indicators led to assign the efficient water appliances and plumbing fixtures the top priority with about one-third of the total weight (33%). In the next position water monitoring system, water strategy and rain water harvesting came with 22%, 20%, and 15% respectively. The rest of the weight was divided by 6% and 4% for landscape irrigation system, and gray water recycling indicators respectively.

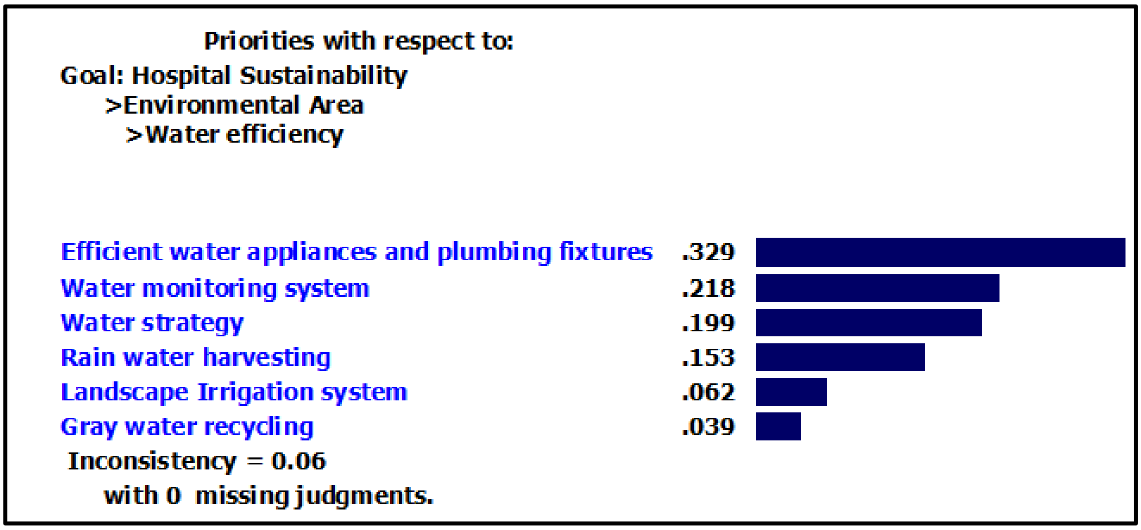

Figure 4.7: Priorities o water efficiency indicators

- **Energy efficiency indicators weighting:**

It should be recalled that the energy efficiency category received the highest priority. Figure 4.8 shows the weighting of indicators for this category, where energy consumption monitoring and management system obtained the highest weight and reached about 29% of the total weight. Then, HVAC system indicators came in second place with a priority of

21%, followed immediately and with a slight difference by renewable energy sources indicator which amounted to 20%. With respect to hot water distribution system indicator; its weight was 12.5%. The remaining of the total weight was assigned to the lighting system, green appliances, energy sub-metering system, and building envelope performance by 9.5%, 4%, 3%, 2%, and 2% respectively.

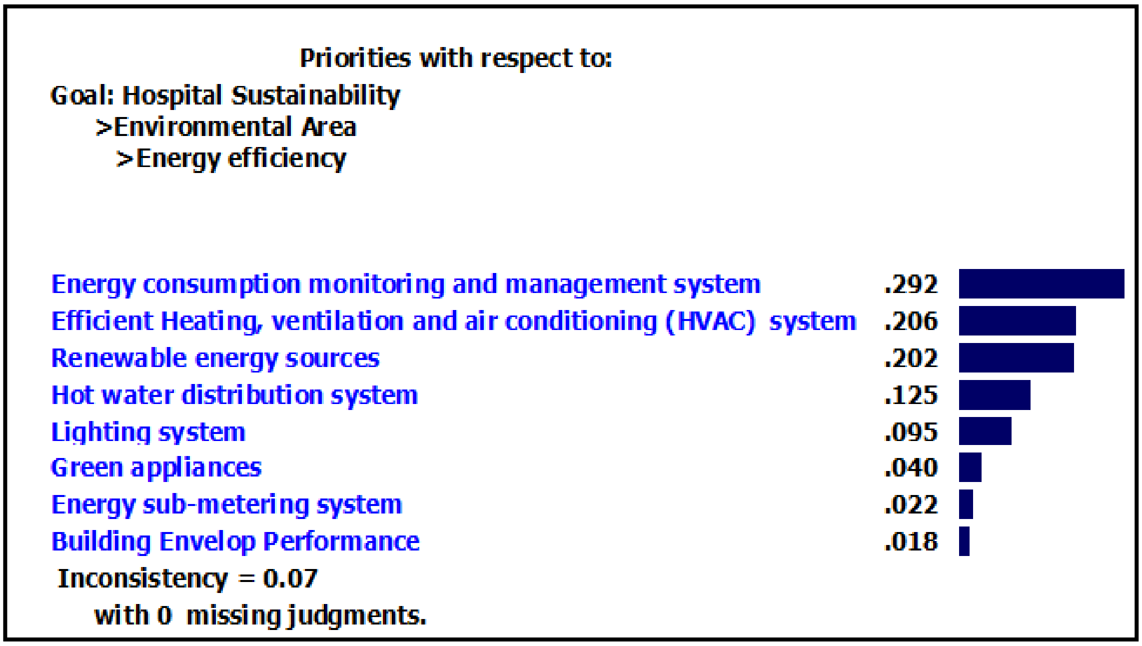

Figure 4.8: Priorities of energy efficiency indicators

- **Site and location quality indicators weighting:**

In Figure 4.9, transport and accessibility obtained the highest priority among other indicators with 57%. The ecological protection of the site and car sharing indicators obtained nearly the same weight but with a very slight difference, and their weights were 13.5% and 13%, respectively. While the remaining fraction of the weight was divided for the recharge of ground water, high quality outdoor spaces and heat island effect indicators by 9%, 4%, and 4% respectively.

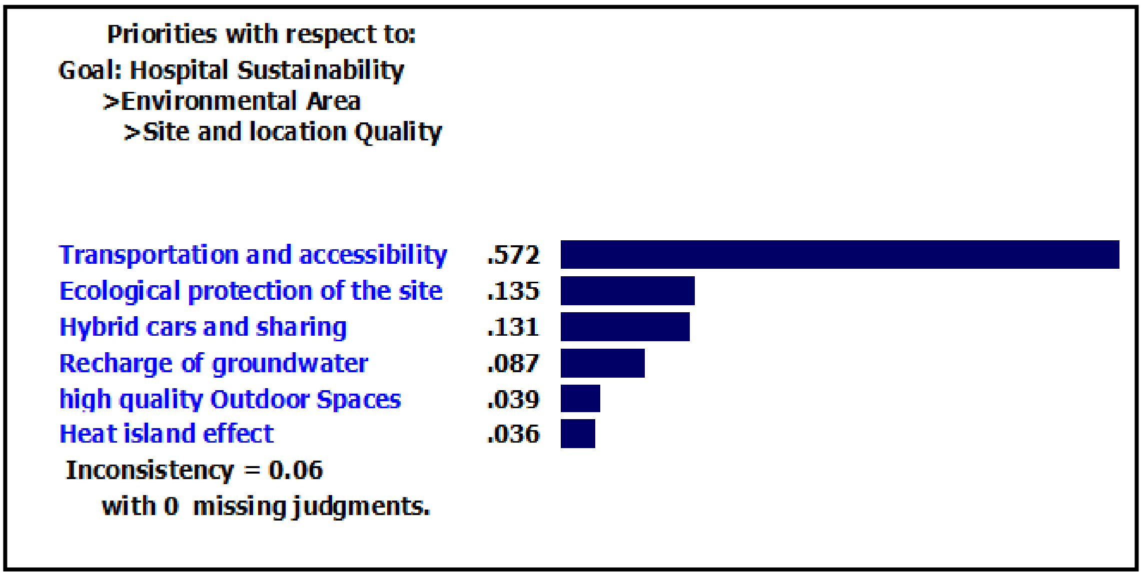

Figure 4.9: Priorities of site quality indicators

- **Waste management indicators:**

Figure 4.10 illustrates that waste management system indicator received the equivalent of three-quarters of the total weight by 75%, while waste management and storage obtained 25%.

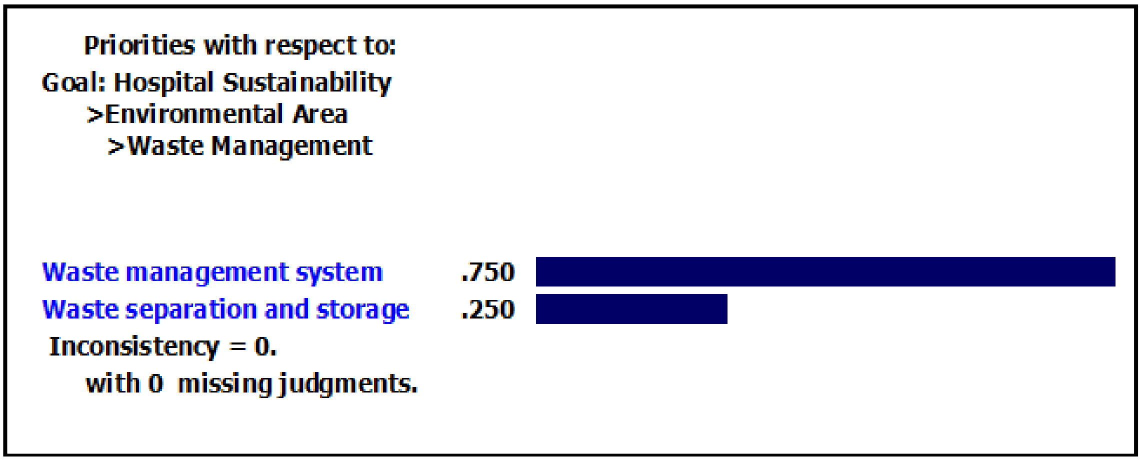

Figure 4.10: Priorities of waste management indicators.

- **Materials indicators:**

Figure 4.11 shows that low environmental impact materials indicator obtained the highest priority among other indicators with 46%. Then came the durable materials indicator in the second order and received a priority value of 42%. Meanwhile, material reuse indicator achieved only 12 %.

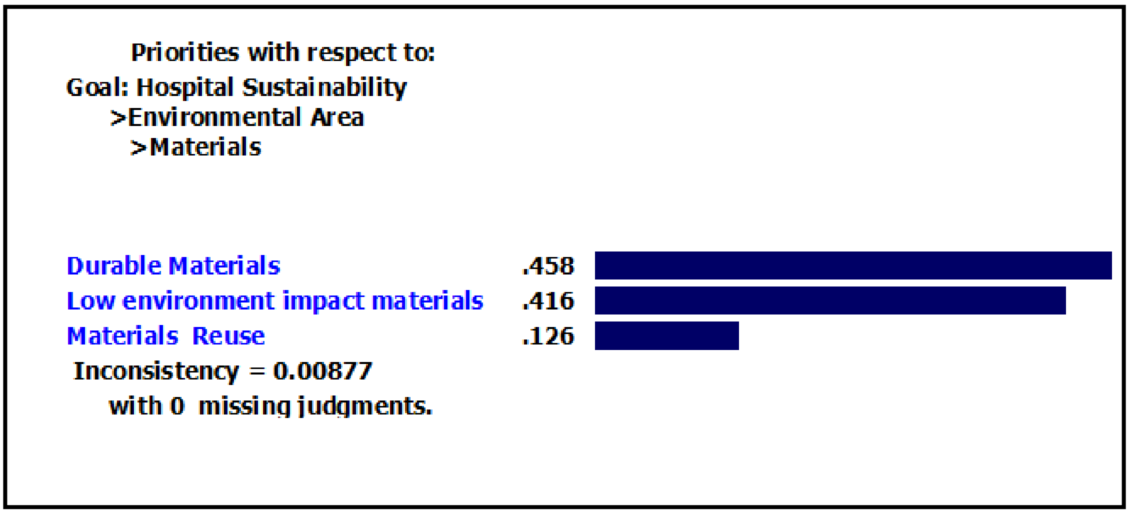

Figure 4.11: Priorities of materials indicators.

- **Pollution and risks indicators weighting :**

According to Figure 4.12, green house gas emissions and pollution management indicators were clearly rated as the most important by 32% and 31%, respectively. Followed by refrigerant indicator with a priority reached to 29%. Finally , night time light pollution rated as the least important indicator with a weight of 8%.

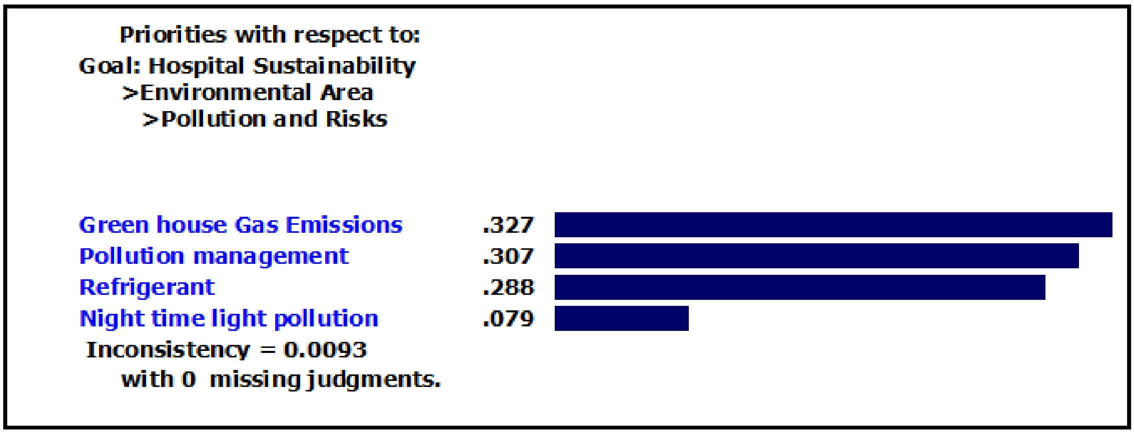

Figure 4.12: Priorities of pollution and risks indicators

- **Management indicators weighting:**

Analyzing Figure 4.13, it is possible to conclude that staff qualification and education has the highest importance with 41%, next technology assessment came with a priority of 33%.

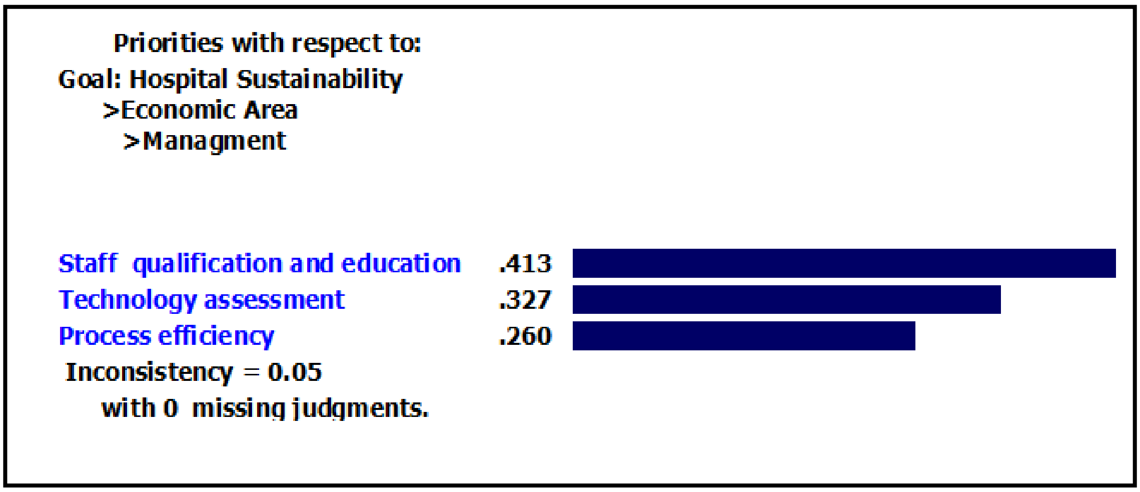

Figure 4.13: Priorities of management indicators

- **Clinical performance indicators weighting:**

It is clear that infection control indicator is more important than drugs administration system indicator, where infection control was received a priority of 67%, whereas drugs administration system obtained 33% of the total weight.

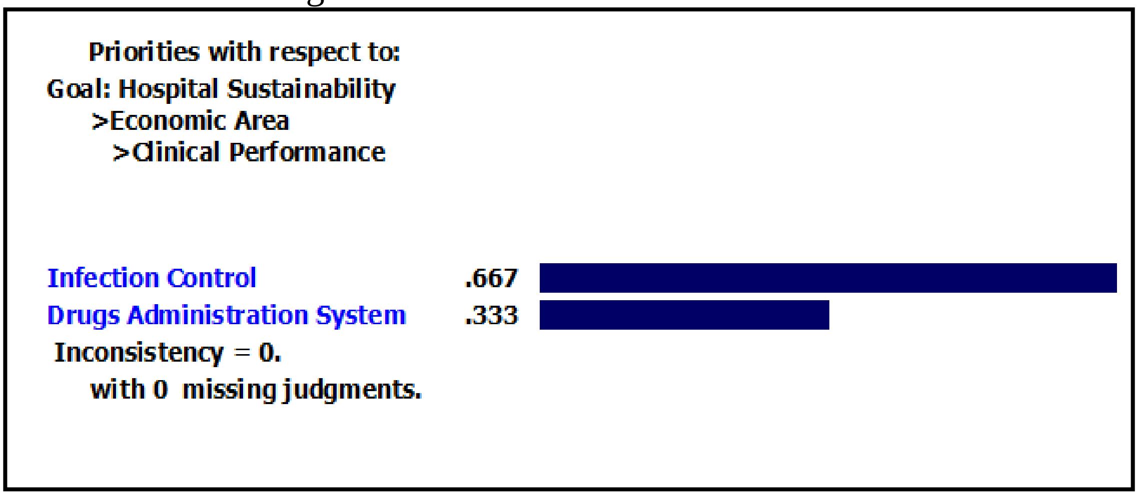

Figure 4.14: Priorities of clinical performance indicators

- **Technological performance indicators weighting:**

In figure 44, medical technology obsolescence was rated as the most important indicator with 75% Meanwhile, ICT indicator obtained only 25%.

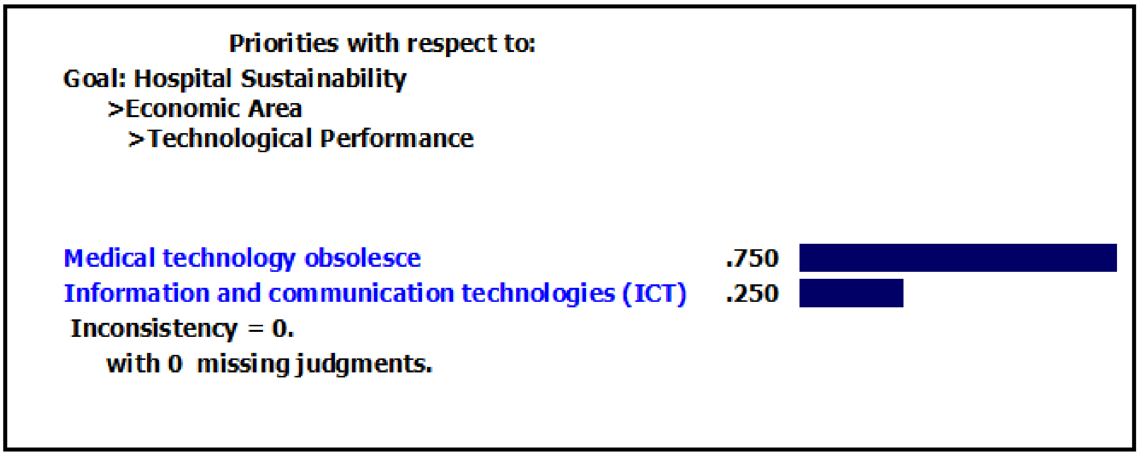

Figure 4.15: Priorities of technological performance indicators

- **Health and well-being indicators weighting:**

Figure 4.16 shows that hazardous material was the most important indicator with 43%, closely followed by security/safety with 41%. While the well-being, health promotion, indicators obtained the same weight of 6%. Finally, the social aspect indicator was decided to have the lowest importance with a weight equals 4%.

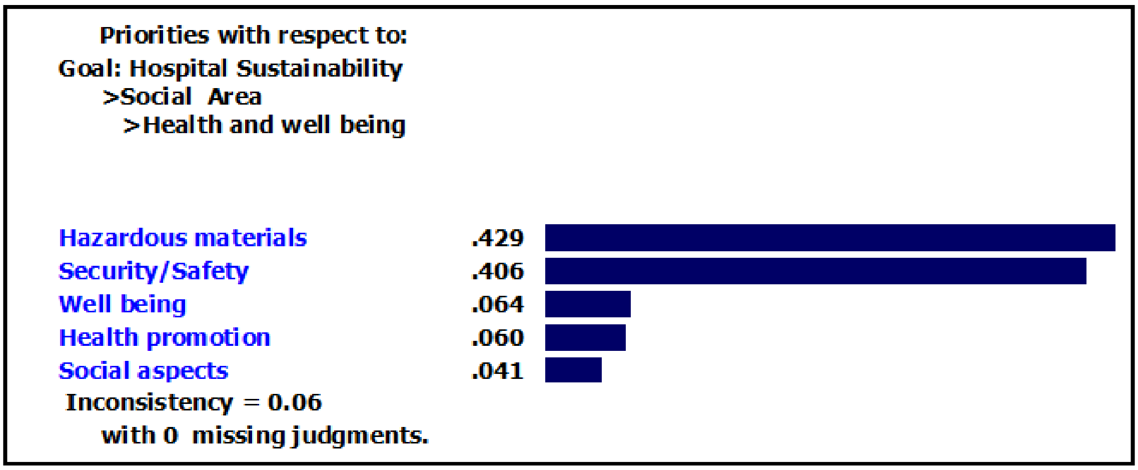

Figure 4.16: Priorities of health and well-being indicators

- **Space flexibility and adaptability indicators weighing:**

Space flexibility received the highest priority with 65%. The remaining weight was divided on paths, block distributions, and departments indicators with 14%, 11%, 10%, respectively (Figure 4.17).

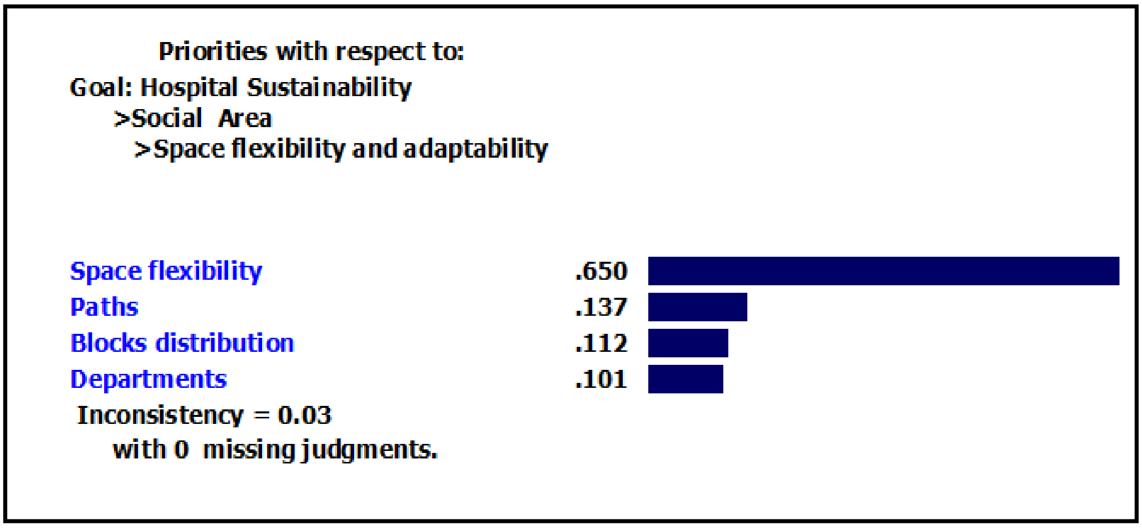

Figure 4.17: Priorities of space flexibility and adaptability indicators

- **Comfort indicators weighting:**

Indoor air quality is very important in the hospital environment; therefore, this indicator received the highest priority with 56%, and then came the thermal comfort indicator with 19%, closely followed by lighting comfort with 17%. However acoustic and visual comfort indicators obtained the lowest weight with 4% (As illustrated in Figure 4.18).

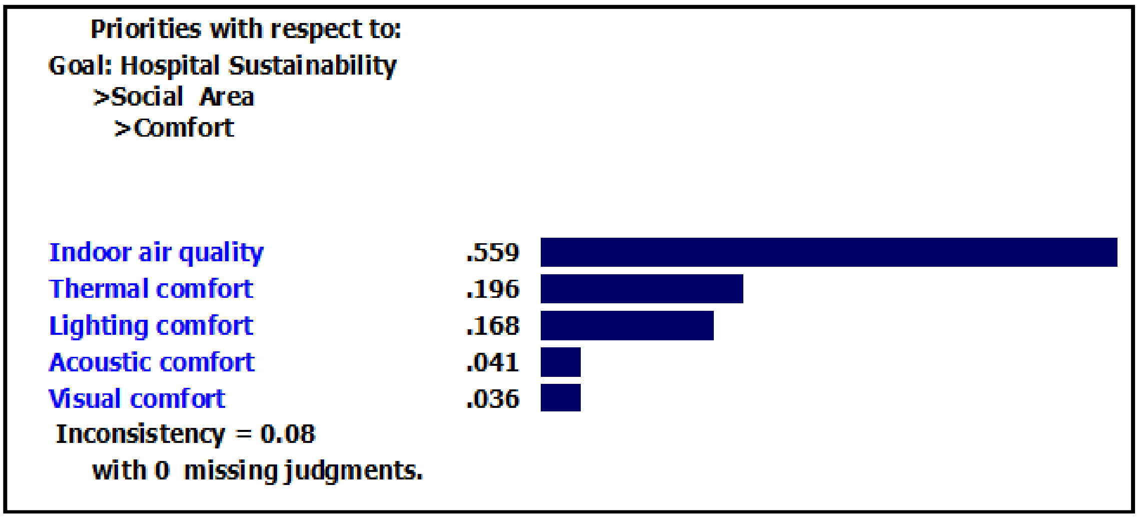

Figure 4.18: Priorities of comfort indicators

4.3.4 Rating formulas and benchmarks:

According to the above discussed weighting system which derived using AHP method, the proposed HSAtool-WB will be able to provide a single score which will indicate how much the hospital is sustainable. The final maximum score will be (100 points). The overall score can be calculated using the following formulas:

Indicator result (Ir) = Indicator weight × indicator Score.

Category score (Cs) $=\sum_{i=1}^{n} Iri$, where n= the number of indicators belong to the category.

Category result (Cr) = Category weight × Category Score.

Area score (As) $=\sum_{i=1}^{n} Cri$, where n= the number of categories belong to the area.

Area result (Ar) = Area weight × Area Score.

Overall Rating $=\sum_{i=1}^{n} Ari$, where n= the number of assessment areas.

After the overall rating is calculated by the abovementioned formulas it is converted into a single ranking expression.

Referring to the discussion about the international SA tools in section 2.3.6, it could be concluded that all of them provide a final rating expression based on the final calculated rating score. In addition, many researchers considered various levels of certifications. For instance, Ali & Al Nsairat. (2009) adopted three performance levels including not green (score <50%), green (score between 50 and 79%), very green (score between 80 and 100 %). Others such as Alyami 2015, considered a broader set of performance levels including “unclassified” for a score less than 35 points, “pass” for a score between 35 and 45, “bronze” for rating between 45 and 55, “silver” for a score from 55 to 75, “gold” for building rated between 75 and 85, and “diamond” is given for any building that achieve more than 85 points. Finally, within the context of hospital SA Bottero, et al. (2015) proposed five performance levels for hospital SA. These levels start from red for 0–20 points, orange for scoring 20–40 points, yellow for score ranging from 40 to 60 points, light green for 60 to 80 gained points, and finally green is given for hospitals that achieve points from 80 to 100.

Using a similar approach to the abovementioned tools and studies, the HSAtool-WB adopted six levels of certification as illustrated in Table 4.19

Table 4.19 HSAtool-WB rating benchmarks

HSAtool-WB	%score
UNCLASSIFIED	<45
PASS	45 – 59
BRONZE	60 – 74
SILVER	75 – 89
GOLD	>=90

4.4 Results and discussion of hospitals assessment

4.4.1 Overview:

The final stage of this study is to apply the developed tool on Palestinian hospitals to evaluate their sustainability performance. This was carried out using the evaluation form (Appendix D). This chapter presents the results and discussions which included a detailed descriptive statistical analysis for the acquired data. SPSS v24 program was used to perform the required data analysis. Firstly, the section begins with showing hospitals general characteristics. Furthermore, the section explores, analyze, and discuss the scores of all assessment items including indicators, categories, main areas, and the total score. Finally, the last part presents and discusses the results of the study hypotheses testing.

4.4.2 Hospitals demographic analysis:

In the following subsections, sample characteristics will be presented. This will include hospitals distributions based on location, classification by specialty, classification by service provider, quality certificates, number of beds, buildings area, and year of establishment.

1- Location:

In Table 4.20, it can be noted that half of the hospitals are from the northern part of the West Bank (n=14) while about 29% (n=8) of hospitals are located in the center of WB. The rest are located in the southern part and represent about 21% (n=14) of the sample.

Table 4.20: Distribution of hospitals based on location

Location	Frequency	Percentage (%)
North	14	50%
Center	8	29%
South	6	21%

2- Year of establishment:

According to Table 4.21, it is clear that 43% (n=12) of the hospitals in the sample were built in the nineties of the last century, the period in which the Palestinian Authority was established. During that time many new projects including hospitals were established. Furthermore, 29% (n=8) of the hospitals were established after 2000. Moreover, about one-third of the sample represents old hospitals established in the pre-1990s period, of which 14% (n=4) were established in the 1960 to 1990 period and 14% (n=4) pre-1960 period.

Table 4.21: Distribution of hospitals based on year of establishment.

Year of establishment	Frequency	Percentage (%)
Before 1960	4	14%
From 1960 to 1990	4	14%
From 1990 and 2000	12	43%
After 2000	8	29%

3- Specialty:

It is clear that more than half of the sample is general hospitals and represents about 57% (n=16). Then, the specialized hospitals came in the second place with 32% (n=9). While maternity hospitals represent about 11% (n=3). (Refer to Table 4.22)

Table 4.22: Distribution of hospitals based on Specialty.

Location	Frequency	Percentage (%)
General	16	57%
Maternity	3	11%
Special	9	32%

4- **Service provider**:

Table 4.23 shows that 61% (n=17) of the evaluated hospitals were private hospitals and 39% (n=11) were MoH hospitals.

Table 4.23: Distribution of hospitals based on the service provider.

Service provider	Frequency	Percentage (%)
MoH	11	39%
Private	17	61%

5- Number of beds:

Regarding the number of beds, 46% (n=13) of hospitals have less than or equal 50 bed capacity, 25 % (n=7) have abed capacity from 50 to 100 beds, 18% (n=5) of them have 100 to 200, and only 11% (n=3) of hospitals have more than 200 beds (Table 4.24). Additionally, the mean of bed capacity was about 84 beds. The minimum bed capacity was 10, while the maximum was 250 beds. (As illustrated in Table 4.25)

Table 4.24: Distribution of hospitals based on the number of beds.

Bed capacity	Frequency	Percentage (%)
Less than or equal 50 beds	13	46%
From 50 to 100 beds	7	25%
From 100 to 200 beds	5	18%
More than 200 beds	3	11%

Table 4.25: Minimum, maximum, mean, std for hospitals' number of beds

	N	Minimum	Maximum	Mean	std
Bed capacity	28	10.00	250.00	84.0357	69.30

6- Buildings area:

Table 4.26 shows hospitals distribution with respect to buildings area. As it can be seen, most of the hospitals buildings areas are less than or equal 5000m2 which equals 61% (n=17), while 21% (n=6) of the hospitals have buildings with area ranging from 5000 to 1000m^2, and 18% (n=5) have buildings with an area of more than 10000m^2.

Table 4.26: Distribution of hospitals based on buildings area

Buildings area	Frequency	Percentage (%)
Less than or equal 5000 m2	17	61%
From 5000 to 10000 m2	6	21%
More than 10000 m2	5	18%

7- Quality certificates:

Out of the 28 hospitals that were included in the sample, two hospitals only are quality certified.

Table 4.27: Distribution of hospitals based on quality certificates

Quality certificates	Frequency	Percentage (%)
Without	26	93%
Certified	2	6%

4.4.3 Indicators scores and sustainable strategies:

Hospitals performance was evaluated according to all indicators by assigning a score from 1 (poor performance) to 10 (best performance). The only three exceptions were: Annual water consumption which was measured in cubic meters per bed, annual energy consumption measured in dollars per bed, and bed capacity indicator measured by the number of beds. In the following sub-sections, results and discussions of the hospital evaluation are presented. These discussions include means, standard deviations, and the level of indicators, categories, areas, and overall scores. In addition, Importance Factor (IF) values were used to suggest effective sustainable solutions. Finally, it should be noted that the scores of the indicators were multiplied by 10 to obtain a final hospital sustainability score out of 100 points.

4.4.3.1 Environmental indicators:

In this section, environmental indicators scores are to be discussed. These discussions are provided for each environmental category. This will include means, standard deviations, level of performance, and Importance Factor (IF).

1. **Water efficiency indicators:**

Table 4.28 illustrates water efficiency indicators results averages for all hospitals. This category was decided to be one of the most important environmental assessment categories. The values in the Mean column represent the mean of each indicator for all the hospitals multiplied by 10 so as to compute the overall sustainability score. The hospitals' water efficiency total weighted score was poor (30.93). This value was calculated by averaging all the results of multiplying each indicator's mean with its corresponding weight (Refer to section 4.3.4**).** Moreover, the level of performance values, was assigned for the indicators depending on the following scale : 'Very poor' for 0 -19.9 mean values, 'Poor' for 20 – 39.9 values, 'Fair' for 40 – 59.9 values, 'Good' for 60-79.9 values, and 80 to 100 means values are considered as 'Very good'.

Table 4.28: Means, stds, levels of performance and IF for water efficiency indicators.

Water efficiency	Mean	std	Level	IF
Gray water recycling	12.14	11.34	Very poor	0.033
Rain water harvesting	10.00	0.00	Very poor	0.150
Efficient water appliances and plumbing fixtures	38.21	15.17	Poor	0.086
Water monitoring	44.64	11.38	Fair	0.049
Water conservation strategy	13.57	5.59	Very poor	0.147
Landscape Irrigation system	63.21	19.26	Good	0.009
Total	**30.93**	**7.96**	**Poor**	

- **Indicators results:**

It could be concluded out of Table 4.28 that, the landscape irrigation system indicator achieved the highest score with 63.21which shows a good level of performance. The researcher attributes this to the fact that most Palestinian hospitals lack the existence of gardens and outdoor green spaces, and others have gardens planted with large and old trees that depend on rainwater in winters. Moreover, all hospitals, to some extent, monitor water system in term of quality and leakage detection. This inspection is done as one of the routine procedures but is not documented as a clear strategy. For this reason, the water monitoring indicator had a fair score (44.64) while water conservation strategy indicator had a very poor score (13.57).

Furthermore, strategies such as gray water recycling and rain water harvesting are not adopted by all hospitals except one hospital in the south region of West Bank. This hospital recycles gray water and uses it for irrigation.

Finally, the majority of hospitals do not consider the installation of efficient water appliances and plumbing fixtures. However, they install what is available in the market according to the prices and quality.

- **Recommended sustainable strategies:**

Rain water harvesting indicator had the largest IF value (.150). This value was derived by dividing the weight of rain water harvesting indicator which was about .15 (Refer to Figure 4.7) by the indicator's mean value which was about 1. It should be noted that all hospitals do not harvest rain water. Therefore, adopting rain water harvesting strategies would be an important solution in the West Bank which already suffers from water scarcity. Furthermore, adopting clear documented water strategy would be a reasonable solution which helps to reduce water consumption.

Finally, installing efficient water equipment (WCs, urinals hand washing basins, showers... etc.) will reduce the overall water consumption.

2- Energy efficiency indicators:

Table 4.29 shows that the hospitals achieved a fair energy performance level which amounted to 44.44.

Table 4.29: Means, stds, levels of performance and IF for energy efficiency indicators.

Energy efficiency	Mean	std	Level	IF
Building Envelope Performance	54.29	13.45	Fair	0.004
Energy monitoring and management	51.07	11.00	Fair	0.057
Energy sub-metering system	12.50	9.28	Very poor	0.016
Renewable energy	15.36	17.10	Very poor	0.130
HVAC system	55.36	15.27	Fair	0.038
Lighting efficiency	48.93	11.33	Fair	0.020
Hot water distribution system	57.50	12.06	Fair	0.023
Green appliances	48.21	11.56	Fair	0.008
Total	**44.44**	**10.28**	**Fair**	

- **Indicators results:**

When highlighting the energy efficiency indicators scores in Table 4.29, it is clear that a good proportion of hospitals do not monitor the performance of energy in buildings as desired, where the level of this indicator was fair (51.07). Although most hospitals buildings are considered to be old, they are somehow insulated. However, most of the problems related to insulation were observed in the doors and windows. As a result, building envelope performance indicator value was fair (54.29).

With regard to the exploitation of alternative energy sources for electricity generation such as solar and wind energy, only two hospitals use it. A hospital uses solar energy to generate electricity and the other uses wind energy to do so. For this reason, the result of renewable energy indicator was very poor and did not exceed 15.36. In addition, energy sub-metering system is only used in some wards in one hospital**.**

HVAC system and Hot water distribution system indicators scores are about 55.36 and 57.50 respectively which considered as a fair. However, it was noticed that some HVAC systems in some hospitals are not very efficient, especially old ones that were built more than 30 years ago. In addition, there are other hospitals located inside buildings that have not been established to be hospitals from the beginning. Regarding the hot water distribution system, the solar energy is not exploited as it should be in many hospitals as they are using electricity and gas to heat water. In addition, many hospitals suffer from other problems related to boilers and distribution network efficiency.

Concerning Green appliances indicator, the score was fair (48.21). This attributed to the fact that there are factors such as quality and performance are considered to be more important than being green in hospitals. For example, there are refrigerators that are manufactured on demand with different dimensions depending on location and needs.

In a hospital environment that operates around the clock, the performance of the lighting system is very important. The mean of the sample hospitals for this indicator was 48.93. The result reflects that a large number of hospitals do not use energy-saving lighting such as Light Emitting Diode (LED) nor auto-sensored lighting system.

- **Recommended sustainable strategies:**

The results in Table 4.29 show that the first priority is to harness renewable energy sources such as solar energy. Solar energy can be directly used to heat water or to be converted to other forms of energy, like electricity. Additionally, adopting energy monitoring and management system offers a good opportunity to reduce the consumption of various kinds of energy. Moreover, installing effective HVAC systems, will decrease energy consumption and provide healthier indoor air quality. However, changing HVAC system may require time, high cost, and significant changes in the hospital structure. Finally, installing efficient water heating and distribution system will improve the overall sustainability score.

3- Site and location quality indicators

Site and location quality category indicators scores, and the category overall score are presented in Table 4.30. It could be noted that the site and location category score was good (63).

Table 4.30: Means, stds, and levels of performance and IF for site and location quality indicators.

Site and location Quality	Mean	std	Level	IF
Ecological protection of the site	75.00	5.09	good	0.019
Heat island effect	10.00	0.00	Very poor	0.040
Recharge of groundwater	11.07	4.16	Very poor	0.081
Transportation and accessibility	77.14	5.35	good	0.074
Outdoor Spaces quality	42.86	15.36	Fair	0.009
Hybrid cars and sharing	43.93	9.94	Fair	0.030
Total	**63.00**	**3.39**	**Good**	

- **Indicators results:**

Firstly, it is necessary to highlight that ecological protection of the site and transportation and accessibility indicators achieved the highest score with 75.00 and 77.14 respectively which considered as good. This is due to the fact that the majority of the Palestinian hospitals are located in urban areas inside the cities where the public transportations are available. However, the presence of a hospital in the city center may hinder the arrival of emergency cases due to traffic jams. Moreover, there are no planted areas around the hospitals. However, only two hospitals are located within areas planted with trees.

In addition, it has been found that no heat island effect or recharge of groundwater strategies are adopted by any of the hospitals. As a consequence of this, the results of the two indicators were very poor. Additionally, the majority of hospitals lack the existence of outdoor spaces and gardens. Therefore, this indicator recorded a fair score (42.86).

Finally, hospitals adopt car sharing policies to some extent but without using hybrid cars.

- **Recommended sustainable strategies:**

Despite the fact that this category obtained a good score, the required improvement solutions may require large sums of money and consume a lot of time. This is due to the fact that implementing any solution to improve the hospital's site indicators will require major modification of the hospital structure.

The results of the IF values which are showed in Table 4.30 give the highest priority to adopting solutions to increase recharging of ground water and accessibility to hospitals, and decreasing heat island effect.

However, the vast majority of Palestinian hospitals lack the existence of outside spaces. Therefore, it is difficult to implement solutions to improve outdoor spaces quality, implement projects to increase recharge of groundwater and decrease heat island effect. Finally, increasing car sharing strategies and using hybrid cars will improve hospitals sustainability.

4- Waste management indicators

Table 4.31 shows that the mean of the waste management score was poor (29.64). This result is not satisfactory for the hospital building, which produces many types of waste, including hazardous and non-hazardous ones.

Table 4.31: Means, stds, levels of performance and IF for waste management indicators.

Waste Management	Mean	std	Level	IF
Waste management system	22.14	9.57	Poor	0.339
Waste separation and storage	52.14	4.99	Fair	0.048
Total	**29.64**	**8.07**	**Poor**	

- **Indicators results:**

In terms of waste management strategies, all hospitals separate hazardous waste from non-hazardous waste only. The separation of non-hazardous waste into sections such as paper, plastic, etc. is not available. However, one hospital separates one type of plastic containers. Therefore, the results of the waste management system and waste separation and storage were poor (22.14) and fair (52.14) respectively. (See table 4.31).

- **Recommended sustainable strategies:**

Referring to Table 4.31 it could be noticed that adopting strategies to align waste management policies with the waste hierarchy (reduce, reuse, and recycle) would improve environmental sustainability. These strategies aim to minimize the amount of waste sent to landfill or incinerators. This includes monitoring all waste streams in hospitals and implementing waste separation and storage procedures such as providing labeled waste bins for different types of non-hazardous waste.

5- Materials indicators

The results of the materials indicators revealed that the Palestinian hospitals do not give adequate attention to the environmental impact may be caused by various materials used in hospitals' different operations. The total score of this category was fair (55.40), (See table 4.32)

Table 4.32: Means, stds, levels of performance and IF for waste management indicators.

Materials	Mean	std	Level	IF
Low environment impact materials	46.79	12.19	Fair	0.090
Materials durability	67.86	12.58	Good	0.068
Materials Reuse	38.57	10.08	Poor	0.034
Total	**55.40**	**10.42**	**Fair**	

- **Indicators results:**

Hospitals use materials which are available in the market regardless of the environmental damage it may cause. Some hospitals confirmed that they buy durable materials and reuse some materials and components, especially equipment components as spare parts for maintenance. Therefore, the results of the low environmental impact materials, durable materials, materials reuse indicators were fair (46.79), good (67.86), and poor (38.57) respectively.

- **Recommended sustainable strategies:**

Depending on the IF values provided in Table 4.32 it is obvious that it would be important for WB hospitals to consider the environmental impact of their procurements. This includes minimizing the use of VOC emitting materials when using paints, cleaning materials, flooring materials, and office furniture. Moreover, the hospitals should focus on purchasing durable materials which require less maintenance.

6- Pollution and Risks indicators

The results in Table 4.33 show that hospitals do not pay enough attention to pollution and risks issues. Therefore, the overall rating for the pollution and risks category was unsatisfactory; it was poor (39.78).

Table 4.33: Means, stds, levels of performance and IF for materials indicators.

Pollution and Risks	Mean	std	Level	IF
Greenhouse Gas Emissions	16.43	13.11	Very poor	0.201
Night time light pollution	56.79	12.78	Fair	0.014
Pollution management	32.86	8.97	Poor	0.094
Refrigerant	68.93	13.97	Good	0.042
Total	**39.78**	**8.48**	**Poor**	

- **Indicators results**

The vast majority of hospitals do not take any measures to reduce carbon dioxide emissions. As a result, the indicator recorded only 16.43. Furthermore, regarding refrigerant, the majority of hospitals use environmentally friendly ones. The result of light pollution was 56.79, which represent a fair level as some hospitals do not cause light pollution to neighboring buildings. Finally, pollution management indicators mean was 32.86, which indicates that there is a great lack of attention given by hospitals to reduce various types of pollution. (Refer to Table 4.33)

- **Recommended sustainable strategies:**

Hospitals can reduce the amount of greenhouse gases emissions by adopting many approaches, including reusing of materials, replacing harmful anesthetic gases with others less impactful, and installing filters on chimneys of boilers and HVAC systems. In Fact, management plays a crucial role in reducing and preventing pollution. Therefore, a good suggested solution is to adopt a pollution management system with the responsibility of identifying ways to reduce and prevent pollution and to increase awareness of hospital's users toward pollution dangers. One of the inexpensive solutions is to reduce light pollution at night, where it is possible to reduce the proportion of light that reaches the residential areas surrounding the hospital.

4.4.3.2 Economic indicators:

In this section, the environmental indicators' scores will be discussed. These results will be discussed for each economic category. This will include means, standard deviations, level of performance, and Importance factor (IF).

1- **Management indicators**

The management category scored about 60.09, which represents a good level of importance. Table 4.34 illustrated management indicators results.

Table 4.34: Means, stds, levels of performance and IF for management indicators

Management	Mean	std	Level	IF
Process efficiency	67.14	10.49	Good	0.039
Staff qualification and education	62.50	10.41	Good	0.066
Technology assessment	51.43	10.79	Fair	0.064
Total	**60.09**	**9.05**	**Good**	

- **Indicators results:**

Analysis of Table 4.34 shows that the results of the process efficiency and staff educations and qualifications indicators obtained a good level of performance, reaching more than 60, while the technology assessment indicators achieved a fair level of performance. In fact, for governmental hospitals, the results of the evaluation of these indicators were almost identical. The recruitment process, the job description of the employees and their job titles are carried out by the Palestinian General Public Council (GPC). In addition, staff training and developing is the responsibility of the Palestinian MoH. Finally, the process of technology assessment is carried out by specialized committees in each governmental hospital. This committee submits recommendations and writes them up to a Palestinian MoH committee, which in turn studies the recommendations and takes the necessary measures. However, under difficult economic circumstances, most medical equipment is granted from international or local donors. Concerning private hospitals Process efficiency, staff qualification and education, technology assessment indicators results showed great variations.

- **Recommended sustainable strategies:**

Management sustainable strategies cost the hospital less than environmental solutions. As these strategies focus on managerial procedures enhancements which do not require major modifications in the hospital's structure.

IF values of the management indicators show that the first priority is to improve the staff qualification indicator score by implementing programs to improve staff competencies and increase the opportunity to exchange experiences between them. Then, the second priority is to assign a multidisciplinary technology assessment committee to evaluate hospital technology. Finally, adopting a clear administrative structure design in which staff qualifications and job descriptions are available is considered as a good solution that contributes significantly to the hospital's processes efficiency. (Table 4.34)

2- Clinical performance indicators

Clinical performance scored about 50.49 which can be considered as fair a level of performance. Table 4.35 presents Means, stds, levels of performance and IF for clinical performance indicators.

Table 4.35: Means, stds, levels of performance and IF for materials indicators

Clinical performance	Mean	std	Level	IF
Infection control	60.00	13.88	Good	0.112
Drugs administration system	31.43	7.05	Poor	0.105
Total	**50.49**	**10.76**	**Fair**	

- **Indicators results:**

In respect of clinical performance, the vast majority of hospitals have infection control units to ensure the prevention of infection. The infection control indicator suggests a good level (60.00). In addition, a large proportion of hospitals have a clinical pharmacist to monitor the doses of medications given to patients. However, all hospitals lack the existence of computerized drugs administration system to manage the prescriptions and dosages. Therefore, this indicator result was poor (31.43).

- **Recommended sustainable strategies**

Hospitals have to employ more infection control protocols to reduce infection occurrences; this will improve the clinical performance score. In addition, the implementation of drugs administration system helps in reducing the possibility of therapeutic mistakes with regard to incorrect medication doses or drug conflicts.

3- Technological performance indicators

Table 4.36 shows that Technological performance result indicates a fair level. The achieved score was 48.84.

Table 4.36: Means, stds, levels of performance and IF for technological performance indicators

Technological performance	Mean	std	Level	IF
Information systems	62.50	21.19	Good	0.040
Medical technology obsolescence	44.29	12.00	Fair	0.169
Total	**48.84**	**13.51**	**Fair**	

- **Indicators results:**

Table 4.36 indicates that the result of the information systems indicator was better than the result of medical technology obsolescence.

The results were 62.5 for information systems and 44.29 for medical technology obsolescence. These results can be justified when describing the following two reasons. The first reason is that some hospitals do not use computer information systems to manage patients and employee's data. The other reason is their use of old or out-dated medical equipment.

- **Recommended sustainable strategies**

In fact, the Medical technologies are very expensive, and the Palestinian hospitals particularly the governmental ones obtain most of the medical technologies as donations. Therefore, any suggested solutions to improve technological performance will require substantial funding. Regarding the other indicator (Information systems), utilizing information technologies to manage various hospital's records is considered to be an effective solution.

4.4.3.3 Social indicators:

In this section, the social indicators' scores will be discussed. These indicators are divided into three categories: health and well-being, space flexibility and adaptability, and comfort. These results will be discussed for each category. This will include means, standard deviations, level of performance, and Importance factor (IF). It should be recalled here that the social area rated as the least important assessment area in West Bank context. It received the lowest weight (20%) (Refer to Figure 4.3). However, this section will suggest sustainable strategies to improve hospitals' social sustainability.

1- Health and well-being

Health and well-being is considered as one of the most important social categories as it is concerned with human health, and maintaining the health of the human being is the primary goal of the hospital. Table 4.37 presents the total score of health and well-being category which was fair (47.59). in addition, the table presents Health and well-being indicators' results.

Table 4.37: Means, stds, levels of performance and IF for health and well-being indicators

Health and well being	Mean	std	Level	IF
Hazardous materials	43.57	11.29	Fair	0.099
Security/Safety	53.21	14.16	Fair	0.077
Health promotion	39.29	17.62	Poor	0.015
Well-being	45.36	15.03	Fair	0.013
Social aspects	49.64	11.05	Fair	0.008
Total	**47.59**	**10.84**	**Fair**	

- **Indicators results:**

The results in Table 4.37 indicate that the Security/Safety indicator obtained the highest score which was only 53.21. The result can be explained by the fact that some hospitals have no security control and do not conduct a satisfaction survey to obtain patients feedback about hospital services in addition to the weak credibility of provided services perceived by patients. With respect to social aspects indicator the result was fair (49.64). This is attributed to some reasons such as the absence of meeting rooms for staff and patients. In addition, some hospitals do not provide hospitality to patients' relatives.

Regarding the well-being indicator, which refers to hospital's environment well-being, the result was fair (45.36). The result was so because many hospitals do not give enough attention to well-being which is represented in furniture, colors, quality of views, restaurants and other facilities.

Finally, it was noted that the majority of hospitals do not provide health promotion in term of conducting campaigns and using natural and non-toxic materials. Therefore, health promotion indicator achieved only 39.29 which is considered as a poor result. However, it should be highlighted that some hospitals adopt health promotion programs, while the majority do not.

- **Recommended sustainable strategies:**

According to the IFs values in Table 4.37, it is suggested that in order to promote the health and well-being performance, the focus should be mainly on hazardous materials and security/safety indicators as they have the highest IF values (0.099 for hazardous materials and 0.077 for security/safety). Regarding hazardous materials, Palestinian hospitals should pay more attention to the components of purchased materials free VOC chemicals. These chemicals include cleaning, painting, flooring, adhesives, and finishing materials. Concerning safety/security hospital can improve them by adopting adequate security policies in order to enhance the hospital users' perceived safety. In addition, conducting prevention and promotion campaigns and increase the use of natural materials would be a reasonable solution that improves social sustainability.

2- Space flexibility and adaptability

From the summary in of the result in Table 4.38 below the total score of space flexibility and adaptability category 52.92 which suggest a fair level of performance.

Table 4.38: Means, stds, levels of performance and IF for space flexibility and adaptability indicators

Space flexibility and adaptability	Mean	std	Level	IF
Space flexibility	53.93	18.53	Fair	0.121
Blocks Distribution	57.14	10.13	Fair	0.019
Departments	48.57	10.08	Fair	0.021
Paths	47.86	11.66	Fair	0.029
Total	**52.92**	**13.21**	**Fair**	

- **Indicators results**

To assess the space flexibility and adaptability category four indicators were evaluated. For the space flexibility indicator, the mean was 53.93. It can be noted that there is great variance between hospitals in this indicator results (std =18.53). This is because some hospitals have the capability to expand horizontally, and vertically, others can expand only horizontally or vertically. However, some hospitals don't have the ability to expand either horizontally or vertically. (Table 4.38)

Other indicators such as blocks distribution, and departments achieved 57.14 and 48.57 respectively. The results revealed that most hospitals do not have enough Corridors' width (more than 2.25 m). In addition, the majority of hospitals do not separate paths for patients from other paths. The paths indicator the result was Fair (47.86).

In summary, it is necessary to highlight that the most important reason why the results of space flexibility and adaptability indicators came as such is that a number of the evaluated hospitals are located inside old buildings that were not designed to be a hospital.

- **Recommended sustainable strategies**

In fact, space flexibility issues are difficult to improve as they require major structural changes in the hospital building. Therefore, any suggested improvement strategies will cost the hospitals a large number of resources in term of money and time. However, hospitals still have the ability to redistribute the internal departments in a way to enhance the accessibility inside the internal environment. But this is still depending on the hospital structure nature.

3- Comfort indicators

From the summary of the results in Table 4.39 below, the total score of the comfort category was 52.01 which suggest a fair level of performance.

Table 4.39: Means, stds, levels of performance and IF for comfort indicators

Comfort	Mean	std	Level	IF
Thermal comfort	55.71	9.59	Fair	0.036
Indoor air quality	51.07	13.15	Fair	0.110
Lighting comfort	52.14	11.97	Fair	0.033
Visual comfort	52.14	12.58	Fair	0.008
Acoustic comfort	46.43	10.62	Fair	0.009
Total	**52.01**	**10.97**	**Fair**	

- **Indicators results**

Regarding the last social assessment category (comfort), the scores were all fair. Thermal comfort and lighting comfort indicators scored about 55.71and 52.14 respectively. As discussed in Sec (4.4.3.1), thermal and lighting comfort depend on HVAC and lighting systems efficiency respectively which in fact received an assessment results equal to 55.36 and 48.93 respectively, (See Table 4.39). Indoor air quality indicator obtained 51.07. The result was so because some hospitals do not control smoking and do adopt strategies to mitigate the harmful emissions from some types of furniture and cleaning materials.

Concerning visual comfort indicator, the result was 52.14. This result can be attributed to the fact that most of the evaluated hospitals are located within the city which limits access to views. Additionally, some hospitals' interior environment needs some repairs and has limited sunlight access.

The final indicator to present is the acoustic comfort indicator which depends heavily on the insulation in walls and type of doors and windows. This indicator's result was 46.43. Undoubtedly, this result is correlated to building envelope performance indicator result which was 54.29 as the acoustic comfort depends mainly on building envelope performance (See Table 4.29).

- **Recommended sustainable strategies**

Before suggesting any improvement solutions, it should be noted that, the comfort indicators scores depend mainly on other indicators. For example, thermal comfort and lighting comfort depend heavily on HVAC and lighting systems efficiency respectively. Moreover, Indoor air quality depends also on HVAC system efficiency and also depends on hazardous materials usage. In summary, comfort indicators are already included in the suggested improvement solutions discussed above. However other solutions include modifying the interior environment aesthetically in terms of using contemporary paints and furniture.

4.4.4 Results of annual water and energy consumption, and car parking capacity per bed indicators:

Table 4.40 presents the minimum, maximum, mean, and std for annual water and energy consumptions indicators with respect to the number of beds. The results show that the mean of annual water consumption was about 12769.44 m^3/bed. In addition, minimum annual consumption was 100m^3/bed water, while the maximum consumption value reached about 29534.88 m^3/bed.

It should be noted that the value of std equals to 6848.56 which means that there is a significant difference between hospitals in term of annual water consumptions. This can be attributed to many reasons and the most important ones are:1) the significant difference of hospitals bed capacities, where the smallest bed capacity was 10 beds and the highest reached more than 200 beds.2) the presence of the dialysis units in some hospitals. Dialysis units consume a large amount of potable water daily in a way that cannot be rationalized.

With respect to annual energy consumption, the mean was 215.3976 $ /bed with std equals 175.90. The smallest amount of consumption was 40$ /bed, while the maximum amount reached 870.37$ /bed/year. By highlighting these results, it is obvious that there is a significant difference between hospitals in term of energy consumption; this is due to the difference in type and effectiveness of energy systems such as HVAC, Hot water distribution, and lighting systems. Another reason for this difference is that some hospitals own vehicles while others do not.

Regarding the car parking capacity, the results showed that the mean of this indicator was about .5464 parking spaces per bed. The minimum value was 0.03 spaces per bed and the maximum reached to 1.667 parking spaces per bed. It should be noted that the vast majority of WB hospitals lacks adequate car parking places.

Table E-3 in Appendix E presents the hospitals' scores in all assessment indicators. In addition, the table provides the values of the categories, areas, and the overall score for all hospitals.

Table 4.40: Means and stds for annual water consumption, annual energy consumption, and car parking capacity.

	N	Minimum	Maximum	Mean	SD
Annual water consumption (m^3/bed)	28	100.00	29534.88	12769.44	6848.56
Annual energy consumption ($/bed)	28	40.00	870.37	215.39	175.90
Car parking capacity (per bed)	28	0.030	1.667	.5464	.45015

4.4.5 Results of assessment categories:

The previous sub-sections included the total assessment categories scores. But in order to highlight the assessment categories scores in a comparative manner these scores are presented again in a single table (See Table 4.41).

Table 4.41: Means, stds and levels of performance for assessment categories

Environmental area	Mean	std	Level
Water efficiency	30.93	7.96	Poor
Energy efficiency	44.44	10.28	Fair
Site and Location quality	63.00	3.39	Good
Waste management	29.64	8.07	Poor
Materials	55.40	10.42	Fair
Pollution and Risks	39.78	8.48	Fair
Economic area	**Mean**	**std**	**Level**
Management	60.09	9.05	Good
Clinical performance	50.49	10.76	Fair
Technological performance	48.84	13.51	Fair
Social area	**Mean**	**std**	**Level**
Health and well-being	47.59	10.84	Fair
Space flexibility and adaptability	52.92	13.21	Fair
Comfort	52.01	10.97	Fair

Regarding the environmental categories, it can be noted all the categories scores did not reach 60 except the site and location quality category which scored about 63. The rest of the categories achieved an either fair or poor level of performance; materials obtained a fair performance level (55.40), while energy efficiency scored about 44.44, and pollution and risks with 39.78. Finally, water efficiency, and waste management categories received the lowest scores with 30.93 and 29.64 respectively.

The low environmental categories results can be ascribed to the fact that most of these categories include at least one indicator in which the score for the majority of hospitals was very low. For example, when water efficiency indicators were evaluated it was found that rainwater is not harvested in any of the hospitals and gray water is recycled only in one hospital. (Refer to Table E-3 in Appendix E).

Results of economic categories scores ranged from fair to good. The highest result was for the management category and amounted to about 60.09, followed by clinical performance category with 50.49. Finally, the lowest result was for the technological performance category which achieved 48.84.

The last records in Table 4.41 present the results of social categories which were all fair with simple differences. The space flexibility and adaptability received the highest score with 52.92, closely followed by comfort category health and well-being with 52.01. Finally, the lowest result was for the Health and well-being category which achieved only 47.59.

4.4.6 Results of main assessment areas:

According to the aggregated results which are presented in table 4.42, it can be concluded that the most important area which significantly contributes to the total sustainability in the economic area (54.47). Then social area came with about 50.44. Finally, the environmental area scored about 39.06. The overall assessment result of the evaluation was fair and reached about 48.89.

Table 4.42: Means, stds and levels of performance for main assessment areas

Assessment Aspect/ area	Mean	std	Level
Environmental	39.06	7.33	Fair
Economic	54.47	9.69	Fair
Social	50.44	9.93	Fair
Total	48.89	8.14	Fair

4.4.7 Hospitals overall scores:

In the previous subsections, the averages of all hospitals results were discussed in tables. These tables covered the hospitals' results at all the hierarchal levels of the HSAtool-WB, including indicators, categories, areas, and overall sustainability scores.

This section presents the results of the environmental, economic, social, and overall scoring for all the assessed hospitals which are coded from H1 to H28 without mentioning the name due to the privacy concerns. Moreover, the certification level for each hospital is also provided (See Table 4.19). The results are illustrated in Table 4.43.

Table 4.43: Hospitals' environmental, economic, and social sustainability, overall scores, and certification levels.

Hospital code	Environmental sustainability	Economic sustainability	Social sustainability	Overall score	Certification level
H1	23.15	17.01	6.76	34	UNCLASSIFIED
H2	37.21	26.83	10.67	54	PASS
H3	34.08	24.56	9.76	50	PASS
H4	34.84	23.46	9.33	48	PASS
H5	31.47	22.21	8.83	45	PASS
H6	15.00	12.48	4.96	25	UNCLASSIFIED
H7	26.72	21.50	8.55	44	UNCLASSIFIED
H8	24.71	18.38	7.31	37	UNCLASSIFIED
H9	26.56	19.77	7.86	40	UNCLASSIFIED
H10	35.31	27.81	11.06	56	PASS
H11	35.04	26.51	10.54	54	PASS
H12	34.02	24.59	9.78	50	PASS
H13	38.48	27.47	10.92	56	PASS
H14	39.04	28.36	11.27	58	PASS
H15	33.00	24.33	9.67	49	PASS
H16	31.04	23.01	9.15	47	PASS
H17	28.78	22.30	8.87	45	PASS
H18	26.48	19.52	7.76	40	UNCLASSIFIED
H19	37.82	27.59	10.97	56	PASS
H20	34.46	25.68	10.21	52	PASS
H21	32.67	24.92	9.91	51	PASS
H22	32.91	25.19	10.02	51	PASS
H23	40.01	30.79	12.24	62	BRONZE
H24	39.37	28.76	11.44	58	PASS
H25	33.60	23.97	9.53	49	PASS
H26	37.86	28.64	11.39	58	PASS
H27	34.40	24.10	9.58	49	PASS
H28	35.56	25.12	9.99	51	PASS

The results in Table 4.43 show that the maximum rating level was achieved by a relatively new specialized hospital. The achieved score was 62.46 which considered a "BRONZE" level. While the minimum score (25.31), was given to a small maternity hospital. This hospital considered as "UNCLASSIFIED"

In summary, the assessment results revealed that six hospitals of the sample were rated as “UNCLASSIFIED” as they scored less than 45 points. Moreover, other 21 hospitals were rated as “PASS” as they scored between 45 and 59. Finally, only one hospital was rated as “BRONZE”. Table E-3 in Appendix E provides detailed information about the hospitals’ scores.

4.4.8 Hypotheses testing and discussion:

The study proposed nine hypotheses. Seven of them are to identify if there are any differences in the hospitals’ scores attributed to their location, specialty, and service provider, number of beds, buildings area, year of establishment, and quality certificates. The other two hypotheses were proposed to investigate if there any correlations between the hospitals’ sustainability score and the annual water consumption per bed or the annual energy consumption per bed. The following subsections discuss the results of the hypotheses tests.

1- **Result of the first hypothesis (H1):**

H1 states that There are no statistically significant differences at (α =0.05) level between hospitals’ overall score, environmental, economic, and social sustainability attributed to the variable of location.

In order to test the hypothesis, One-Way ANOVA Test was used. Table (4.44, 4.45) present frequencies, means, and standard deviations of the main assessment areas according to hospital location and the results of One Way ANOVA test respectively.

Table 4.44: Means and standard deviations for assessment areas and overall scores due to hospital location

Assessment Area	Location	N	Mean(score)	std
Environmental area	North	14	38.16	8.78
	Center	8	39.01	5.86
	South	6	41.25	5.79
Economic area	North	14	54.53	8.71
	Center	8	50.24	12.88
	South	6	59.98	3.57
Social area	North	14	49.34	9.12
	Center	8	49.05	13.60
	South	6	54.88	5.18
Overall score	North	14	48.42	7.95
	Center	8	46.51	10.20
	South	6	53.16	4.06

Table 4.44 shows that there are no differences in the levels of assessment areas that are attributed to the variable of location. In the environmental area, the highest score was for south region hospitals, while the lowest score was for the hospitals that are located in the north of the WB. In the economic area, the highest score also obtained by hospitals in the south region of WB, while the lowest score was for center. For the social area, the highest score was for the south and the lowest was for the center hospitals. Concerning the overall sustainability score in the total degree, the highest is for south and the lowest was for the center.

Table 4.45: One Way ANOVA to test the difference of the assessment areas and overall scores due to hospital location.

Domain		Sum of Squares	DF	Mean Square	F	Sig.
Environmental area	Between Groups	40.349	2	20.175	0.358	0.703
	Within Groups	1409.834	25	56.393		
	Total	1450.183	27			
Economic area	Between Groups	325.655	2	162.827	1.841	0.180
	Within Groups	2211.390	25	88.456		
	Total	2537.044	27			
Social area	Between Groups	150.334	2	75.167	0.748	0.483
	Within Groups	2510.864	25	100.435		
	Total	2661.198	27			
Overall score	Between Groups	157.416	2	78.708	1.206	0.316
	Within Groups	1631.103	25	65.244		
	Total	1788.518	27			

***. The mean difference is significant at the 0.05 level.**

Table 4.45 shows that there are no statistically significant differences at (α =0.05) level between environmental, economic, social, and overall sustainability scores attributed to the variable of location. This means that the first hypothesis is accepted. The reason why the hospitals' scores were not significantly different is attributed to the fact that all WB regions included old, new, governmental, private, general, specialized, maternity hospitals. As a results, the mean of the hospital scores was fairly close.

2- Result of the second hypothesis (H2):

H2 states that: There are no statistically significant differences at (α =0.05) level between hospitals' overall score, environmental, economic, and social sustainability attributed to the variable of date of establishment.

In order to test the hypothesis, One-Way ANOVA Test was used. Table (4.46, 4.47) present frequencies, means, and standard deviations of the main assessment areas according to hospital date of establishment and the results of One Way ANOVA test respectively.

Table 4.46: Means and standard deviations for assessment areas and overall scores due to hospital date of establishment.

Assessment Area	Date of establishment	N	Mean	std
Environmental area	Before 1960	4	32.735	3.122
	From 1960 to 1990	4	35.035	4.507
	From 1990 and 2000	12	38.874	7.000
	After 2000	8	44.526	7.139
Economic area	Before 1960	4	57.055	0.837
	From 1960 to 1990	4	48.395	11.630
	From 1990 and 2000	12	52.278	11.975
	After 2000	8	59.506	4.085
Social area	Before 1960	4	50.328	9.716
	From 1960 to 1990	4	45.030	5.450
	From 1990 and 2000	12	48.462	11.473
	After 2000	8	56.184	7.680
Overall score	Before 1960	4	48.170	2.399
	From 1960 to 1990	4	43.580	7.667
	From 1990 and 2000	12	47.362	9.775
	After 2000	8	54.196	5.009

Table 4.46 shows that there are statistically significant differences between environmental, economic, social, and overall sustainability scores attributed to the variable of date of establishment. In environmental, economic, social, and overall sustainability score the hospitals which were established after 2000 achieved the highest score. The hospitals that were established in the period from 1960 to 1990 had the lowest scores in economic, social areas, and the overall score. Finally, the hospitals which dated back to the period before 1960 achieved the lowest environmental sustainability score.

Table 4.47: One Way ANOVA to test the difference of assessment areas and overall scores due to hospital date of establishment.

Domain		Sum of Squares	DF	Mean Square	F	Sig.
Environmental area	Between Groups	464.278	3	154.759	3.767	*0.024
	Within Groups	985.905	24	41.079		
	Total	1450.183	27			
Economic area	Between Groups	434.903	3	144.968	1.655	0.203
	Within Groups	2102.141	24	87.589		
	Total	2537.044	27			
Social area	Between Groups	428.013	3	142.671	1.533	0.231
	Within Groups	2233.185	24	93.049		
	Total	2661.198	27			
Overall score	Between Groups	368.138	3	122.713	2.073	0.130
	Within Groups	1420.381	24	59.183		
	Total	1788.518	27			

***. The mean difference is significant at the 0.05 level.**

Table 4.48 shows that there are statistically significant differences at (α =0.05) level between environmental sustainability scores attributed to the variable of date of establishment. This means that the second hypothesis (H2) is rejected. To clarify these differences, Post hoc test for comparison (LSD) was applied.

Table 4.48 Post hoc tests for comparison (LSD) for differences environmental area attributed to the variable of date of establishment.

Domain	Level	Before 1960	From 1960 to 1990	From 1990 and 2000	After 2000
Environmental area	Before 1960	____	-2.30000	-6.13917	-11.79125*
	From 1960 to 1990	____	____	-3.83917	-.95062*
	From 1990 and 2000	____	____	____	-5.65208

***. The mean difference is significant at the 0.05 level.**

As shown in Table 4.48 there are statistically significant differences in environmental sustainability score between hospitals according to the establishment date. The hospitals that were established after 2000 apply more environment practices than the hospitals that were established in the periods before 1960 and the period from 1960 to 1990. However, there are no differences between the "after 2000" hospitals and the "from 1990 and 2000" hospitals in environmental practices.

This result refers mainly to the fact that some environmental indicators (such as HVAC system, Hot water system, and others) scores depend to some extent on the structure of the hospital. Therefore, the newly established hospitals which have more suitable structures scored more in the environmental area. The second reason is that social and economic issues depend more on hospital management which is not affected by the fact that the hospital is old or new.

3- Result of the third hypothesis (H3):

H3 states that there are no statistically significant differences at (α =0.05) level between hospitals' overall score, environmental, economic, and social sustainability attributed to the variable of specialty. In order to test the hypothesis, One-Way ANOVA Test was used. Table (4.49, 4.50) present frequencies, means, and standard deviations of the main assessment areas according to hospital specialty and the results of One Way ANOVA test respectively.

Table 4.49: Means and standard deviations for assessment areas and overall scores due to hospital Specialty.

Assessment Area	Specialty	N	Mean	SD
Environmental area	General	16	37.65	5.63
	Maternity	3	32.68	5.01
	Specialized	9	43.71	8.48
Economic area	General	16	57.20	4.35
	Maternity	3	31.61	6.79
	Specialized	9	57.24	7.12
Social area	General	16	51.67	7.15
	Maternity	3	37.67	12.19
	Specialized	9	52.53	11.43
Overall score	General	16	50.03	4.59
	Maternity	3	33.13	7.24
	Specialized	9	52.11	7.97

Table 4.49 shows that there are statistically significant differences between environmental, economic, social, and overall sustainability scores attributed to the variable of specialty. The specialized hospitals gained the highest scores in environmental, social, and overall sustainability. While maternity hospitals achieved the lowest scores.

Table 4.50: One Way ANOVA to test the difference of assessment areas and overall scores due to hospital Specialty.

Domain		Sum of Squares	DF	Mean Square	F	Sig.
Environmental area	Between Groups	348.909	2	174.454	3.960	*0.032
	Within Groups	1101.274	25	44.051		
	Total	1450.183	27			
Economic area	Between Groups	1756.039	2	878.020	28.105	*0.000
	Within Groups	781.005	25	31.240		
	Total	2537.044	27			
Social area	Between Groups	552.259	2	276.129	3.273	0.055
	Within Groups	2108.940	25	84.358		
	Total	2661.198	27			
Overall score	Between Groups	858.935	2	429.468	11.550	*0.000
	Within Groups	929.583	25	37.183		
	Total	1788.518	27			

***. The mean difference is significant at the 0.05 level.**

Table 4.50 shows that there are statistically significant differences at (α =0.05) level between environmental, economic, and overall sustainability scores attributed to the variable of specialty. The significance in all the assessment areas is less than 0.05 which means that the third hypothesis (H3) is not valid. To clarify these differences, Post hoc test for comparison (LSD) was applied.

Table 4.51: Post hoc tests for comparison (LSD) for differences environmental area attributed to the variable specialty.

Domain	Level	General	Maternity	Specialized
Environmental area	General	____	4.96563	-6.06660*
	Maternity	____	____	-11.03222*
Economic area	General	____	25.59188*	-0.03479
	Maternity	____	____	-25.62667*
Overall score	General	____	16.90042*	-2.07403
	Maternity	____	____	-18.97444*

***. The mean difference is significant at the 0.05 level.**

The main observations from Table 4.51show that there are obvious or significant differences between hospitals in term of environmental, economic, and overall sustainability scores:

1- At Environmental area, the specialized hospitals score more significant measurement compared to general and maternity hospitals. Hence we can say that the specialized hospitals adopting better environmental strategies compared to general and maternity hospitals, whereas, there are no significant differences between general and maternity**.**

2- At economic area and the overall score, both of general and specialized hospitals score more significant measurement compared to maternity hospitals. This result ascribed to the fact that maternity hospitals are small hospitals with bed capacity does not exceed 30 beds. Therefore, Administrative and financial procedures were not adequately organized.

However, there are no significant differences between general and specialized hospitals.

4- Result of the fourth hypothesis (H4):

H4 states that There are no statistically significant differences at (α =0.05) level between hospitals' overall score, environmental, economic, and social sustainability attributed to the variable of service provider. In order to test the hypothesis, the Independent two sample t-test was used. The test result is illustrated in Table 4.52.

Table 4.52 Independent two sample t-test result.

Domain	Service provider	N	Mean	std	t	Sig.*
Environmental area	MoH	11	38.55	4.40	-0.337	0.739
	Private	17	39.40	8.84		
Economic area	MoH	11	58.27	1.97	2.138	*0.047
	Private	17	52.01	11.82		
Social area	MoH	11	51.93	7.55	0.628	0.535
	Private	17	49.49	11.32		
Overall score	MoH	11	50.89	3.37	1.253	0.224
	Private	17	47.59	10.01		

Table 4.52 indicates that there are significant differences between hospitals according to the service provider in economic sustainability. The results show that because MoH hospitals apply more economic procedures compare to private hospitals. The most important reason for this result is that financial and administrative procedures in governmental hospitals are centralized and managed by the Palestinian MoH.

5- Result of the fifth hypothesis (H5):

H5 states that there are no statistically significant differences at (α =0.05) level between hospitals' overall score, environmental, economic, and social sustainability attributed to the variable of bed capacity. In order to test the hypothesis, One-Way ANOVA Test was used. Table (4.53, 4.54) present frequencies, means, and standard deviations of the main assessment areas according to hospital number of beds and the results of One Way ANOVA test respectively.

Table 4.53: Means and standard deviations for assessment areas and overall scores due to hospital number of beds.

Assessment Area	Specialty	N	Mean	std
Environmental area	Less than or equal 50 beds	13	37.26	6.57
	From 50 to 100 beds	7	41.14	7.41
	From 100 to 200 beds	5	40.57	10.15
	More than 200 beds	3	39.50	7.29
Economic area	Less than or equal 50 beds	13	50.00	11.88
	From 50 to 100 beds	7	57.32	6.42
	From 100 to 200 beds	5	58.84	3.59
	More than 200 beds	3	59.91	4.67
Social area	Less than or equal 50 beds	13	48.89	12.11
	From 50 to 100 beds	7	51.85	7.92
	From 100 to 200 beds	5	49.90	10.09
	More than 200 beds	3	54.80	2.64
Overall score	Less than or equal 50 beds	13	45.82	9.46
	From 50 to 100 beds	7	51.22	6.62
	From 100 to 200 beds	5	51.41	6.54
	More than 200 beds	3	52.56	4.94

Table 4.53 shows that there are no statistically significant differences between environmental, economic, social, and overall sustainability scores attributed to the variable of bed capacity. Despite the fact that no significant differences were found between hospitals, it should be noted that the hospitals with the smallest bed capacity (Less than or equal 50 beds) achieved the lowest scores in all of the environmental, economic, social, and overall sustainability.

Table 4.54: One Way ANOVA to test the difference of assessment areas and overall scores due to hospital bed capacity.

Domain		Sum of Squares	DF	Mean Square	F	Sig.
Environmental area	Between Groups	84.245	3	28.082	0.493	0.690
	Within Groups	1365.938	24	56.914		
	Total	1450.183	27			
Economic area	Between Groups	500.778	3	166.926	1.967	0.146
	Within Groups	2036.266	24	84.844		
	Total	2537.044	27			
Social area	Between Groups	103.496	3	34.499	0.324	0.808
	Within Groups	2557.702	24	106.571		
	Total	2661.198	27			
Overall score	Between Groups	232.125	3	77.375	1.193	0.333
	Within Groups	1556.393	24	64.850		
	Total	1788.518	27			

Table 4.54 shows that there are no statistically significant differences at (α =0.05) level between environmental, economic, social, and overall sustainability scores attributed to the variable of bed capacity. This means that the fifth hypothesis (H5) is accepted. These results could be ascribed to many reasons. The first reason relates to the fact that the sample beds capacities were not significantly different. The second reason is that in each of the bed capacity categories included in the analysis there were old, new, governmental, private, general, specialized, maternity hospitals. As a result, the mean of the hospital scores was fairly close.

6- Result of the sixth hypothesis (H6):

H6 states that there are no statistically significant differences at (α =0.05) level between hospitals' overall score, environmental, economic, and social sustainability attributed to the variable of building areas. In order to test the hypothesis, One-Way ANOVA Test was used. Table (4.55, 4.56) present frequencies, means, and standard deviations of the main assessment areas according to hospital buildings area and the results of One Way ANOVA test respectively.

Table 4.55: Means and standard deviations for assessment areas and overall scores due to hospital building area.

Assessment Area	Specialty	N	Mean	std
Environmental area	Less than or equal 5000 m2	13	37.99	6.82
	From 5000 to 10000 m2	7	39.33	6.74
	More than 10000 m2	5	42.41	10.04
Economic area	Less than or equal 5000 m2	13	51.62	11.24
	From 5000 to 10000 m2	7	57.50	3.64
	More than 10000 m2	5	60.51	4.29
Social area	Less than or equal 5000 m2	13	47.51	10.94
	From 5000 to 10000 m2	7	54.16	7.40
	More than 10000 m2	3	55.95	4.81
Overall score	Less than or equal 5000 m2	13	46.58	8.96
	From 5000 to 10000 m2	5	51.19	4.65
	More than 10000 m2	3	53.99	6.00

Table 4.55 shows that there are no statistically significant differences between environmental, economic, social, and overall sustainability scores attributed to the variable of buildings area. Despite the fact that no significant differences were found between hospitals, it should be noted that the hospitals with the smallest buildings areas (Less than or equal 5000 m^2) achieved the lowest scores in all of the environmental, economic, social, and overall sustainability.

Table 4.56: One Way ANOVA to test the difference of assessment areas and overall scores due to hospital buildings area.

Domain		Sum of Squares	DF	Mean Square	F	Sig.
Environmental area	Between Groups	76.281	2	38.140	0.694	0.509
	Within Groups	1373.902	25	54.956		
	Total	1450.183	27			
Economic area	Between Groups	375.597	2	187.799	2.172	0.135
	Within Groups	2161.447	25	86.458		
	Total	2537.044	27			
Social area	Between Groups	380.760	2	190.380	2.087	0.145
	Within Groups	2280.438	25	91.218		
	Total	2661.198	27			
Overall score	Between Groups	252.725	2	126.362	2.057	0.149
	Within Groups	1535.794	25	61.432		
	Total	1788.518	27			

Table 4.56 shows that there are no statistically significant differences at (α =0.05) level between environmental, economic, social, and overall sustainability scores attributed to the variable of buildings area. This means that the fifth hypothesis (H6) is accepted. These results can be attributed to the same reasons as for the bed capacity variable. Therefore, it could be considered that each of the buildings areas categories included in the analysis there were old, new, governmental, private, general, specialized, maternity hospitals. As a result, the mean of the hospital scores was fairly close.

7- **Result of the seventh hypothesis (H7):**

H7 states that There are no statistically significant differences at (α =0.05) level between hospitals' overall score, environmental, economic, and social sustainability attributed to the variable of quality certificates. In order to test the hypothesis, the Independent two sample t-test was used. The test result is illustrated in Table 4.57.

Table 4.57: Independent two sample t-test result.

Domain	Quality Certificates	N	Mean	std	t	Sig.*
Environmental area	Without	26	37.93	6.17	-3.529	*0.002
	Certified	2	53.83	5.32		
Economic area	Without	26	53.75	9.69	-1.446	0.160
	Certified	2	63.84	1.79		
Social area	Without	26	49.92	9.96	-1.006	0.324
	Certified	2	57.25	8.90		
Overall score	Without	26	48.08	7.82	-2.005	0.055
	Certified	2	59.44	4.28		

The main observations from Table 4.57 show that there are significant differences between hospitals in term of environmental sustainability scores. Hospitals with quality certificates adopt more environmentally friendly procedures. This is due to the fact that quality certified hospitals must meet the certification minimum requirements which enforce the hospital to install effective systems and to operate more efficiently.

8- **Result of the eighth hypothesis (H8):**

H8 states that There is no statistically significant correlation at (α =0.05) level between annual water consumption and hospital overall score. To test the hypothesis Pearson correlation test was conducted. The test results are shown in Table 4.58

Table 4.58: Pearson correlation test between annual water consumption and overall sustainability score

		Annual water consumption per bed	Overall score
Annual water consumption per bed	Pearson Correlation	1	0.176
	Sig. (2-tailed)		0.371
	N	28	28
Overall score	Pearson Correlation	0.176	1
	Sig. (2-tailed)	0.371	
	N	28	28

***. Correlation is significant at the .05 level (2-tailed).**

As it clears from Table 4.58 there is no statistically significant correlation between annual water consumption per bed and hospital overall score. Therefore, the hypothesis is accepted. This result can be attributed to the fact that some hospitals have uncontrolled water consumption that are used in dialysis units. Therefore, large annual water consumption per bed does not necessarily mean that the hospital has low scores in water efficiency indicators. In other words, the overall sustainability score is not necessarily negatively affected by annual water consumption (Refer to Table E-3 Appendix E)

9- Result of the ninth hypothesis (H9):

H8 states that There is no statistically significant correlation at (α =0.05) level between annual energy consumption and hospital overall score. To test the hypothesis Pearson correlation test was conducted. The test results are shown in Table 4.59

Table 4.59: Pearson correlation test between annual energy consumption and overall sustainability score

		Annual energy consumption per bed	Overall score
Annual energy consumption per bed	Pearson Correlation	1	.456*
	Sig. (2-tailed)		0.015
	N	28	28
Overall score	Pearson Correlation	.456*	1
	Sig. (2-tailed)	0.015	
	N	28	28

***. Correlation is significant at the .05 level (2-tailed).**

The results in Table 4.59 reveal that there is a positive correlation between annual energy consumption per bed and overall sustainability score where the significant value was 0.456. At first glance, the result may suggest a contradiction, as high energy consumption may indicate non-effectiveness in various energy systems and at the end a lower overall score. Before discussing the results, it should be recalled that the energy consumption indicator includes electricity, fuel, and cooking gas consumptions. This result can be attributed mainly to two reasons. The first reason is that hospitals differ in term of the energy type they use in heating water, operating HVAC system, for sterilization purposes, and others. The second reason is ascribed to the fact that some hospitals own vehicles which increases the hospital's energy consumption. In summary, within the WB context, a high sustainability score may be accompanied by high energy consumption.

4.4.8.1 Summary of Hypotheses Testing

Table 4.60 presents a summary of the results of the study's hypotheses testing. This includes the result of the hypothesis test with a brief explanation of the result.

Table 4.60: Hypotheses Testing Summary.

Hypothesis	Result
H1: Tests if there are differences between hospitals results that are attributed to hospital's location	**Accepted:** All WB regions included old, new, governmental, private, general, specialized, maternity hospitals. As a result, the mean of the hospital scores was fairly close.
H2: Tests if there are differences between hospitals results that are attributed to hospital's Date of establishment	**Rejected:** After 2000 hospitals apply more environmental practices than the hospitals which were established before 1960 and from **1960 to 1990** periods. Because the newly established hospitals have more suitable structures.
H3: Tests if there are differences between hospitals results that are attributed to hospital's Specialty	**Rejected:** Specialized hospitals apply more environmental practices than General and Maternity ones . Moreover, Specialized and General sored more economic measurement than Maternity.
H4: Tests if there are differences between hospitals results that are attributed to hospital's Service Provider	**Rejected:** MoH hospitals apply more economic procedures than private ones. Because financial and administrative procedures in governmental hospitals are centralized and managed by the Palestinian MoH.
H5: Tests if there are differences between hospitals results that are attributed to hospital's number of beds	**Accepted:** each of the number of beds categories included in the analysis there were old, new, governmental, private, general, specialized, maternity hospitals. As a result, the mean of the hospital scores was fairly close.
H6: Tests if there are differences between hospitals results that are attributed to hospital's buildings areas	**Accepted:** each of the buildings areas categories included in the analysis there were old, new, governmental, private, general, specialized, maternity hospitals. As a result, the mean of the hospital scores was fairly close.
H7: Tests if there are differences between hospitals results that are attributed to hospital's quality certificates.	**Rejected:** Quality certificated hospitals adopt more environmentally friendly procedures.
H8: Test if there is a correlation between annual water consumption per bed and the hospital's result.	**Accepted:** No correlation because some hospitals have uncontrolled water consumption that are used in dialysis units.
H9: Test if there is a correlation between annual water consumption per bed and the hospital's result.	**Rejected:** Positive correlation. Because the energy consumption indicator includes electricity, fuel, and cooking gas consumptions. Hospitals use different energy types, and some hospitals own vehicles while others not

Chapter Five

Conclusions and Recommendations

Chapter Five

Conclusions and Recommendations

5.1 Overview

This chapter presents the main conclusions of the study as well as its recommendations. It also reviews the limitations that were faced during conducting the study. Finally, the chapter ends this study by providing many suggestions for future work.

5.2 Summary

The main aim of this study was to develop a hospital sustainability assessment tool to assess and improve hospitals sustainability in WB (HSAtool-WB). To achieve this, the study focused mainly on two issues. First, the focus was on developing the HSAtool-WB. This was carried out by many procedures. In the beginning, a comprehensive set of indicators were proposed. This was done through a deep literature review and an exploration of four well-known SA tools (LEED, BREEAM, Green Star, and CASBEE).

The second step was to determine the most appropriate indicators to WB context. This was achieved by highlighting the WB context and conducting open meeting discussions and a structured interview (questionnaire) with many experts from various disciplines. Thirdly, a weighting system for the HSAtool-WB was proposed to ensure its suitability for WB context. This was applied through pairwise comparison approach conducted through a structured interview (pairwise comparison questionnaire).

Finally, the final HSAtool-WB form was formulated. It comprises three levels of weighted items: three main assessment areas at the top level. The areas are subdivided into 12 categories in the next lower level, and the lowest level contains 50 assessment indicators. In addition, HSAtool-WB provides a score ranging from 0 to 100 this score is then interpreted to a single expression ranging from "UNCLASSIFIED" to "GOLD" that reflects the hospital is sustainability level.

The second part of the study was evaluating the hospitals in WB using the HSAtool-WB. 28 hospitals were evaluated by the tool and the results suggest that the vast majority of the hospitals in WB obtained an unsatisfactory sustainability assessment score, where the maximum score was only about 62 which considered as BRONZE. The mean of the overall score for all hospitals was 48.89. It should be noted that specialized hospitals achieved the highest scores while the lowest scores were obtained by maternity hospitals. Moreover, MoH hospitals apply more economic procedures.

Additionally, based on the results of the indicators' scores, the study proposed many sustainable strategies that included many reasonable solutions. These solutions will in no doubt improve the WB hospitals' sustainability while they are operating. The managerial solutions considered to be the most important ones that do not require major changes in the structure of hospitals.

Finally, to get a better understanding of the studied hospitals' situations, the study proposed nine hypotheses. The hypotheses testing results demonstrated that there are no significant differences between hospitals sustainability scores that can be attributed to their location, bed capacity, and buildings areas. Whereas the results showed a significant difference between the hospitals' sustainability scores that can be attributed to specialty, service provider, age, and quality certificates. Further, it was found that there is no correlation between the overall sustainability score and annual water consumption, whereas the overall sustainability score is positively correlated with annual energy consumption.

5.3 Conclusions:

Based on the results achieved in this research, the following can be inferred:

- The Leading SA tools such as (LEED, BREEAM, Green Star, and CASBEE) are not fully comprehensive and focus on the environment dimension while neglecting some important economic and social aspects which considered as critical in the hospital system.

- Developing SA tool requires the involvement of all stakeholders to align both the assessment items and weighting system with their expectations so as to increase the tool effectiveness.
- For the WB context, economic considerations are more important than environmental and social when it comes to assessing the sustainability of an operative hospital.
- HSAtool-WB tool can be used to support the decision making and raise the performance of the hospitals' sustainable practices in WB.
- The vast majority of WB hospitals do not adopt sustainable practices as they should be, particularly in the environmental area which achieved the lowest results.

5.4 Recommendations

Based on the study findings; the following recommendations have been set:

- Environmental, economic, and social conditions vary with time. Therefore, almost all the SA tools are updated. HSAtool-WB is recommended to be revised and updated over time to consider any new conditions.
- It is recommended to firstly impose prerequisite criteria by a group of a multidisciplinary team. These criteria have to be satisfied before using the HSAtool-WB.

- The Application of the HSAtool-WB is recommended to be conducted by an assessor who has enough knowledge about SD issues related to the hospitals environmental, economic, and social performances.

- The success of any improvement in the level of sustainability requires the top management commitment and staff involvement.

- As the application of HSAtool-WB was limited to a sample size of 28 of WB hospital it is recommended to include more hospitals in the future to have a clearer image about the Palestinian hospitals in WB.

- Regarding the solutions that may improve the sustainability of hospitals in the WB, many reasonable solutions can be recommended and the most important of which are the following:

1. Exploiting the renewable energy sources, especially solar energy which available in the WB to heat water and produce electricity.

2. Reducing potable water consumption by collecting rain water and installing efficient water appliances in all hospital wards.

3. Adopting clear policies for using of low-impact substances on the environment and human health.

4. Formulating clear sustainable strategies to manage energy, water, materials, waste, and pollution issues.

5. Adopting a clear administrative structure in which all staff qualifications, needs, roles, and duties are clear so as to increase process efficiency and optimize resources.

6. Manage processes in a way that encourages the experiences exchange between staff.

7. Maximizing the use of information technology systems for managing various hospitals' information.

8. Modify some interior decorations in a way that increases the aesthetic effect.

9. Adopt clear policies and procedures to guarantee a high indoor air quality such as controlling smoking inside the hospital.

Finally, the study advises many recommendations to be followed at the national level to ensure better hospitals' sustainability results:

- MoH could adopt the HSAtool-WB to rate and certify the Palestinian hospitals.

- MoH could use the results of the study (particularly the hospitals' evaluation results) to enrich the national database regarding the status of hospitals in the WB.

- MoH can Offer incentives for the adoption of sustainable practices to encourage sustainability initiatives.

5.5 Limitations

A number of limitations were faced during conducting this study. The first limitation was the unfamiliarity of the concept of sustainability among some experts which required additional effort from the researcher to clarify the concept during the interviews

The second limitation of this study was the inability to include Gaza strip in the study.

The third limitation was that the HSAtool-WB was tested in only 28 hospitals in WB because of the lack of cooperation from a number of hospitals, and due to the financial and time constraints.

5.6 Future research

Future work may expand the scope of HSAtool-WB. This study suggests many expansions that might be conducted for future work:

Frist, HSAtool-WB evaluates an operative hospital, future work may include assessing hospitals at different life cycle stages including design, construction, operating, repair, renovation, and demolition.

Second, the developed HSAtool-WB is suitable for hospitals, future research may include the development of similar tools or customizing HSAtool-WB to assess other building types such as schools, universities, residential, offices, …etc.

Third, due to financial, time, political constraints the HSAtool-WB was developed for the use in WB region, future studies may highlight the environmental, economic, and social conditions in Gaza and modify the HSAtool-WB to include Gaza strip region.

Fourth, standardizations bodies such as ISO and CEN started to define new standard requirements for the application of environmental and sustainable principles in the field of construction. Future studies may include the work of the abovementioned standards, taking into account appropriateness of their work within Palestinian context.

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Appendices

Appendix A

The Initial List of Assessment Items

Areas	Categories	indicators
A1 Environmental Area	**C1** Water efficiency	**I1** Gray water recycling
		I2 Rain water harvesting
		I3 Efficient Water appliances and plumbing fixtures
		I4 Water monitoring system
		I5 Water strategy
		I6 Landscape Irrigation system
	C2 Energy efficiency	**I7** Building Envelop Performance
		I8 Energy consumption monitoring and management system
		I9 Energy sub-metering system
		I10 Renewable energy sources
		I11 Efficient Heating, ventilation and air conditioning (HVAC) system
		I12 Lighting system
		I13 Hot water distribution system
		I14 Green appliances
	C3 Site and location Quality	**I15** Ecological protection of the site
		I16 Heat island effect
		I17 Recharge of groundwater
		I18 Transportation and accessibility
		I19 high quality Outdoor Spaces
		I20 Parking capacity
		I21 Hybrid cars and sharing
		I22 Cycling routes and facilities
	C4 Materials And Waste Management	**I23** Waste management system
		I24 Non- hazardous waste generation
		I25 Hazardous Waste generation
		I26 Waste separation and storage
		I27 Organic waste(kitchen, garden)
		I28 Sustainable procurement policy
		I29 Low environment impact materials
		I30 durable Materials
		I31 Materials Reuse
		I32 Recycled materials
		I33 Recyclable materials
	C5 Pollution and	**I34** Greenhouse Gas Emissions
		I35 Night time light pollution
		I36 Pollution management

	Risks	**I37** Refrigerant
		I38 Natural disasters
A2 Economic area	**C6** Management	**I39** Process efficiency
		I40 Staff qualification and education
		I41 Technology assessment
	C7 Clinical performance	**I42** Infection control
		I43 Drugs administration system
	C8 Technological performance	**I44**Information and communication technologies (ICT)
		I45 Medical technology obsolescence
A3 Social area	**C9** Health and well-being	**I46**Hazardous materials
		I47 Security/Safety
		I48 Health promotion
		I49 Well-being
		I50 Social aspects
	C10 Space flexibility and adaptability	**I51** Space flexibility
		I52 Blocks Distribution
		I53 Departments
		I54 Paths
	C11 Comfort	**I55** Thermal comfort
		I56 Indoor air quality
		I57 Lighting comfort
		I58 Visual comfort
		I59 Acoustic comfort

Appendix B

Developing sustainability assessment tool for hospital – Case of West Bank

A Questionnaire Submitted for the Requirement of Research for the Degree of Master of Engineering Management at Al-Najah National University.

Dear respondent please read the general guidance before answering the questionnaire

Sustainability assessment tool provides an effective framework for evaluating hospital environmental, social, and economic performance, and align sustainable development goals with hospital strategy and objectives. It can also be used as a management tool to organize and structure environmental, social, and economic concerns during the plan, design, construction, and operations phases.

The main aim of this research is to develop a sustainability assessment tool to be used in the local Palestinian hospitals specifically in West Bank. The developed tool is intended to provide a comprehensive evaluation of operative hospitals and proposes effective solutions. This questionnaire aims at identifying the most important areas, categories, and indicators of the developed tool to suit the Palestinian local context.

This questionnaire will be used only for the purpose of academic research

Prepared by: Mohammed Amer

Part 1 Background:

1.1 Gender : ☐ **Male** ☐ **Female**
1.2 Profession: ☐ **Architect** ☐ **Engineer** ☐ **Manager** ☐ **Other. Specify:……………………**
1.3 Type of orgnization : ☐ **Construction company** ☐ **Hospital** ☐ **Government Agency** ☐ **Education** ☐ **Design Consultancy** ☐ **Other. Specify: ………………….**
1.4 Years of experience ☐ **< 5** ☐ **5-10** ☐ **More than 10**
1.5 Highest Level of education: ☐ **BSc** ☐ **MSc** ☐ **PhD** ☐ **other. Specify: …………**

Part 2: Assessment areas (sustainability issues):

Q2.1 Please rate the importance for the three below sustainability areas/aspects in establishing sustainability assessment tool for hospitals in Palestine-West Bank.

Note: please tick (√) your answers.

Assessment Aspect/ area	Not important	Of little importance	Moderately important	Important	Very important
	1	2	3	4	5
Environmental					
Economic					
Social					

Part 3: Assessment Categories and indicators:

Q3.1 For each of sustainability area listed in Q2.1 there are number of categories, each category has its own indicators to be considered in evaluating the sustainability performance of a hospital. Please indicate the level of importance of these indicators**.**

Note: please tick (√) your answers.

Environmental area	Not important	Of little importance	Moderately important	Important	Very importan t
A Water efficiency	**1**	**2**	**3**	**4**	**5**
Use **Gray water recycling** to reduce using of potable water					
Use **Rain water harvesting** to reduce using of potable water					
Use **Efficient water appliances and plumbing fixtures** (Low flush WC's, Showers heads, Washing machines.)					
Install **Water monitoring system** (water metering, Leak detection system, Water quality control system)					
Adopt **Water strategy** to maintain water systems					
Minimize using of potable water for **Landscape Irrigation system** by installing (moisture sensors, drip irrigation, …)					
Other:……………………………					
Other:……………………………					
B Energy efficiency	**1**	**2**	**3**	**4**	**5**
Building Envelop Performance (thermally resistant envelope, air leakage...)					
Use **Energy consumption monitoring and management system** (monitor energy consumption and using the manage the data)					
Use **Energy sub-metering system** for hospital sections and					

wards					
Increase the capacity of **Renewable energy sources** (solar photovoltaic and solar thermal).					
Use of an **Efficient Heating, ventilation and air conditioning (HVAC) system**(design, pipe insulation, location, etc)					
Use of efficient **Lighting system** (integrated lighting concept, auto-sensored lighting system)					
Use an efficient **Hot water distribution system** (generation, used energy, distribution)					
Increase the use of **Green appliances** (refrigerators, washing machines, dryers...).					
Other:………………………………					
Other:………………………………					
C Site and location Quality	**1**	**2**	**3**	**4**	**5**
Increase **Ecological protection of the site**					
Minimize **Heat island effect** (roofing, paving areas)					
Recharge of groundwater (permeable paving or landscaping).					
Transportation and accessibility (access to public transportation, Distance to amenities, Paths to access the hospital)					
Provide **high quality Outdoor Spaces** (gardens, paths, plants, setting places, ..etc)					
Use **hybrid cars and sharing**					
Other:………………………………					
Other:………………………………					
D Waste Management	**1**	**2**	**3**	**4**	**5**
Provide **Waste management system** (3 R's, Auditing of waste streams)					
Waste separation and storage procedures					
Other:………………………………					

Other:………………………… …					
E Materials	**1**	**2**	**3**	**4**	**5**
Use **Low environment impact materials** (paints, roofing, walls and floors, detergents ...etc)					
Use **durable Materials** (High strength materials that require less maintenance)					
Materials Reuse (Reuse of components and materials)					
Other:………………………… …					
Other:………………………… …					
F Pollution and Risks	**1**	**2**	**3**	**4**	**5**
Decrease **Green house Gas Emissions** (CO_2 mitigation strategy)					
Decrease **Night time light pollution** (Internal and external night light pollution)					
Pollution management (adopt Pollution response plan)					
Refrigerant (Reduce refrigerants environmental impact)					
Other:………………………… …					
Other:………………………… …					
Economic area	Not important	Of little importance	Moderately important	Important	Very importan t
G Management	**1**	**2**	**3**	**4**	**5**
Increase **Process efficiency** (Lean process)					
Increase **Staff qualification and education** (Staffing plans, Staffing plans, Opportunities to learn and exchange experiences)					
Presence of **Technology assessment** (Healthcare Technology Assessment (HTA) process to improve service quality, minimize waste, and optimize resources allocations)					
Other:………………………… …					
Other:………………………… …					

H Clinical performance	**1**	**2**	**3**	**4**	**5**
Infection Control (Risk assessment, infection prevention protocols)					
Adopt **drugs administration system** to control adverse drug events					
Other:………………………………					
Other:………………………………					
I Technological performance	**1**	**2**	**3**	**4**	**5**
Use **Information and communication technologies (ICT)** (Electronic health record (EHR), Online access to clinical tests' results)					
Manage **Medical technology obsolesce** (Equipment age, Equipment replacement)					
Other:………………………………					
Other:………………………………					
Social area	Not important	Of little importance	Moderately important	Important	Very important
J Health and well being	**1**	**2**	**3**	**4**	**5**
Reduce **Hazardous materials**(Adhesives and sealants, Paints and coatings, Formaldehyde reduction, Carpet and hard flooring, Ceiling systems)					
Provide adequate **Security/Safety** (security control, Perceived security with regards to theft, Perceived personal safety, Trust in hospital services)					
Provide **Health promotion**(Prevention and promotion campaigns, using of natural and non-toxic materials)					
Attention toward **Well-being** (Comfort: colors, materials, artificial and natural lighting, furniture quality , Clear signals and paths , activities/facilities for staff and patients/ visitors: sport, culture,					

restaurant areas, libraries, WI-FI areas, etc., Quality of green areas and outside views)					
Attention toward **Social aspects** (Discriminatory behavior:, Patient involvement, Spaces for meetings, Hospitality to patients' relatives, collaboration between hospital staff)					
Other:………………………………					
Other:………………………………					
K Space flexibility and adaptability	**1**	**2**	**3**	**4**	**5**
Increase **Space flexibility** (Horizontal or vertical expansion, Free spaces(soft spaces), Rooms for future use, Presence of modular furniture)					
Appropriate **Blocks Distribution** (Blocks typology, distance between the patients rooms and main vertical connections)					
Departments (Departments' position, Presence of relax areas)					
Paths (Corridors' width, separation of paths to enhance access of hospital wards)					
Other:………………………………					
Other:………………………………					
L Comfort	**1**	**2**	**3**	**4**	**5**
Improve **Thermal comfort** (Indoor temperature, Relative humidity, Room temperature control, Humidity control)					
Improve **Indoor air quality** (CO2,CO,NO monitoring, low or zero gassing interior finishing materials, Smoking control, Volatile organic compounds)					
Improve **Lighting comfort** (Good daylight distribution, Lighting Fixture Performance, Lighting controllability, glare control, Illuminance levels)					
Improve **Visual comfort** (Aesthetic impact, Access to views, Visual privacy from the exterior, Access to sunlight)					
Minimize noise levels and provide appropriate **Acoustic**					

comfort					
Other:……………………………					
Other:……………………………					

Q3.2: Please indicate the level of importance of the categories; each category is detailed in Q3.1 above.

Note: please tick (√) your answers.

Environmental area	Not important	Of little importance	Moderately important	Important	Very important
	1	**2**	**3**	**4**	**5**
A Water efficiency					
B Energy efficiency					
C Site and Location quality					
D Waste management					
E Materials					
F Pollution and Risks					
Other………………..					
Economic area	Not important	Of little importance	Moderately important	Important	Very important
	1	**2**	**3**	**4**	**5**
G Management					
H Clinical performance					
I Technological performance					
Other……………………..					
Social area	Not important	Of little importance	Moderately important	Important	Very important
	1	**2**	**3**	**4**	**5**
J Health and well being					
K Space flexibility and adaptability					
L Comfort					
Other…………….					

Appendix C

Developing sustainability assessment Method for hospital – Case of Palestine

A Questionnaire Submitted for the Requirement of Research for the Degree of Master of Engineering Management at Al-Najah National University.

Dear respondent

The main aim of this research is to develop a sustainability assessment tool to be used in the local Palestinian context specifically in West Bank. The developed tool is intended to provide a comprehensive evaluation for operative hospitals and proposes effective solutions.

The tool has a hierarchal structure with the main sustainability area/aspect at the top of the hierarchy. Each area/aspect is evaluated through a number of categories which are the elements concurring to the sustainability of the specific area/aspect. Each category relates to one key aspect of sustainability, and may be described by one or more indicators. This questionnaire aims at assigning weights for the areas, categories, and indicators of the developed tool to suit the Palestinian local context.

A pair wise comparison approach will be carried out to prioritize the aspects/areas, categories, and indicators. The results of the comparisons will be analyzed using Analytical hierarchy process (AHP) to determine the weighting system for sustainability assessment tool for Palestinian hospitals

This questionnaire will be used only for the purpose of academic research

Prepared by: Mohammed Amer

Illustration of filling the survey's questions

In this questionnaire every assessment item (area/aspect, category, and indicator) will be rated according to the degree of relative importance when compared to another assessment item using the Saaty's numerical scale from 1 to 9 as follows:

Degree of importance	Definition
1	Assessment item 'i' and 'j' are of equal importance
3	Assessment item 'i' has a moderate importance over 'j'
5	Assessment item 'i' has a strong importance over 'j'
7	Assessment item 'i' has a very strong or demonstrated importance over 'j'
9	Assessment item 'i' has extreme /absolute importance over 'j'
2,4,6,8	Intermediate values between two adjacent degrees of importance
Reciprocals	Assessment item 'i' has lower importance than 'j'

Direction of filling the question:

- **Each question asks the respondent to assign the relative importance between criterion in row i with criterion in column j at a time.**
- If the weight of 'A' is equally to 'B' your response will be 1, this usually occurs when an assessment item is compared to itself.
- If 'A' is moderately important than 'B', your response will be 3.
- If 'A' is moderately less important than 'B', your response will be 1/3.
- If 'A' is extremely important than 'B', your response will be 9.

Assessment items	A	B	C
A	1		
B		1	
C			1

Could you please perform the following pair wise comparisons to determine the applicable weighing system for hospital sustainability assessment method that suits the Palestinian context?

Notes:

1- Please fill the questionnaire patiently to enable achieve an acceptable level of consistency as lack of consistency may require a refill of the questionnaire

2-please do the pair wise comparisons in the uncolored boxes only don't fill the colored boxes

1-please perform the pair wise comparisons for the main assessment items (sustainability areas/areas).

Sustainability areas/aspects	Environmental area	Economic area	Social area
Environmental area	**1**		
Economic area		**1**	
Social area			**1**

Environmental area: comprises water efficiency, energy efficiency, site quality, waste management, materials, pollution and risks.

Economic area: includes clinical and technological performance.

Social area: includes Health and well-being, Space flexibility and adaptability, and comfort

2-please perform the pair wise comparisons for the assessment categories.

	Water efficiency	Energy efficiency	Site and location Quality	Waste Management	Materials	Pollution and Risks	Management	Clinical performance	Technological performance	Health and well being	Space flexibility and adaptability	comfort
Water efficiency	**1**											
Energy efficiency		**1**										
Site and location Quality			**1**									
Waste Management				**1**								
Materials					**1**							
Pollution and Risks						**1**						
Management							**1**					
Clinical performance								**1**				
Technological performance									**1**			
Health and well being										**1**		
Space flexibility and adaptability											**1**	
Comfort												**1**

3-please perform the pair wise comparisons for the **Water efficiency** indicators.

	Gray water recycling	Rain water harvesting	Water efficient appliances and plumbing fixtures	Water monitoring system	Water strategy	Landscape Irrigation system
Gray water recycling	**1**					
Rain water harvesting		**1**				
Water efficient appliances and plumbing fixtures			**1**			
Water monitoring system				**1**		
Water strategy					**1**	
Landscape Irrigation system						**1**

4-please perform the pair wise comparisons for the **Energy efficiency** indicators.

	Building Envelop Performance	Energy consumption monitoring and management system	Energy sub-metering system	Renewable energy sources	(HVAC) system	Lighting system	Hot water distribution system	Green appliances
Building Envelop Performance	1							
Energy consumption monitoring and management system		1						
Energy sub-metering system			1					
Renewable energy sources				1				
(HVAC) system					1			
Lighting system						1		
Hot water distribution system							1	
Green appliances								1

5-please perform the pair wise comparisons for the **Site and Location quality** indicators.

	Ecological protection of the site	Heat island effect	Recharge of groundwater	Transportation and accessibility	high quality Outdoor Spaces	Hybrid car and sharing
Ecological protection of the site	1					
Heat island effect		1				
Recharge of groundwater			1			
Transportation and accessibility				1		
high quality Outdoor Spaces					1	
car sharing methods						1

6-please perform the pair wise comparisons for the **Waste management** indicators.

	Waste management system	Waste separation and storage
Waste management system	1	
Waste separation and storage		1

7-please perform the pair wise comparisons for the **Materials** indicators.

	Low environment impact materials	durable Materials	Materials Reuse
Low environment impact materials	1		
durable Materials		1	
Materials Reuse			1

8-please perform the pair wise comparisons for the **Pollution and risks** indicators.

	Green house Gas Emissions	Night time light pollution	Pollution management	Refrigerant
Green house Gas Emissions	1			
Night time light pollution		1		
Pollution management			1	
Refrigerant				1

9-please perform the pair wise comparisons for the **Management** indicators.

	Low environment impact materials	Staff qualification and education	Technology assessment
Process efficiency	1		
Staff qualification and education		1	
Technology assessment			1

10-please perform the pair wise comparisons for the **Clinical performance** indicators.

	Infection Control	Drugs management system
Infection Control	1	
Drugs management system		1

11-please perform the pair wise comparisons for the **Technological performance** indicators.

	Information and communication technologies (ICT)	Medical technology obsolesce
Information and communication technologies (ICT)	1	
Medical technology obsolesce		1

12-please perform the pair wise comparisons for the **Health and wellbeing** indicators.

	Hazardous materials	**Security/ Safety**	**Health promotion**	**Well being**	**Social aspects**
Hazardous materials	**1**				
Security/Safety		**1**			
Health promotion			**1**		
Well being				**1**	
Social aspects					**1**

13-please perform the pair wise comparisons for the **Space flexibility and adaptability** indicators.

	Space flexibility	**Blocks Distribution**	**Departments**	**Paths**
Space flexibility	**1**			
Blocks Distribution		**1**		
Departments			**1**	
Paths				**1**

14-please perform the pair wise comparisons for the **Comfort** indicators.

	Thermal comfort	**Indoor air quality**	**Lighting comfort**	**Ventilation**	**Visual comfort**	**Acoustic comfort**
Thermal comfort	**1**					
Indoor air quality		**1**				
Lighting comfort			**1**			
Ventilation				**1**		
Visual comfort					**1**	
Acoustic comfort						**1**

Thank you

Appendix D

Hospital sustainability assessment tool (HSAtool-WB) evaluation form

Part one: Hospital demographic information

1.1 Hospital code ……………………………………………
1.2 location in West Bank : ☐Nourth ☐Center ☐South
1.3 Date of construction: …………………………………….
1.4 Number of beds :…………………………..
1.5 Classification by Specialty: ☐General ☐ Specialized ☐Maternity ☐ Rehabilitation and Physiotherapy
1.6 Services Provider : ☐ MoH ☐Private ☐UNRWA ☐ PMMS
1.7 Quality certificates :………………………….

Part 2: assessment indicators scores:

Environmental area	
A Water efficiency	
Annual **Potable water consumption** in m^3	Consumption:………… notes:
Use **Gray water recycling** to reduce using of potable water	1 2 3 4 5 6 7 8 9 10 notes:
Use **Rain water harvesting** to reduce using of potable water	1 2 3 4 5 6 7 8 9 10 notes:
Use **Water efficient appliances and plumbing fixtures** (Low flush WC's, Showers heads, Washing machines.)	1 2 3 4 5 6 7 8 9 10 notes:
Install **Water monitoring system**(water metering, Leak detection system, Water quality control system)	1 2 3 4 5 6 7 8 9 10 notes:
Adopt **Water strategy** to maintain water systems	1 2 3 4 5 6 7 8 9 10 notes:
Minimize using of potable water for **Landscape Irrigation system** by installing (moisture sensors, drip irrigation, …)	1 2 3 4 5 6 7 8 9 10 notes:
Comments:	
B Energy efficiency	
Annual energy consumption (electricity, natural gas ,and gas oil consumption)	notes:
Building Envelop Performance (thermally resistant envelope, air leakage, ..)	1 2 3 4 5 6 7 8 9 10 notes:
Use **Energy consumption monitoring and management system** (monitor energy consumption and using the manage the data)	1 2 3 4 5 6 7 8 9 10 notes:
Use **Energy sub-metering system** for hospital sections and wards	1 2 3 4 5 6 7 8 9 10 notes:

Increase the capacity of **Renewable energy sources** (solar photovoltaic and solar thermal).	1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 notes:
Use of an **Efficient Heating, ventilation and air conditioning (HVAC) system**(design, pipe insulation, location, etc)	1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 Notes:
Use of efficient **Lighting system** (integrated lighting concept, auto-sensored lighting system)	1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 notes:
Use an efficient **Hot water distribution system**(generation, used energy, distribution)	1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 notes:
Increase the use of **Green appliances** (refrigerators, washing machines, dryers...).	1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 notes:
Comments:	
C Site and location Quality	
Increase **Ecological protection of the site**	1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 notes:
Minimize **Heat island effect**(roofing, paving areas)	1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 notes:
Recharge of groundwater (permeable paving or landscaping).	1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 notes:
Transportation and accessibility (access to public transportation, Distance to amenities, Paths to access the hospital)	1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 notes:
Car parking capacity	notes:
Provide **high quality Outdoor Spaces** (gardens, paths, plants, setting places,etc)	1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 notes:
Use **Hybrid cars and sharing methods**	1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 notes:

Comments	
D Waste Management	
Provide **Waste management system** (3 R's, Auditing of waste streams)	1 2 3 4 5 6 7 8 9 10 notes:
Waste separation and storage	1 2 3 4 5 6 7 8 9 10 notes:
Comments:	
E Materials	
Use **Low environment impact materials** (paints, roofing, walls and floors, detergents ..etc)	1 2 3 4 5 6 7 8 9 10 notes:
Use **durable Materials** (High strength materials that require less maintenance)	1 2 3 4 5 6 7 8 9 10 notes:
Materials Reuse (Reuse of components and materials)	1 2 3 4 5 6 7 8 9 10 notes:
Comments :	
F Pollution and Risks	
Decrease **Greenhouse Gas Emissions**(CO2 mitigation strategy)	1 2 3 4 5 6 7 8 9 10 notes:
Decrease **Night time light pollution** (Internal and external night light pollution)	1 2 3 4 5 6 7 8 9 10 notes:
Pollution management(adopt Pollution response plan)	1 2 3 4 5 6 7 8 9 10 notes:
Refrigerant (Reduce refrigerants environmental impact)	1 2 3 4 5 6 7 8 9 10 notes:

Comments:

Economic area

G	Management
Increase **Process efficiency** (Lean process)	1 2 3 4 5 6 7 8 9 10 notes:
Increase **Staff qualification and education**(Staffing plans, Opportunities to learn and exchange experiences)	1 2 3 4 5 6 7 8 9 10 notes:
Presence of **Technology assessment**(Healthcare Technology Assessment (HTA) process to improve service quality, minimize waste, and optimize resources allocations)	1 2 3 4 5 6 7 8 9 10 notes:
Comments:	

H	Clinical performance
Infection Control (Risk assessment, hospital acquired infections (HAI) prevention protocols)	1 2 3 4 5 6 7 8 9 10 notes:
Adopt drugs **administration system** to control adverse drug events	1 2 3 4 5 6 7 8 9 10 notes:
Comments:	

I	Technological performance
Use **Information and communication technologies (ICT)** (Electronic health record (EHR), Online access to clinical tests' results)	1 2 3 4 5 6 7 8 9 10 notes:
Manage **Medical technology obsolesce** (Equipment age, Equipment replacement)	1 2 3 4 5 6 7 8 9 10 notes:
Comments:	

Social area	
J Health and well being	
Reduce **Hazardous materials**(Adhesives and sealants, Paints and coatings, Formaldehyde reduction, Carpet and hard flooring, Ceiling systems)	1 2 3 4 5 6 7 8 9 10 notes:
Provide adequate **Security/Safety**(security control, Perceived security with regards to theft, Perceived personal safety, Trust in hospital services)	1 2 3 4 5 6 7 8 9 10 notes:
Provide **Health promotion**(Prevention and promotion campaigns, using of natural and non-toxic materials)	1 2 3 4 5 6 7 8 9 10 notes:
Attention toward **Well-being** (Comfort: colors, materials, artificial and natural lighting, furniture quality , Clear signals and paths , activities/facilities for staff and patients/ visitors: sport, culture, restaurant areas, libraries, WI-FI areas, etc., Quality of green areas and outside views)	1 2 3 4 5 6 7 8 9 10 notes:
Attention toward **Social aspects** (Discriminatory behaviour:, Patient involvement, Spaces for meetings, Hospitality to patients' relatives, collaboration between hospital staff)	1 2 3 4 5 6 7 8 9 10 notes:
Comments:	
K Space flexibility and adaptability	
Increase **Space flexibility** (Horizontal or vertical expansion, Free spaces(soft spaces), Rooms for future use, Presence of modular furniture)	1 2 3 4 5 6 7 8 9 10 notes:
Appropriate **Blocks Distribution** (Blocks typology, distance between the patients rooms and main vertical connections)	1 2 3 4 5 6 7 8 9 10 notes:
Departments (Departments' position, Presence of relax areas)	1 2 3 4 5 6 7 8 9 10 notes:
Paths (Corridors' width, separation of paths to enhance access of hospital wards)	1 2 3 4 5 6 7 8 9 10 notes:

Comments:	
L **Comfort**	
provide **Thermal comfort** (Indoor temperature, Relative humidity, Room temperature control, Humidity control)	1 2 3 4 5 6 7 8 9 10 notes:
provide **Indoor air quality** (CO_2,CO,NO monitoring, low or zero gassing interior finishing materials, Smoking control, Volatile organic compounds)	1 2 3 4 5 6 7 8 9 10 notes:
provide **Lighting comfort** (Good daylight distribution, Lighting Fixture Performance, Lighting controllability, glare control, Illuminance levels)	1 2 3 4 5 6 7 8 9 10 notes:
provide **Visual comfort** (Aesthetic impact, Access to views, Visual privacy from the exterior, Access to sunlight)	1 2 3 4 5 6 7 8 9 10 notes:
Minimize noise levels and provide appropriate **Acoustic comfort**	1 2 3 4 5 6 7 8 9 10 notes:
Comments	

Appendix E

Table E-1 Distribution of Hospitals and by Governorate and Specialty, (MOH,2016)

Governorate	General		Specialized		Rehabilitation		Maternity		Total	
	No of hospitals	No of beds	No of hospitals	No of beds	No of hospitals	No of beds	No of hospitals	No of beds	No of hospitals	No of beds
West Bank	**29**	**2,706**	**8**	**679**	**3**	**145**	**11**		**51**	**3,747**
% of beds	**44.0%**		**11.0%**		**2.4%**		**3.5%**		**61.0%**	
Jenin	2	244					1		3	264
Tubas	1	44							1	44
Tulkarm	2	153					1		3	173
Nablus	4	354	3	286					7	640
Qalqiliya	2	125							2	125
Salfit	1	50							1	50
Ramallah &Al Bireh	4	340	2	83	1	27	2		9	480
Jericho & Al Aghwar	1	56							1	56
Jerusalem	4	596	1	48	1	24	1		7	698
Bethlehem	2	149	2	262	1	94	3		8	588
Hebron	6	595					3		9	629
Gaza Strip	**14**	**1,749**	**13**	**527**	**1**	**44**	**2**		**30**	**2,399**
% of beds	**28.5%**		**8.6%**		**0.7%**		**1.3%**		**39.0%**	
North Gaza	4		1	19					5	315
Gaza	4		9	424	1	44	1		15	1,194
Deir Al Balah	1		1	28					2	161
Khan Yunis	4		1	24					5	614
Rafah	1		1	32			1		3	115
Palestine	**43**	**4,455**	**21**	**1,206**	**4**	**189**	**13**	**296**	**81**	**6,146**
% of beds	72.5%		19.6%		3.1%		4.8%		100%	

Table E-2: HSAtool-WB Weighting System

Assessment Areas	Assessment Categories	Assessment indicators	Weight
A1 Environmental Area **(31%)**	**C1** Water efficiency **(30%)**	**I1** Gray water recycling	**4%**
		I2 Rain water harvesting	**15%**
		I3 Water efficient appliances and plumbing fixtures	**33%**
		I4 Water monitoring system	**22%**
		I5 Water strategy	**20%**
		I6 Landscape Irrigation system	**6%**
	C2 Energy efficiency **(33%)**	**I7** Building Envelop Performance	**2%**
		I8 Energy consumption monitoring and management system	**29%**
		I9 Energy sub-metering system	**2%**
		I10 Renewable energy sources	**20%**
		I11 Efficient Heating, ventilation and air conditioning (HVAC) system	**21%**
		I12 Lighting system	**10%**
		I13 Hot water distribution system	**13%**
		I14 Green appliances	**4%**
	C3 Site and location Quality **(3%)**	**I15** Ecological protection of the site	**14%**
		I16 Heat island effect	**4%**
		I17 Recharge of groundwater	**9%**
		I18 Transportation and accessibility	**57%**
		I19 high quality Outdoor Spaces	**4%**
		I20 Hybrid cars and sharing	**13%**
	C4 Waste Management **(15%)**	**I21** Waste management system	**75%**
		I22 Waste separation and storage	**25%**
	C5 Materials **(8%)**	**I23** Low environment impact materials	**42%**
		I24 durable Materials	**46%**
		I25 Materials Reuse	**13%**
	C6 Pollution and Risks **(11%)**	**I26** Greenhouse Gas Emissions	**33%**
		I27 Night time light pollution	**8%**
		I28 Pollution management	**31%**
		I29 Refrigerant	**29%**
A2 Economic area **(49%)**	**C7** Management **(44%)**	**I30**Process efficiency	**26%**
		I31 Staff qualification and education	**41%**
		I32 Technology assessment	**33%**
	C8 Clinical	**I33** Infection control	**67%**
		I34 Drugs administration system	**33%**

	performance **(39%)**		
	C9 Technological performance **(17%)**	**I35**Information and communication technologies (ICT)	**25%**
		I36 Medical technology obsolesce	**75%**
A3 Social area **(20%)**	**C10** Health and well being **(45%)**	**I37**Hazardous materials	**43%**
		I38 Security/Safety	**41%**
		I39 Health promotion	**6%**
		I40 Well being	**6%**
		I41 Social aspects	**4%**
	C11 Space flexibility and adaptability **(48%)**	**I42** Space flexibility	**65%**
		I43 Blocks Distribution	**11%**
		I44 Departments	**10%**
		I45 Paths	**14%**
	C12 Comfort **(7%)**	**I46** Thermal comfort	**20%**
		I47 Indoor air quality	**56%**
		I48 Lighting comfort	**17%**
		I49 Visual comfort	**4%**
		I50 Acoustic comfort	**4%**

Table E-3 Hospitals scores

Hospital code	Location	Date Of Establishment	Speciallty	Service Provider	number of beds	Buildings area (m^2)	Quality certificates	Annual water consumption per bed	Gray water recycling (Score × 10)	Rain water harvesting (Score × 10)	Water fixtures (Score × 10)	Water monitoring (Score × 10)
H1	North	1973	Maternity	Private	18	1500	-	3000	10	10	20	40
H2	Center	2011	Special	Private	44	5500	-	5340	10	10	70	60
H3	Center	2009	General	MoH	40	12000		25116	10	10	30	30
H4	North	1900	General	Private	50	4500	-	6500	10	10	20	30
H5	North	1990	General	Private	60	7000	-	14400	10	10	20	30
H6	Center	1990	Maternity	Private	10	500	-	400	10	10	20	20
H7	Center	1999	Special	Private	27	900	-	7000	10	10	30	40
H8	North	1993	Special	Private	10	1000	-	3000	10	10	20	30
H9	North	1970	General	Private	51	4000	-	7200	10	10	30	40
H10	North	2000	Special	Private	90	4500	ISO 9001:2015	15000	10	10	50	60
H11	Center	1998	Special	Private	39	4500	-	13500	10	10	50	50
H12	Center	1993	General	Private	45	1600		18500	10	10	30	50
H13	Center	2002	General	MoH	50	3500	-	6850	10	10	40	40
H14	North	2014	General	MoH	43	1200	-	9200	10	10	60	60
H15	North	1996	General	MoH	160	9400	-	24000	10	10	40	50
H16	North	2002	Special	Private	50	5000	-	6720	10	10	50	40
H17	North	1890	General	MoH	106	4000	-	7080	10	10	30	40
H18	Center	1990	Maternity	Private	25	500		2666	10	10	40	40
H19	North	1996	Special	Private	54	4200	-	13500	10	10	40	60
H20	South	1997	General	MoH	54	3174	-	47000	70	10	50	40
H21	South	2004	General	MoH	75	3500	-	8400	10	10	40	50

H22	North	1976	General	MoH	200	7000	-	18984	10	10	30	50
H23	North	2013	Special	Private	139	17000	GSI-ISO9001	32850	10	10	70	60
H24	South	1999	Special	Private	85	9000		17654	10	10	60	60
H25	North	1961	General	MoH	210	14000	-	20000	10	10	30	40
H26	South	1993	General	Private	250	12000		29000	10	10	50	60
H27	South	1955	General	MoH	131	8600		23000	10	10	20	40
H28	South	1957	General	MoH	237	22000		27000	10	10	30	40

Water strategy(Score × 10)	Landscape irrigation(Score × 10)	Annual Energy consumption per bed	Envilope performance(Score × 10)	Energy monitoring(Score × 10)	Energy sub-monitoring(Score × 10)	Renewable energy(Score × 10)	HVAC system(Score × 10)	Lighting system(Score × 10)	Hot water system(Score × 10)	Green appliances(Score × 10)
10	40	240000	40	60	10	10	40	40	40	40
20	70	672000	70	60	10	10	80	70	60	60
10	70	900000	50	50	10	10	60	50	70	50
10	50	1032000	40	30	10	10	30	40	40	50
10	80	1020000	40	40	10	10	50	40	40	40
10	60	1000	30	40	10	10	30	40	50	50
10	80	197000	50	50	10	10	60	50	50	50
10	70	15800	50	30	10	10	40	40	40	30
10	40	567000	30	40	10	10	40	30	40	30
20	80	1000000	70	70	50	10	70	60	70	50
20	80	415340	60	60	10	10	70	50	60	60
10	80	780560	60	50	10	10	50	40	60	50
10	60	804143	70	60	10	10	70	60	60	60
10	70	1270000	80	60	10	10	80	70	70	70

10	80	1080000	60	50	10	10	60	40	70	50
20	30	827400	60	30	10	10	50	40	40	50
10	60	998650	40	50	10	10	30	40	60	40
10	80	65000	40	50	10	10	50	40	50	30
20	80	627158	60	60	10	10	60	60	70	70
10	80	1500000	60	60	10	10	60	60	60	50
10	20	620904	70	40	10	20	60	60	50	30
20	80	2000000	50	50	10	10	60	40	70	50
30	40	1720000	70	70	40	70	80	70	70	60
20	60	980000	70	60	10	10	70	60	60	50
10	40	2380000	50	50	10	20	50	40	50	50
20	30	2600000	60	60	10	80	70	50	80	60
10	80	2050000	40	50	10	10	40	40	60	30
10	80	2300000	50	50	10	10	40	50	70	40

Site Ecological protection(Score × 10)	Heat island effect(Score × 10)	Recharge of groundwater(Score × 10)	Transportation & accessibility(Score × 10)	Outdoor Spaces quality (Score × 10)	Hybid cars and sharing(Score × 10)	Waste management system (Score × 10)	Waste separation and storage(Score × 10)	Low environment impact materials(Score × 10)	Materials durability(Score × 10)
70	10	10	80	30	30	20	50	50	50
80	10	10	80	50	10	20	50	40	70
70	10	10	80	60	40	20	50	40	60
70	10	30	60	60	50	20	50	40	50
70	10	10	70	40	50	20	50	30	40
70	10	20	70	40	40	20	50	30	50
80	10	10	80	30	30	20	50	40	70
80	10	10	80	30	40	20	50	40	60

70	10	10	70	30	30	20	50	30	70
80	10	10	80	30	50	40	60	40	80
80	10	10	80	30	40	30	60	50	80
80	10	10	70	10	50	20	50	60	70
70	10	10	80	50	50	20	50	60	80
70	10	10	80	70	50	20	50	40	80
70	10	10	80	30	30	20	50	30	40
80	10	10	80	40	50	20	50	50	80
70	10	10	80	50	50	10	50	40	70
70	10	10	80	30	50	30	50	60	70
80	10	10	80	30	50	30	50	60	80
80	10	10	70	60	50	20	50	60	80
70	10	10	80	30	50	40	60	20	70
80	10	10	80	40	50	20	50	60	70
70	10	10	80	70	50	50	70	60	80
80	10	10	80	70	50	30	50	60	80
70	10	10	70	40	40	10	50	50	60
80	10	10	80	60	50	10	60	60	80
80	10	10	80	40	50	10	50	50	60
80	10	10	80	50	50	10	50	60	70

Materials Reuse (Score × 10)	Green house Gas Emissions (Score × 10)	Night time light pollution (Score × 10)	Pollution management(Score × 10)	Refrigerant(Score × 10)	Process efficiency(Score × 10)	Staff qualification(Score × 10)	Technology assessment(Score × 10)	Infection control(Score × 10)	Drugs administration system(Score × 10)	Information systems (Score × 10)
30	10	50	20	50	50	40	30	30	30	40

30	10	50	30	80	70	50	60	60	40	70
30	10	50	20	70	70	60	60	60	40	70
40	10	50	30	60	70	70	50	60	30	60
20	10	50	30	60	70	60	50	60	30	50
20	10	40	20	40	20	30	30	20	20	10
40	10	60	30	70	70	70	40	60	30	40
20	10	60	20	30	60	70	40	40	20	20
40	40	50	30	40	70	50	40	50	20	70
50	50	50	40	80	70	70	60	70	40	80
30	10	60	40	80	70	70	50	70	40	70
50	30	70	50	80	70	50	50	70	30	70
40	40	70	30	80	70	70	60	70	30	80
40	10	80	30	80	70	70	60	70	30	80
20	10	60	30	70	70	60	60	60	30	80
50	10	60	50	70	70	60	40	70	30	50
40	10	60	20	70	70	60	50	70	20	80
40	10	50	20	70	60	70	30	30	20	10
50	10	70	40	80	70	70	60	70	30	70
40	10	70	40	70	70	60	50	70	40	70
50	30	60	40	80	70	60	60	70	30	50
40	50	70	40	80	70	70	60	60	30	80
50	10	50	40	80	70	70	60	70	40	80
50	10	60	40	80	70	70	60	70	40	80
40	10	60	40	60	70	60	50	60	40	70
50	10	10	40	70	80	70	70	70	40	80
40	10	60	30	70	70	70	50	60	30	70
40	10	60	30	80	70	70	60	60	30	70

Medical technology obsolesce (Score × 10)	Hazardous materials (Score × 10)	Security/ Safety (Score × 10)	Health promotion (Score × 10)	Well being (Score ×10)	Social aspects (Score × 10)	Space flexibility (Score × 10)	Blocks Distribution (Score × 10)	Departments (Score × 10)	Paths (Score × 10)	Thermal comfort (Score × 10)
20	30	30	10	40	50	60	40	40	30	50
50	50	60	50	70	70	70	70	70	70	70
50	30	60	20	50	50	60	70	60	50	50
50	40	60	40	40	60	70	60	50	40	50
40	40	40	30	30	50	70	50	30	30	40
30	30	10	10	30	40	20	40	30	40	30
30	40	30	20	30	30	30	40	40	40	60
30	30	50	50	30	40	30	50	40	40	40
30	30	60	60	30	50	30	50	50	40	60
50	60	70	60	60	70	20	70	50	70	70
40	60	50	30	50	60	50	70	60	50	50
40	60	60	50	50	60	50	70	50	40	60
50	60	60	30	70	50	70	70	50	60	60
60	60	60	30	70	60	70	70	60	60	70
50	40	60	40	40	40	50	60	50	50	50
30	30	50	60	40	40	50	60	60	60	50
50	40	60	60	30	50	10	50	40	40	60
20	30	40	10	30	30	70	50	50	40	60
50	50	60	60	50	50	70	60	60	70	60
40	40	50	10	50	50	70	40	50	50	60
50	30	30	30	50	50	70	60	30	30	50
50	40	60	40	30	50	40	60	50	50	60
70	60	60	60	70	60	70	50	60	60	70
60	50	70	60	70	70	70	60	50	50	60
50	40	60	40	40	40	60	50	40	50	50
50	50	60	60	60	40	60	60	50	50	60

50	50	60	40	30	40	60	60	40	40	60
50	50	70	40	30	40	60	60	50	40	50

Indoor air quality(Score × 10)	Lighting comfort(Score × 10)	Visual comfort (Score × 10)	Acoustic comfort(Score × 10)	Water effeciency	Energy effeciency	Site	Waste management	Materials	Pollution	Management Performance
40	30	40	40	21.69	39.12	61.54	27.50	47.48	27.75	39.33
70	70	70	70	46.35	54.05	61.05	27.50	52.48	39.46	58.47
50	50	60	60	24.66	45.60	64.02	27.50	47.90	33.51	62.60
50	50	60	50	20.13	28.70	55.63	27.50	44.58	33.70	63.46
40	40	40	40	21.99	35.34	58.83	27.50	33.32	33.70	59.33
30	30	50	30	18.57	32.69	58.39	27.50	37.90	24.08	27.40
40	40	40	40	27.46	43.10	62.89	27.50	53.74	37.37	60.19
20	30	30	30	21.37	30.14	64.20	27.50	46.64	22.78	57.59
30	50	40	40	24.98	31.75	55.82	27.50	49.58	37.72	51.93
70	70	50	50	40.39	55.69	65.51	45.00	59.58	55.57	66.73
50	60	50	50	38.21	49.91	64.20	37.50	61.22	43.32	63.46
60	50	50	50	29.64	41.52	59.01	27.50	63.32	53.70	55.20
60	60	70	60	29.51	51.04	64.94	27.50	66.64	50.82	66.73

50	70	70	60	41.07	55.88	65.72	27.50	58.32	41.83	66.73
40	50	50	40	32.93	44.83	61.54	27.50	33.32	37.37	62.60
40	40	50	50	32.93	33.18	65.90	27.50	63.74	43.51	56.06
40	60	30	30	26.22	36.64	64.94	20.00	53.74	34.30	59.33
50	40	50	30	30.75	39.11	64.16	35.00	62.06	33.51	54.32
50	50	50	50	37.10	50.45	65.51	35.00	67.90	44.11	66.73
60	50	60	50	36.38	48.40	60.96	27.50	66.64	41.23	59.33
60	60	60	40	29.21	42.71	64.16	45.00	46.68	49.84	62.60
60	60	40	50	31.63	44.65	65.90	27.50	62.06	57.15	66.73
70	70	70	60	46.48	71.00	65.72	55.00	67.90	42.53	66.73
70	60	70	60	42.44	50.64	67.07	35.00	67.90	43.32	66.73
50	50	60	40	24.98	42.11	57.52	20.00	53.32	37.56	59.33
60	60	70	50	37.29	66.55	66.68	22.50	67.90	36.49	72.60
60	50	40	40	24.17	38.30	65.90	20.00	53.32	37.37	63.46
60	60	40	40	27.46	41.08	66.29	20.00	62.06	40.25	66.73

Clinical Performance	Technological performance	Health and well being	Space flexibility	Comfort	Environmental area	Economic area	Social area	Overall Score	Benchmarks
30.00	25.00	30.26	51.63	40.28	32.21	33.30	41.15	34.50	UNCLASSIFIED
53.34	55.00	56.16	70.00	70.00	46.24	55.90	63.74	54.43	PASS
53.34	55.00	43.68	59.75	50.77	35.99	57.73	51.84	49.81	PASS
50.01	52.50	48.94	62.75	50.36	28.58	56.40	55.62	47.60	PASS
50.01	42.50	39.17	58.24	40.00	30.56	52.88	48.31	45.04	PASS
20.00	25.00	21.09	25.99	30.72	27.92	24.13	24.12	25.31	UNCLASSIFIED
50.01	32.50	33.69	33.50	43.92	36.86	51.57	34.34	43.62	UNCLASSIFIED
33.34	27.50	39.73	34.62	26.37	28.64	43.12	36.34	37.29	UNCLASSIFIED
40.01	40.00	44.80	35.63	40.01	31.88	45.30	40.09	40.11	UNCLASSIFIED
60.01	57.50	64.47	35.48	68.46	50.07	62.57	50.96	56.41	PASS
60.01	47.50	53.50	53.25	51.68	45.11	59.43	53.25	53.76	PASS
56.68	47.50	58.76	50.87	57.55	39.43	54.47	54.92	49.88	PASS
56.68	57.50	58.43	66.61	60.36	42.63	61.28	62.46	55.71	PASS
56.68	65.00	58.84	67.62	58.41	46.10	62.55	62.99	57.52	PASS
50.01	57.50	48.12	51.12	44.00	37.48	56.87	49.25	49.35	PASS

56.68	35.00	40.97	53.50	42.73	36.82	52.74	47.06	46.68	PASS
53.35	57.50	49.09	21.62	46.51	32.97	56.71	35.83	45.23	PASS
26.67	17.50	32.86	61.63	49.46	37.91	37.40	47.75	39.59	UNCLASSIFIED
56.68	55.00	54.66	67.87	51.96	45.22	60.86	60.75	55.97	PASS
60.01	47.50	43.31	61.88	57.91	42.64	57.59	53.20	52.08	PASS
56.68	50.00	32.10	59.36	57.22	40.77	58.18	46.88	50.55	PASS
50.01	57.50	47.89	44.62	58.87	41.57	58.70	47.12	51.10	PASS
60.01	72.50	60.64	65.38	69.59	57.59	65.10	63.54	62.46	BRONZE
60.01	65.00	60.82	64.12	65.95	46.86	63.84	62.76	58.35	PASS
53.34	55.00	48.12	55.49	49.95	34.48	56.28	51.76	48.61	PASS
60.01	57.50	54.89	57.62	59.95	47.86	65.18	56.55	58.10	PASS
50.01	55.00	51.77	55.24	56.78	33.24	56.83	53.78	48.89	PASS
50.01	55.00	55.83	56.25	56.50	36.15	58.28	56.08	50.96	PASS

جامعة النجاح الوطنية
كلية الدراسات العليا

تقييم الإستدامة للمستشفيات في الضفة الغربية

إعداد
محمد سليم عامر

إشراف
د. أحمد الرمحي
د. يحيى صالح

قُدمت هذه الأطروحة إستكمالاً لمتطلبات الحصول على درجة الماجستير في الإدارة الهندسية بكلية الدراسات العليا في جامعة النجاح الوطنية في نابلس ، فلسطين
2019

تقييم الإستدامة للمستشفيات في الضفة الغربية

إعداد

محمد سليم عامر

إشراف

د. أحمد الرمحي

د. يحيى صالح

الملخص

تعد المستشفيات أهم عنصر في قطاع الرعاية الصحية والذي يهدف بشكل أساسي إلى الحفاظ على صحة أفضل للمجتمع ويساهم في تحقيق الرفاهية الوطنية. ومع ذلك، فإن المستشفيات لديها أنظمة معقدة ذات تأثير اجتماعي واقتصادي وبيئي. فلسطين بلد نام يعاني من العديد من التحديات البيئية والاقتصادية والاجتماعية. فهو بحاجة ماسة إلى تطبيق مفاهيم التنمية المستدامة في القطاعات جميعها بما في ذلك قطاع الرعاية الصحية. توفر أدوات تقييم الاستدامة إطارًا فعالًا لتقييم أداء المستشفى وتوجيهه من حيث المنظورات البيئية والاقتصادية والاجتماعية ودمج مفهوم التنمية المستدامة في تخطيط المستشفيات وإدارتها وتشغيلها.

انطلاقًا من هذه الافتراضات، تهدف هذه الدراسة إلى تطوير أداة لتقييم استدامة مستشفيات الضفة الغربية وتحسينها؛ ولتحقيق هذا الهدف، تبنى البحث منهجية متعددة الأبعاد تضمنت جمع العديد من أنواع البيانات وتحليلها وتفسيرها، حيث تم الحصول على البيانات من مصادر متعددة باستخدام التقنيات المختلفة. تبدأ الدراسة بإنشاء المجموعة الأولى من عناصر التقييم للأداة من خلال دراسة الأدبيات ذات الصلة، واستكشاف عدد من أدوات تقييم الاستدامة المعروفة. بعد ذلك، تم تنقيح عناصر التقييم وفقًا لمدى ملاءمتها لسياق الضفة الغربية. تم ذلك من خلال تسليط الضوء على السياق المحلي للضفة الغربية وإجراء مقابلات منظمة (لملء استبيان) مع (60) خبيرًا محليًا. علاوة على ذلك، عند تطبيق المقارنات الزوجية وعملية التحليل الهرمي (AHP)، كان من الممكن تطوير نظام أوزان يتم فيه تحديد أولويات عناصر التقييم المقترحة وفقًا لظروف الضفة الغربية. حيث أُجريت المقارنات الزوجية في شكل مقابلات منظمة (لملء استبيان) مع 30 خبيرا. نتيجة

البحث هي أداه لتقييم إستدامة المستشفيات تُلائم سياق الضفة الغربية (HSAtool-WB). الاداة منظمة في هيكل هرمي من ثلاثة مستويات: يوجد خمسون مؤشرا في اسفل التسلسل الهرمي، ثم، في المستوى المتوسط، يتم تنظيم المؤشرات في 12 فئة. يتم توزيع هذه الفئات عبر ثلاثة مجالات رئيسية تغطي الأبعاد البيئية والاقتصادية والاجتماعية للاستدامة.

تم تطبيق HSAtool-WB لتقييم الاستدامة في 28 من المستشفيات الفلسطينية في الضفة الغربية. أظهرت النتائج أن مستشفيات الضفة الغربية لا تعتمد ممارسات مستدامة كما ينبغي أن تكون. حيث حققت درجة الاستدامة الكلية للمستشفيات التي تم تقييمها فقط حوالي 100/49 نقطة. كما وجد أن نتائج المؤشرات البيئية كانت الأقل في حين حققت المستشفيات نتائج أفضل في المؤشرات الاقتصادية والاجتماعية.

أخيرًا، أوصت الدراسة بالعديد من الاستراتيجيات المستدامة من حيث التكلفة لتحسين استدامة مستشفيات الضفة الغربية بناءً على نقاط الضعف التي تم تحديدها خلال تقييمات المؤشرات.