AN INVESTIGATION OF CRITICAL SUCCESS FACTORS FOR GREEN RETROFITTING OF EXISTING HEALTHCARE BUILDINGS

A Thesis

By

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Submitted to the
Graduate School of Sciences and Engineering
In Partial Fulfillment of the Requirements for
the Degree of

Master of Architecture
in the
Department of Architecture

Özyeğin University
January 2020

AN INVESTIGATION OF CRITICAL SUCCESS FACTORS FOR GREEN RETROFITTING OF EXISTING HEALTHCARE BUILDINGS

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To Soner, Dilşad, and Ece…

ABSTRACT

AN INVESTIGATION OF CRITICAL SUCCESS FACTORS FOR GREEN RETROFITTING OF EXISTING HEALTHCARE BUILDINGS

The fundamental principle of health care practice is ‘first do no harm,’ but ironically, the activities of healthcare itself consume critical pollution, and, consequently, indirect adverse effects on public health. Concerted efforts to enhance the sustainability performance of existing healthcare buildings could reduce impacts directly through waste and carbon footprint reduction, saving of energy, and indirectly through reducing pollution. Therefore, the first motivation is that existing healthcare buildings are large users of energy, and they contribute an opportunity and potential to mitigate these resources consumption for the sustainability performance of existing healthcare buildings. At this point, the green healthcare building can be identified as one that improves occupant well-being and assist the healing process while using natural resources.

In the green buildings’ research agenda, the relationship between buildings and health has drawn considerable attention over the last two decades. Thus, the second motivation for healthcare buildings is to incorporate construction, sustainable green design as well as operating practices. That action improves not only indoor environmental quality but also the health of patients, professionals, staff, and visitors.

Several studies have shown that green healthcare buildings have various positive outcomes, such as reducing the recovery duration of patients, improving the health and well-being of patients, and improving the performance of staff. In the existing literature, there is much published about the going green of the healthcare buildings which will be newly constructed, but there is more limited literature available about the green retrofitting of existing healthcare buildings (GREHB). Hence, the objectives of this thesis are;

i) to do comprehensive literature research to put the research in context

ii) to identify, to categorize, and prioritize a set of critical success factors (CSFs) for prospering green retrofitting of existing healthcare building projects.

iii) to develop a conceptual CSFs framework for GREHB

In the context of this thesis, initial CSFs were identified according to a structured literature review and categorized systematically based on GREHB. A questionnaire survey was designed according to identified CSFs and applied to get thoughts about the CSFs for retrofitting of existing healthcare buildings from academics and professionals who have experience in green buildings. According to the results of the questionnaire survey, a conceptual CSFs framework for GREHB was finalized. Furthermore, the developed framework was presented to professionals and practitioners from the industry and its validity and reliability were validated by them.

This set of CSFs can be used as potential inputs, which can be considered as a possible checklist for practitioners and stakeholders when conducting a green retrofitting of a healthcare project in the preparation phase. Therefore, this study will be beneficial for the implementation of green retrofitting of existing hospitals and any future research related to this subject.

ÖZET

MEVCUT HASTANE BİNALARININ YEŞİL DÖNÜŞÜMÜ İÇİN KRİTİK BAŞARI FAKTÖRLERİNİN BİR ARAŞTIRMASI

Sağlık uygulamalarının temel ilkesi "önce zarar verme" dir, ancak ironik bir şekilde, sağlık hizmetleri faaliyetlerinin kendisi önemli derecede kirliliğe ve dolayısıyla halk sağlığı üzerinde dolaylı olumsuz etkilere neden olabilmektedir. Mevcut sağlık binalarının sürdürülebilirlik performansını arttırmaya yönelik çabalar doğrudan atık ve karbon ayak izini azaltma, enerji tasarrufları ve dolaylı olarak kirliliği azaltmak yoluyla doğrudan etkileri azaltabilir. Bu noktada, yeşil sağlık binası, çevre dostu tutumda doğal kaynaklar kullanırken aynı zamanda iyileşme sürecine yardımcı olan, hastaların ve çalışanların refahını artıran bir yapı olarak tanımlanabilir. Bu nedenle, yeşil olmanın ilk motivasyonu mevcut sağlık binalarının büyük enerji tüketicileri olmaları sebebiyle sürdürülebilirlik performansı adına söz konusu kaynakların tüketimini azaltma potansiyeli sunmasıdır.

Yeşil binaların araştırma gündeminde, binalar ve sağlık arasındaki bağlantı son yirmi yılda artan bir ilgi görmüştür. Bu nedenle, sağlık tesisleri için ikinci motivasyon sürdürülebilir yeşil tasarım, yapım ve işletme uygulamalarını bir araya getirmektir. Bu yaklaşım sadece iç mekân çevre kalitesini değil aynı zamanda hastaların, profesyonellerin, çalışanların ve ziyaretçilerin sağlığını, konforunu da olumlu etkiler.

Birçok araştırma, yeşil hastane binalarının hastaların iyileşme süresinin azaltılması, hastaların sağlık ve konforu ile çalışan personelin performansını arttırması gibi çeşitli olumlu sonuçlar doğurduğunu göstermiştir. Güncel literatürde, yeni inşa edilecek olan sağlık binalarının yeşil dönüşümü ile ilgili çok fazla yayın bulunmaktadır, ancak mevcut sağlık binalarının yeşil dönüşümleri/yenilenmeleri konusunda daha sınırlı bir literatür mevcuttur. Dolayısıyla, bu tezin amaçları;

i) araştırmanın bağlamını ortaya koymak adına kapsamlı bir literatür araştırması yapmak,

ii) mevcut sağlık binalarının yeşil dönüşümü için kavramsal bir çerçeve geliştirmek.

iii) mevcut sağlık yapılarını yeşil bina haline getirmek için kavramsal çerçeve ile uyumlu bir dizi kritik başarı faktörünü belirlemek, kategorize etmek ve önceliklendirmek,

Bu tez kapsamında kritik başarı faktörleri yapılandırılmış bir literatür taramasına göre tanımlanmış ve mevcut sağlık binalarının yeşil dönüşümü bağlamında sistematik olarak kategorize edilmiştir. Belirlenen kritik başarı faktörlerini içeren bir anket formu tasarlanarak mevcut sağlık binalarının yeşil güçlendirilmesi/dönüşümü için yeşil binalar hakkında konusunda deneyimli akademisyenlerden ve profesyonellerden kritik başarı faktörleri hakkında değerlendirmelerini almak için uygulanmıştır. Anket sonuçlarına göre, mevcut sağlık binalarının yeşil dönüşümü/güçlendirilmesi için önerilen kavramsal çerçeve son haline getirilmiştir. Ayrıca, geliştirilen çerçeve akademisyenler ve sektörden profesyonellere gösterilerek geçerliliği sınanarak doğrulanmıştır.

Tez kapsamında belirlenen mevcut sağlık yapılarının yeşil dönüşümlerine ilişkin kritik başarı faktörleri seti, süreçteki paydaşlar için olası bir kontrol listesinin hazırlık aşamasında düşünülebilecek potansiyel girdiler olarak kullanılabilir. Bu nedenle, bu çalışma mevcut sağlık yapılarının yeşil dönüşüm uygulamaları için ve bu konuyla ilgili gelecekteki herhangi bir araştırma için faydalı olacaktır.

ACKNOWLEDGEMENTS

First of all, I am deeply grateful to my thesis advisor Dr.Işılay TEKÇE who is more than a thesis advisor to me and has always been there for me with her endless patience, motivation, and support. During my master's years, it was an excellent opportunity for me to work with someone who has always supported me with her vision and academic knowledge as an advisor.

I would like to thank my thesis committee members, Dr. Touraj ASHRAFİAN and Prof. Dr. Begüm SERTYEŞİLIŞIK, for their valuable time and their kindly acceptance of being members of the thesis committee.

As well, I would like to express my sincerest thanks to my friends who always supported and encouraged me during each phase of my thesis.

Finally, I must express my biggest gratitude to my father, mother, and sister for their endless and loving support, patience, and encouragement throughout this thesis process. Especially, I am grateful to my father for his unlimited, loving support and assistance to finalize my thesis. I know he is always there for me, even if he can't see that I completed my thesis..

January 2020 Aslıhan ERGİN

Architect

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LIST OF ACRONYMS / ABBREVIATIONS

AEDET: Achieving Excellence Design Evaluation Toolkit

ARBİS: Researcher Information System

ASPECT: A Staff and Patient Environment Calibration Tool

BEER: Building Energy Efficiency Retrofits

BREEM: Building Research Establishment Assessment Method

CASSBEE: Comprehensive Assessment System for Building Environment Efficiency

CEN: European Committee for Standardization

CHD: Center for Healthcare Design

CSFs: Critical Success Factors

DFD: Design for Disassembly

DGNB: German Sustainable Building Council

ECMs: Energy Conservations Measures

EMS: Environmental Management System

EPC: Energy Performance Contracting

GBCA: Green Building Council of Australia

GBI: Green Building Index

GBTs: Green Building Technologies

GGHC: Green Guide for Health Care

GGHH: Global Green and Healthy Hospitals

GHBD: Green Hospital Building Development

GHG: Greenhouse Gas Emissions

GREB: Green Retrofitting of Existing Buildings

GREHB: Green Retrofitting of Existing Healthcare Buildings

HBSA: Healthcare Building Sustainability Assessment

HCWH: Health Care Without Harm

HHF's: Hospitals and Healthcare Facilities

HSE: Health Safety Environment

HVAC: Heating Ventilating and Air Conditioning

IAQ: Indoor Air Quality

IDM: Integrated Retrofit Design Methodology

ISO: International Organizations for Standardization

IT: Information Technology

LEED: Leadership in Energy and Environmental Design

M&V: Measurement and Verification

OH&S: Occupational Health and Safety

POE: Post Occupancy Evaluation

ROI: Return on Predictable Investments

SCO: Sustainable Campus Operation

TUBİTAK: Scientific and Technological Research Council of Turkey

USGBC: U.S. Green Building Council

WHO: World Health Organization

CHAPTER I

I. INTRODUCTION

Sustainability has environmental, social, economic, cultural, and structural components, and it is also a way to provide a balance between nature and human beings [1]. Due to environmental concerns sustainability has become a common research area [2]. Notably, enhancing sustainability has become an extensive concern in the construction industry (CI) since buildings consume large amounts of natural resources and total energy and produce excessive CO_2 emissions as well as waste [3].

The importance of sustainability at the building level has led to an increase in green building practices in the CI. Aspect of the ways of living, people spend their time mostly in buildings so, while enhancing the sustainability performance of buildings, it is significant to enhance the indoor environmental quality (IEQ) as well as well-being and health for building occupants [4].

Notably, in terms of well-being and health, the healthcare industry has a critical part in providing a healthy future for healthcare buildings' patients and staff [5]. The IEQ of healthcare buildings has direct effects on the healing progress and wellbeing of patients [5]. For this reason, sustainability and creating green healthcare buildings have become a substantial concern for the healthcare industry [6]. Not surprisingly, the number of green healthcare buildings' implementations gained a rapid increase worldwide [5]. As a result of this movement, green healthcare buildings became a significant consideration for this research due to the rapid increase of green hospital implementations.

However, creating new environmentally friendly buildings solely does not reduce the environmental effects of the existing building stock [7]. Also, existing healthcare buildings contribute to large amounts of energy usage and contribute to large amounts of emission of harmful gases and particles into the environment, which have a negative influence on the environment [8]. The GREHB has an essential effect on reducing energy consumption, improving the indoor environment, having a smaller carbon footprint, and extending these existing buildings' life cycle [9]. Thus, mitigating the harmful impacts of existing healthcare building stock on the environment is became the main concern for this thesis. This research on GREHB is crucial to reduce the harmful impacts of healthcare buildings and to minimize their environmental footprints.

1.1. Problem Definition

Green retrofitting or refurbishment or greening is a rising trend for green building providers to improve the sustainability performance of existing buildings. In the last decade, retrofitting of existing healthcare buildings has become an important topic, especially in Italy, the United Kingdom, Malaysia, and the United States. In the existing literature, there are studies about existing healthcare buildings refurbishment frameworks with a focus on energy [10], [11], structural upgrading studies based on seismic retrofitting of hospital buildings [12], studies with a stakeholder focus [13] and patients' safety focus [14], and on greening strategies of children's hospitals in the aspects of design, construction, operations, and maintenance [15].

Uniquely, a significant number of decisions need to be accepted during green retrofitting phases since the decision of various determinants can lead to project failure or success. Further, the retrofitting of healthcare buildings includes challenging issues that have essential impacts on staff and patients in terms of infection control and occupants' safety issues [14]. So, the determination of CSFs for GREHB is necessary to achieve the main greening project goals and the main healthcare goals. Moreover, in the literature, there are also studies mainly based on the CSFs for green retrofitting of existing buildings (GREB) [16], [17], [18], [19], and [20].

Despite the growing works of literature associated with the identification of CSFs for green retrofitting, review of the literature demonstrates to us that there is an absence of comprehensive study about the identification of CSFs for green retrofitting with a particular focus on healthcare buildings. Also, there is an absence of a conceptual CSFs framework for GREHB with a holistic view. Therefore, this thesis focuses on the investigation of CSFs for GREHB. Investigation of CSFs will contribute to the success of GREHB during pre-retrofit, retrofit, and after-retrofit stages.

1.2. Aims and Objectives

The primary aims are;

- to investigate the CSFs for GREHB that can assure the success of GREHB,
- to develop a holistic conceptual framework for GREHB

The secondary objectives are;

- to identify the current sustainability-related approaches in the healthcare sector, especially at the building level
- to review the green retrofitting literature specific to the healthcare sector,

Findings of this research can contribute to creating green retrofitting knowledge in the healthcare environment, improving the academic understanding, and helping to reach successful retrofit operations of healthcare buildings for green healthcare providers, professionals, and academics.

1.3. Research Methodology

The research methodology of this thesis involves;

- the investigation and identification of CSFs for GREHB through a structured literature review
- the development of a conceptual CFSs' framework for GREHB
- conducting a questionnaire using the CSFs obtained from a structured literature review
- revision of CSFs set and framework considering the questionnaire survey' results
- an investigation of the validity of the framework by getting experts' opinions for finalizing the conceptual framework. Figure 1. represents these activities and the outputs obtained and their place in this thesis.

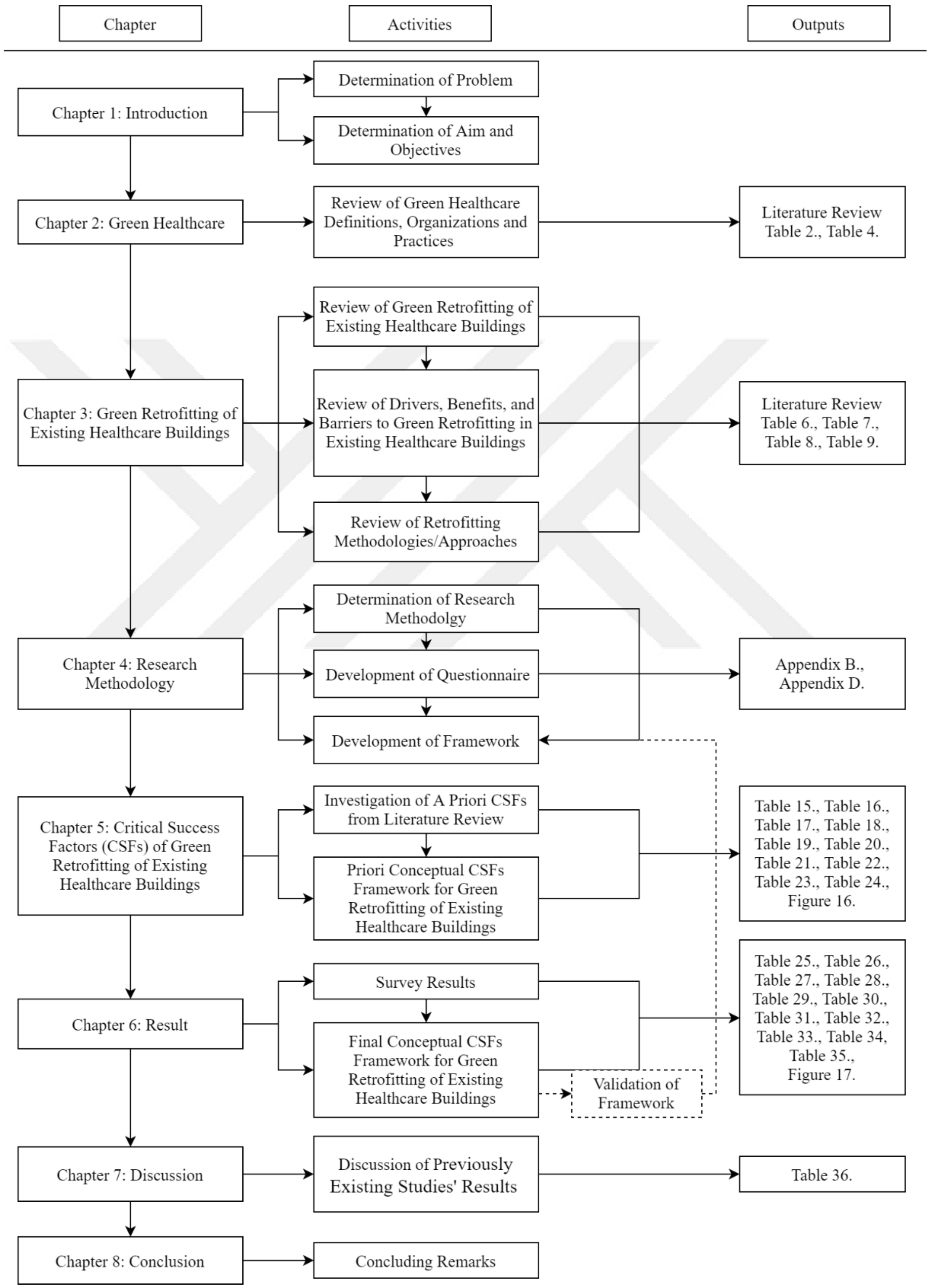


Figure 1: The research methodology flow chart

1.4. Thesis Structure

In chapter 1, problem definition, aims and objectives, limitations, methodology, as well as the structure of this thesis are explained.

In chapter 2, the evolution of sustainable development (SD) in the healthcare environment is clarified, the critical role of sustainability for the healthcare sector is highlighted, and green healthcare buildings and their sustainability performance assessment implementations are explained.

In chapter 3, the necessity of GRHEB are identified, the various types of green retrofit implementations and methodologies are explained, and the main drivers, benefits, and barriers to GRHEB are determined.

In chapter 4, the research methodology is presented. Questionnaire design and administration procedure of the survey, pilot study, and analysis are explained.

In chapter 5, the CSFs of green retrofitting are defined, and the comprehensive CFSs for GRHEB are constructed. The conceptual CSFs framework for GRHEB is presented.

In chapter 6, the results of the study are given. It involves the results and analysis of the questionnaire survey.

In chapter 7, the results of the study are discussed, and the CSFs and conceptual framework for GRHEB are finalized.

In chapter 8, concluding remarks are made.

1.5. Research Limitation

This study has been focused on GREHB, and this research has certain limitations in terms of the research focus. The renovation of historic buildings and adaptive reusing of existing structures were beyond the scope of this research. Green retrofitting or refurbishment is a broad topic, including different perspectives from various disciplines. The renovation of historical hospitals should be considered in terms of structural upgrading and historic preservation. In the aspects of the adaptive reuse of existing structures, buildings' adaptation and functional changeability should be considered. Historical buildings and adaptive reuse need deep and unique considerations, so the determination of limitations was necessary to investigate CSFs for only GREHB.

CHAPTER II

II. GREEN HEALTHCARE

This chapter has two main objectives. The first one is to explain the crucial part of sustainability in the healthcare industry in which SD actions and the rising awareness of sustainability issues and their importance in the healthcare sector are investigated. The second objective is to gain a better understanding of the practices and to evaluate these sustainability practices in the healthcare sector known as green healthcare.

2.1. The Evolution of Sustainability in the Healthcare Sector

In the early 1970s, the topic of "sustainability" emerged due to the rapid increase in the human population, and the increased environmental damage associated with increased resource consumption. The United Nations 1972 Stockholm Conference was held based on finding an approach for an agreement between the advancement, environment and the well-being of the world's poor [21]. In 1987, the Brundtland Report, which is known as Our Common Future, described SD [22]. Cambridge Advanced Learner's Dictionary defines sustainability as the feature of contributing little or no harm to the environment; hence, the capability to proceed for a long time [23].

Sustainability includes three pillars, which are economic, environmental as well as social. The fundamental objective of SD is the reconciliation of these three components. Therefore, sustainability is recognized as an approach to improve and provide the answers to the problems generated by the existing economic and social conditions and a strategy to deal with the environmental issues created by the existing structure [24].

Furthermore, the fundamental aim of sustainability as to eliminate the environmental difficulties and the absence of quality of life of the community, to promote a long-term and healthy environment for occupants of buildings [25]. Also, Heang [25] indicated that sustainability is associated with various criteria, which are energy efficiency, material usage, water usage, quality of life, and well-being.

Poveda and Lipsett [21] highlighted that the significance of sustainability continues to increase, transform, and adapt based on geopolitical, environmental, social, as well as economic conditions. With raising awareness of environmental concern, sustainability strategies have become the most crucial topic that leads to "greening movements" worldwide [26]. Greening or the sustainability movement can be determined as improving the economic, social, as well as environmental quality and providing the opportunity to citizens living in a sustainable condition [27].

Notably, in terms of enhancing improving citizens' well-being and health a critical case emerges for healthcare facilities whose fundamental role is to improve occupants' health in society [5] since, contrary to the fundamental principle of healthcare, the operations of healthcare services lead to significant air, water, and soil pollution, which has substantial side impacts on public health, indirectly and directly [28]. The World Health Organization (WHO) [29] highlighted that the healthcare sector cannot separate itself from its responsibility for environmental sustainability in today's modern world.

The importance of sustainability in healthcare facilities was defined by previous researches [26, 29, 30, 31]. Hence, the quality of life is an essential target element of SD. Health is a significant precondition in SD. Furthermore, SD promotes health and well-being, but sustainability is not achievable in the lack of health [30]. Wagner [31] emphasized that sustainability has a powerful connection with healthcare since sustainable buildings improve the patients' healing process. There are many justifications about why sustainability is significant for healthcare facilities. The first one is that sustainability strategies keep harmful items out of the environment; the second one is that proper medical waste disposal prevents fines and other financial repercussions, and the last one is that health care organizations are part of a community [32].

In the aspect of the economic, social as well as environmental value of SD, a concept defined as the triple bottom line, can also be known as “people, planet, and profit” [33]. In the view of sustainability in the healthcare organization, the social line of sustainability has a direct impact on health [33]. Therefore, a healthcare facility which has a successful triple bottom line leads to positive improvements on health and well-being of occupants by providing energy savings, efficient usage of natural resources, waste reduction, and cost savings [33].

Wagner [6] claims that sustainability strategies have to be one of the critical elements of healthcare facilities' strategic business plan and have to be a driving force for initiatives and infrastructure improvements. Also, she emphasizes that healthcare facilities can reach substantial savings even with main SD exertions that need little or no cost [6]. Moreover, Goh and Marimuthu [34] identified sustainability of healthcare facilities as providing a satisfactory implementation of successful strategies for the stakeholders of facilities in the aspects of human resources, economic, social as well as environmental improvement. So, sustainability in healthcare is a method that demonstrates how to implement sustainability related strategies into healthcare facilities [34].

Today's modern hospitals are unique and complex structures that contain all kinds of different building types such as offices, food & beverage facilities, accommodation, factories, laboratories, and transportation depots, etc. [13]. With the rapid growth of technological advancements, hospitals have started using different high-tech medical equipment with a complex specificity that causes a high level of energy usage. These technological improvements identify the architecture of structures, spatial relations, and also, daily activities of healthcare facilities. Although these improvements have improved the patient's condition, the comfort of the patients has been disregarded, so hospitals have become a stressful place for occupants [35].

The fundamental objective of healthcare facilities is to protect and enhance communities' health; however, they have strong influence socially and environmentally that can cause adverse side impacts on public health and well-being [36]. With the types of technologies as well as equipment that it uses, the resources it consumes, the waste it generates, and the buildings it builds and operates, the healthcare industry and its facilities are an essential source of pollution worldwide and thus unintentionally contribute to the trends that damage public health [37]. Also, a large amount of energy usage and waste generation due to the usage of modern technologies has become a public health concern of some importance [38].

As a complex and sensitive industry, healthcare contributes to the emission of harmful gases, particles [8], and CO_2, to the consumption of a substantial amount of energy and resources [39] and also, to cause a large amount of waste [40]. Therefore, sustainability in healthcare facilities has a unique role to patients, community, the healthcare workforce, policymakers, public and private funders as well as researchers [41].

Numerous efforts have been taken by various organizations worldwide, such as providing approaches, standards, and guidelines to accomplish sustainability practices in the healthcare sector. Practice Greenhealth is one of the well-known networking organizations to enhance sustainability in the healthcare environment providing eco-friendly solutions for health systems and hospitals [42].

The World Healthcare Organization (WHO) provided a strategic roadmap to enhance sustainability in healthcare that can have a substantial amount of environmental benefits. Also, WHO identifies environmentally sustainable healthcare as the healthcare which assists the health and well-being of the occupants, while mitigating adverse environmental effects and taking advantage of opportunities to enhance it [39].

The Green Guide for Health Care (GGHC) is the first quantifiable sustainable design guide for healthcare that integrates developed environmental and health standards and practices into the planning, design, construction, operations, and maintenance phases of healthcare buildings. GGHC enhance the health of healthcare building' occupants while operating economically and efficiently [43].

Health Care Without Harm (HCWH) is an international institution which is known as a leader in environmental sustainability, health, and justice in the global movement by reducing the footprint of the healthcare sector. HCWH is working to decrease the impacts of healthcare facilities that are responsible for environmental pollution and diseases by providing ecologically strong and healthy alternatives [44].

Global Green and Healthy Hospitals (GGHH) is a non-governmental organization and an international network of healthcare facilities from around the world that aims to decrease the environmental footprint and contribute to enhancing public and environmental health by providing a framework and roadmap. Also, GGHH is a project which is conducted by HHWH [45]. GGHH provides a comprehensive framework of 10 interconnected goals, which are energy, chemicals, leadership, waste, pharmaceuticals, water, food, transportation, purchasing as well as buildings [37].

As a result of concerted efforts to advance the sustainability performance of healthcare, buildings have led to the emergence of “green hospital” or “green healthcare” practices. The integration of green practices into healthcare is a prospective solution to reduce environmental footprints of healthcare buildings that contribute to enhancing the health and living conditions of society in densely polluted areas in a sustainable manner [46]. Green practices transform healthcare buildings in terms of design, construction, and operational phases with an integrated approach [31]. Additionally, Pinzone et al., [47] highlighted that combining architectural and organizational levels of healthcare facilities with an integrated approach exerts a substantial influence on improving the sustainability of healthcare facilities.

Therefore, the improvement of sustainability and the rising awareness of SD practices have become a sensitive topic for all kinds of sectors. Notably, the healthcare sector is seen as one of the main participators to enhancing the sustainable environment. Previous literature has shown that sustainability has a direct relationship with healthcare facilities in the aspects of the main aims of SD. To enhance environmentally friendly healthcare facilities, green healthcare is a significant way to keep and improve a sustainable environment. Thus, concerted efforts to advance the sustainability performance of healthcare buildings is an essential issue for providing health and well-being of patients and creating a healthy environment for occupants.

2.2. Sustainability Performance of Green Healthcare Buildings

Healthcare buildings cause the environmental damage and depletion of natural resources with their current situation [48]. Bilec et al., [49] claim that the facilities and operations of healthcare organizations push healthcare organizations into a complicated position in which they are negating their fundamental role of “first do no harm” by failing to minimize their environmental damage. So, developing more environmentally friendly healthcare buildings has been gaining momentum in the healthcare sector [49]. In this context, to minimize the harmful effects of healthcare, from the integration of environmentally friendly green principles emerged a significant term; “green hospital” that promotes health and well-being of people by recognizing the effects of the relation between the health of citizens and the built environment [37].

Moreover, green healthcare can be determined as the integration of sustainability approaches into healthcare delivery that offers improved medical results, lower operating costs, and reduced energy consumption, and water usage [50], [15]. Albrecht and Petrin [51] define the core components that make up the green healthcare movement as social, historical, physical, and policy elements.

Hence, healthcare buildings are one of the parts responsible for the healing process of patients, reaching desired outcomes in terms of healthcare treatments and service quality which is significant in green practices [52]. Notably, creating healthy environment attributes the sensitive healthcare settings for green healthcare in terms of daylight, access to view, and fresh air that leads to the better healing process and a better workplace for occupants [53]. Dhillon determines the main elements of green hospital buildings to reach desirable and sustainable outcomes [54]. Also, Ozdemir [55] states providing planning decisions, creating sufficient indoor air quality (IAQ), enhancing energy and water efficiency, providing effective waste management, providing food and transportation services are green healthcare design approaches. In architectural planning and design of green healthcare facilities, the main focus areas are , clean and green interior materials, lighting, green housekeeping, gardens and landscapes as well as IAQ that result in reducing the length of patients' healing processes, reduced stress levels of occupants, improved care quality, and in minimizing the energy and water usage [56]. Thus, from the perspective of sensitive green healthcare settings, the integration of sustainability practices into both the structure and management of the healthcare building is the only possibility to provide the health and well-being of users of building [36].

As a result of the integration of green approaches into the healthcare structure, the development of various green healthcare certification tools, codes, and standards has accelerated worldwide to classify the sustainability performance of healthcare buildings. To promote green healthcare and to identify the sustainability performance of healthcare buildings, various countries' building sustainability assessment institutions provide guidelines to provide enhanced green design ways [57]. Current literature shows that multiple organizations from different countries take actions to accomplish green healthcare buildings. In determining the sustainability performance of healthcare buildings, these efforts can be divided into four mainstreams as

i. Green Certification Tools

ii. Academic Literature

iii. Post Occupancy Evaluation (POE) Tools

iv. Standards

i. Green Certification Tools

The green building guidelines described as the guidelines which assess the environmental action over the life cycle of buildings as the 'whole building' aspect [58], [59]. Therefore, various countries have improved the green building guidelines for green healthcare such as the U.S.A., Australia, the U.K., Japan, Germany, and Malaysia. The most widely used healthcare-specific ones are selected to review; they are

Leadership in Energy and Environmental Design (LEED)

LEED is a rating tool for green buildings, launched by the U.S. Green Building Council (USGBC). LEED, defined as the international symbol of green buildings worldwide, encourages better and healthier buildings by providing lower carbon emissions, saving electricity costs. LEED aims to accomplish healthier, energy-efficient, and cost-saving green building implementations [60]. Based on a healthcare sustainability assessment, healthcare buildings require essential considerations in terms of seven days and 24 hours usage, energy and water demand, the control of infections, and patients' privacy. The healthcare-specific requirements can lead to experience difficulties in LEED for New Construction (LEED-NC) for healthcare buildings [61]. With this objective, USGBC (has) released the LEED for Healthcare (LEED+HC) certification tool only for healthcare buildings in 2011 [62].

LEED+HC was developed mainly for outpatient as well as inpatient healthcare buildings and deal with the construction and design practices for both new healthcare buildings and significant renovations of existing healthcare buildings [63]. LEED+HC is an opportunity for healthcare buildings to reduce energy consumption and enhance their healthy indoor environments [64]. LEED+HC includes new healthcare-specific credits and includes several credits from LEED-NC in terms of scope and requirements [62].

LEED evaluates the building performance in terms of the following credit categories: Location and Transportation, Sustainable Sites, Water Efficiency, Energy and Atmosphere, Material and Resources, Indoor Environmental Quality, Innovation and also, Regional Priority. In the LEED certification system process, each building type should satisfy all requirements to gain a minimum number of credits for each category. In defining the LEED performance level of buildings, there are four certification levels which are Certified, Silver, Gold, and Platinum [60].

According to the LEED project directory, there have already been healthcare projects certified or currently in the certification process in LEED-NC [65]. The USGBC highlighted a critical point that is related to existing healthcare facilities. The USGBC states that LEED-HC can only be applied to new construction or major renovation projects and adds that there are no future plans for developing a LEED for Existing Healthcare Buildings certification, but healthcare facilities are not prohibited from pursuing LEED for Existing Buildings: Operations & Maintenance (LEED-OM) [66].

The LEED rating system has the same performance determination levels in all its type of certification. The LEED-OM rating system is based on operational and performance areas, including cleaning and (interior/exterior) maintenance of the building, chemical usage, IAQ, energy and water efficiency, recycling, and system upgrades. Additionally, LEED-OM includes enhancing better IAQ, providing a sufficient level of lighting and ventilation, controlling of temperature, reducing the harmful chemical usage and monitoring of CO_2 for health and comfort of patients and staff [67].

Today, LEED-HC has 402 certified or registered healthcare projects, LEED-NC has 222 certified or registered healthcare projects, and also, LEED-OM has 28 certified or registered healthcare projects worldwide [66].

Building Research Establishment's Environmental Assessment Method (BREEAM)

BREEAM is the first sustainability assessment tool in the world, which has led to enhancing the sustainability of the UK's buildings in the aspect of design, construction, and use. BREEAM aims to minimize the harmful effects of buildings, helps to recognize the positive outcomes in terms of sustainability, contributes to a reliable environmental label for buildings, and provides incentives for sustainable building implementations. As an international certification method, BREEAM has several schemas to assess the sustainability performance of buildings. BREEM New Construction is the schema that is used to evaluate the environmental performance of healthcare buildings [68].

BREEAM assesses the sustainable value in various categories, including Energy, Health, and Well Being, Innovation, Land Use, Materials, Management, Pollution, Transport, Waste, and Water. In the BREEM New Construction certification, there are five different ratings: Pass, Good, Very Good, Excellent, and Outstanding [69]. The National Health Service (NHS) is the major contributor in reducing the ecological footprint, CO_2 emissions and water usage and also, waste management in England. The NHS can impact the health and well-being of occupants directly [70]. However, a study conducted by Hudson [71] specified that only 15% of total NHS buildings (approximately 110 buildings) have BREEAM certification.

Today, BREEAM New Construction has 662 certified or registered healthcare projects, and BREEAM In-use has 732 certified or registered healthcare projects and, BREEAM Refurbishment, and Fit-out has three certified or registered healthcare projects worldwide [72].

GREEN STAR

The Green Building Council of Australia GBCA launched the national and voluntary certification tool Green Star in 2003. The Green Star certification tool helps to contain the negative environmental impacts of buildings while improving staff productivity and health of communities [73]. In terms of healthcare practices, GBCA developed the healthcare rating tool, the Green Star – Healthcare v1 in 2009, to promote planning, design, as well as construction of healthcare buildings in a sustainable manner [74]. The Green Star certification system was created by using existing building assessment systems such as BREEAM and LEED to develop environmental evaluation criteria for the Australian marketplace [70]. The Green Star Healthcare promotes cost savings, improved patient outcomes, improved effectiveness of staff, and enhanced healthy indoor environments [74].

The primary assessment areas of Green Star Healthcare are Management, Indoor Environment Quality, Energy, Transport, Water, Materials, Land Use & Ecology, Emissions, and Innovation. In Green Star Healthcare, the rating system includes three certification levels: 4 Star, 5 Star, and 6 Star Green Star Certified Ratings [74]. Today, Green Star Healthcare has 17 certified or registered healthcare projects in the Green Star project directory [75].

DNGB

The German Sustainable Building Council (DGNB – Deutsche Gesellschaft für Nachhaltiges Bauen e.V.) was established in 2007 to contribute to sustainable and economic buildings. The DGNB certification tool evaluates the sustainability performance of buildings. Although certification tools were designed for the specific needs of countries, DGNB certification can be implemented in various countries. Hence, DGNB can be determined as an international certification tool [76].

To evaluate the buildings' sustainability performance, DGNB has different evaluation schemes. In the aspect of the healthcare context, the DGNB system uses its existing scheme DGNB New Construction for healthcare buildings. DGNB New Construction examines buildings based on six different criteria; they are Environmental Quality, Economic Quality, Sociocultural and Functional Quality, Technical Quality, Process Quality, and Site Quality. In the DGNB certification system, there are three levels of assessment criteria, which are Silver, Gold, and Platinum [76].

Today, DGNB New Construction has nine certified or registered healthcare projects in the DGNB projects [77].

Comprehensive Assessment System for Building Environment Efficiency (CASBEE)

CASBEE was developed by Japan in 2001. CASBEE is one of the first tools established in the Asian region, and the reliability of the tool has gained as reputable a status as BREEAM and LEED [78]. CASBEE has been designed with the aim of improving the quality of people's lives and extending the life cycle of resources and reducing environmental loads associated with the built environment. [79], [80]. CASBEE has only one manual assessment tool to be applied to various types of new constructions; it evaluates the sustainability performance of healthcare buildings by using the CASBEE for New Construction (CASBEE-NC) tool [81]. Also, rebuilding projects can be evaluated by CASBEE-NC. At any process of the Preliminary Design, Execution Design or Construction Completion, the environmental quality and performance of the building and its load reduction performance can be assessed [79].

CASBEE-NC implements Building environmental efficiency (BEE). The weighting resulted from the BEE values are based on the environmental load (L) and quality of building performance (Q). The quality of building performance has three assessment categories that are Indoor Environment (Q1), Quality of Service (Q2), and Outdoor Environment (On-site) (Q3). The environmental load has three assessment categories that are Energy (L1), Resources & Materials (L2), and Off-Site Environment (L3). According to the calculation of BEE values (Shown in Figure 2), the certification level of the building can be determined [78].

$$\text{Built Environment Efficiency (BEE)} = \frac{Q\ (Built\ environment\ quality)}{L(Built\ environment\ load)}$$

Figure 2: Calculation of BEE values, Retrieved from [78].

CASBEE-NC has five certification levels; they are: S (Excellent), A (Very Good), B+ (Good), B (Fairly Poor), C (Poor) [78].

Green Building Index (GBI)

GBI is the first comprehensive environmental tool for Malaysia launched by PAM (Pertubuhan Akitek Malaysia / The Malaysian Institute of Architects) and ACEM (the Association of Consulting Engineers Malaysia) to assess the buildings of an environmentally friendly manner. GBI was developed based on existing rating tools and adapted to relate to the Malaysian tropical weather, environmental context, and social as well as cultural needs [82].

GBI evaluates the building's performance in terms of six different criteria, which are Energy Efficiency, Indoor Environment Quality, Sustainable Site Planning & Management, Materials & Resources, Water Efficiency, and Innovation. GBI has four different rating levels, which are Platinum, Gold, Silver, and Certified [82].

In terms of healthcare facilities, GBI has two different rating systems that depend on the kinds of construction projects. The first one is non-residential new construction (NRNC) for the new construction of hospital projects, and the second one is non-residential existing building (NREB) for modification, renovation, refurbishment as well as extension projects [70]. Table 1 indicates the difference between them.

Table 1: Difference between NRNC and NREB, retrieved from [70]

Country/Title	Type	Versions/ Year	Elements and Points	Ratings and levels of certification
Malaysia GBI- Non-Residential Commercial New Construction (NRNC)	Environmental Assessment	NRNC V1.0 2009	Energy Efficiency (35), Indoor Environmental Quality (21), Sustainable Site Planning and Management (16), Materials & Resources (11), Water Efficiency (10), Innovation (7) Total= 100 points	Certified (50 -65) Silver (66-75) Gold (76-85) Platinum (86+)
Malaysia GBI- Non-Residential Existing Building (NREB)	Environmental Assessment	NREB V1.1 2011	Energy Efficiency (38), Indoor Environmental Quality (21), Sustainable Site Planning and Management (10), Materials & Resources (9), Water Efficiency (12), Innovation (10) Total= 100 points	Certified (50 -65) Silver (66-75) Gold (76-85) Platinum (86+)

Consequently, existing certification tools are one of the main contributors to identify sustainability performances of healthcare buildings. Each certification system has their assessment criteria and score calculation. Table 2 shows all certification tools for healthcare, their assessment criteria, certification levels and ratings.

Table 2: Certification tools for healthcare [60], [70], [74], [76], [78], [82] and table adapted from [70]

Certification Tool	*Version*	*Assessment Criteria*	*Certification Levels and Ratings*
LEED	LEED v4.1 BD+C: Healthcare/2019	Location and Transportation, Sustainable Sites, Water Efficiency, Energy and Atmosphere, Material and Resources, Indoor Environmental Quality, Innovation, Regional Priority	Certified (40-49) Silver (50-59) Gold (60-79) Platinum (80+)
BREEAM	BREEAM International New Construction/2016	Energy, Health and Well Being, Innovation, Lan Use, Materials, Management, Pollution, Transport, Waste, and Water	Pass (≥30) Good (≥45) Very Good (≥55) Excellent (≥70) Outstanding (≥85)
Green Star	Green Star – Healthcare v1/ 2012	Management, Indoor Environment Quality, Energy, Transport, Water, Materials, Land Use & Ecology, Emissions, Innovation	4 star (45-59) "Best Practice" 5 star (60-74) "Australian Excellence" 6 star (75-100) "World Leadership"
DGNB	DGNB New Construction/2018	Environmental Quality, Economic Quality, Sociocultural and Functional Quality, Technical Quality, Process Quality, Site Quality	Silver (≥%50) Gold (≥%65) Platinum (≥%80)
CASBEE	CASBEE for New Construction/2014	Indoor Environment (Q1), Quality of Service (Q2), Outdoor Environment (On-site) (Q3), Energy (L1), Resources & Materials (L2), Off-Site Environment (L3)	S (Excellent) (BEE value of S is BEE= 3.0 or more and Q=50 or more), A (Very Good) (BEE value of A is BEE=1.5-3.0 BEE=3.0 or more, and Q is less than 50), B+ (Good) (BEE value of B+ is BEE=1.0-1.5), B (Fairy Poor) (BEE value of B is BEE=0.5-1.0), C (Poor) (BEE value of C is BEE=less than 0.5)
GBI	NRNC V1.0/ 2015	Energy Efficiency, Indoor Environmental Quality, Sustainable Site Planning and Management, Materials & Resources, Water Efficiency, Innovation	Certified (50 -65) Silver (66-75) Gold (76-85) Platinum (86+)

Moreover, Castro et al., [81] analysed buildings' sustainability assessment (BSA) tools for healthcare facilities critically and identified the differences between the BSA methods to healthcare facilities. To gain better understanding the Castro et al., [81] categorized healthcare building sustainability assessment (HBSA) methods in terms of healthcare building types, users of methods, life cycle parts, structure and weighting, healthcare-specific criteria, classification, and communication format of results. Table 3 represents the assessment indicators of LEED, BREEAM, CASBE, and GREEN STAR. The study conducted by Castro et al. [81] indicated that HBSA methods:

- evaluate the performance of life cycle from a different perspective;
- include various sustainability criteria;
- include various benchmarks;
- can be applied in various kinds of healthcare facilities;
- include various life cycle phases;
- use various life cycle evaluation databases;
- use various rating levels and communicate the findings in different ways [81].

Table 3: Assessment indicators of certification tools, Retrieved from [81]

Assessment indicators	Assessment methods			
	LEED for Healthcare	BREEAM New Construction	CASBEE for New Construction	Green Star—Healthcare
Management				
Sustainable procurement		X		X
Responsible construction practices		X		
Construction site impacts		X	X	X
Stakeholder participation		X		
Service life planning and costing		X		X
Indoor environmental quality/well-being				
Visual comfort	X	X	X	X
Indoor air quality	X	X	X	X
Thermal comfort	X	X	X	X
Water quality	X	X		
Acoustic performance	X	X	X	X
Safety and security	X	X		
Indoor chemical and Pollutant source control	X		X	X
Service quality				
Flexibility and adaptability			X	
Service ability			X	
Durability and reliability			X	
Energy				
Reduction of CO_2 emissions		X		X
Energy monitoring	X	X	X	X
Low- or zero-carbon technologies		X		
Efficiency in building service system	X	X	X	X
Natural energy utilization	X		X	
Renewable energy utilization	X			
Building thermal load			X	
Efficient operation	X	X	X	X
Transport				
Public transport accessibility	X	X		X
Cyclist facilities	X	X		X
Car parking capacity	X	X		X
Travel plan		X		X
Fuel-efficient transport	X			X
Water				
Water consumption	X	X	X	X
Water monitoring		X		X
Water leak detection and prevention		X		
Water efficiency	X	X	X	X
Landscape Irrigation	X			X

Table 3: Assessment indicators of certification tools Retrieved from [81] (Continued)

Assessment indicators	Assessment methods			
	LEED for Healthcare	BREEAM New Construction	CASBEE for New Construction	Green Star—Healthcare
Materials				
Life cycle impacts		X		
Recycled content of materials	X		X	X
Hard landscaping and boundary protection		X		
Responsible sourcing of materials	X	X	X	X
Insulation		X	X	
Designing for robustness		X		
Reducing usage of non-renewable resources	X		X	X
Avoiding the use of materials with pollutant content	X		X	X
Building reuse	X		X	X
Furniture and medical furnishings	X			X
Design for disassembly				X
Low-emitting materials	X		X	X
Waste				
Construction waste management	X	X		X
Non-hazardous waste	X			
Hazardous waste	X			
Recycled aggregates		X		X
Operational waste		X		
Speculative floor and ceiling finishes		X		
Sustainable sites				
Site selection	X	X		X
Ecological value of site/protection of ecological features	X	X	X	X
Mitigating ecological impact	X	X	X	X
Enhancing site ecology		X	X	
Heat island effect	X		X	
Long-term impact on biodiversity	X	X	X	X
Townscape and landscape	X		X	
Local characteristics and outdoor amenity		X	X	
Pollution				
Impact of refrigerants		X		X
Emissions	X	X	X	X
Storm water design	X	X		X
Light pollution reduction	X	X	X	X
Noise attenuation	X	X	X	

All in all, existing certification tools for healthcare were analysed in terms of the primary assessment indicators. Table 4 demonstrates the primary indicators of existing certification tools. Additionally, the presented assessment criteria of these certification systems will be used in the identification of the CSFs of existing healthcare buildings for the study of this thesis. The primary indicators identified in Table 4 are included in the identified CSFs shown in Table 15.

Table 4: The primary indicators of existing certification tools., adapted from [81]

Assessment main indicators	Assessment methods					
	LEED for Healthcare	**BREEAM New Construction**	**CASBEE for New Construction**	**Green Star—Healthcare**	**DGNB New Construction**	**GBI-Non-residential new construction (NRNC): Hospital**
Economic Quality					x	
Energy and Atmosphere	x	x	x	x		x
Health and Well Being		x				
Indoor Environmental Quality	x		x	x	x	x
Innovation	x	x				x
Land Use & Ecology		x		x		
Location and Transportation	x	x		x		
Management		x	x			x
Material and Resources	x	x	x	x		x
Off-Site Environment			x			
Pollution		x		x		
Process Quality					x	
Quality of Service			x			
Sociocultural and Functional Quality					x	
Sustainable Sites	x	x	x	x	x	x
Technical Quality					x	
Water Efficiency	x	x		x		x
Waste		x				

ii. Academic Literature

Sustainability performance of existing healthcare buildings has also been tackled by academic researchers. In terms of specific healthcare requirements, sustainable healthcare buildings should be considered in design and operation phases to promote the decision, to adopt solutions, and to help managers and users [57].

The academic study of Castro et al., [57] proposed an HBSA method for the Portuguese context by analysing and comparing the most relevant healthcare building sustainability standardization bodies (Shown in Table 5). A proposed HBSA method includes the three dimensions; environmental, social, and economic [86].

Table 5: HBSA method proposal, retrieved from [57]

Dimensions	Categories	Indicators
Environmental	Climate change and outdoor air quality	Environmental impact associated with the life cycle of buildings
	Soil use and biodiversity	Urban density
		Reuse of previously built or contaminated soil
		Use of autochthonous plants
		Site Selection
		Heat island effect
	Energy	Non-renewable primary energy
		Renewable primary energy
		Energy produced locally
		Electricity
	Materials and Solid Waste	Reuse of materials
		Use of recycled materials
		Use of certified materials
		Use of cement substitutes in concrete
		Use of local materials
		Coating materials
		Storage conditions of solid waste during the building's use phase
		Construction Waste
		Use of mercury
	Water	Water consumption
		Reuse of non-potable water
	Pollution	Reduction of CO2 emissions
		Monitoring energy used for each order
		Monitoring energy used by the user area
Social	Comfort and health of users	The efficiency of natural ventilation in indoor spaces
		Toxicity of finishing materials
		Microbial contamination
		Thermal comfort
		Visual comfort
		Acoustic comfort
		Indoor air quality
		Indoor Environmental quality
		Passive design
		Local development
		Equipment
	Accessibility	Accessibility to public transport
		Low impact mobility
		Amenities
		Space distribution
	Space flexibility and adaptability	Spatial organization and indoor program
		Furniture
		Space adaptability
	Awareness and education for sustainability	Education of occupants
	Cultural Value	Form and implementation
	Innovation	The innovation of the project design
Economic	Life cycle costs	Initial cost
		Operation costs

Another significant academic study aspect of the healthcare sustainability assessment conducted by Buffoli et al. [36] is the Sustainable Healthcare Evaluation Tool. This research provides an innovative assessment tool to identify the sustainability performance of healthcare buildings that already exist or are in the design stage in the European context. The assessment method consists of analysing social, environmental, and economic sustainability with a set of criteria determined by measurable indicators. [36].

According to the assessment criteria of healthcare buildings' sustainability performance, Sahamir et al., [83] have identified the crucial components to be measured in green evaluation issues of healthcare facilities based on social, economic, and environmental considerations of sustainability, helped the Green Hospital Building Development (GHBD) (Figure 3).

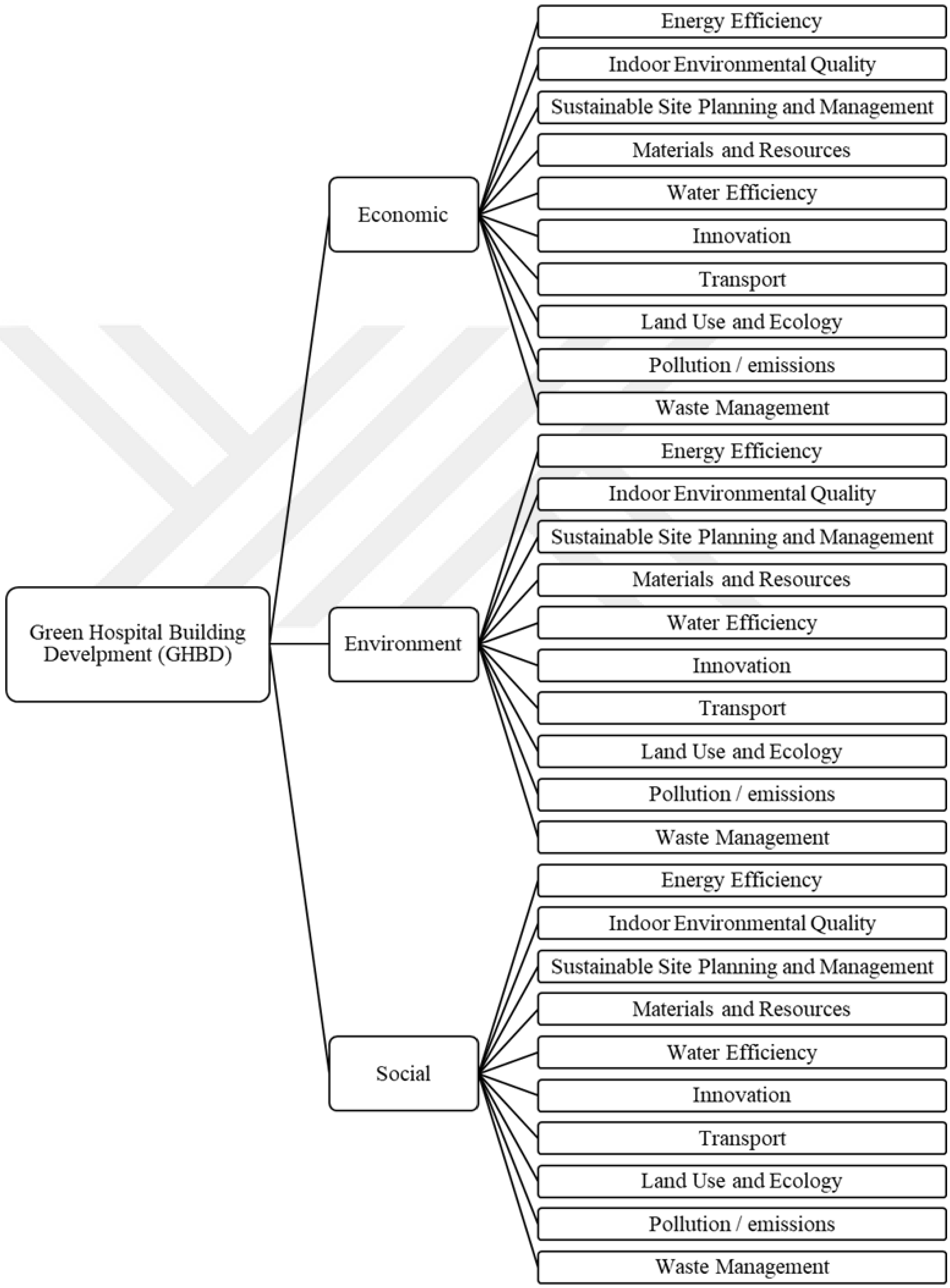


Figure 3: GHBD , retrieved from [83]

iii. Post Occupancy Evaluation (POE) Tools

Many projects cannot perform as planned; this leads to a significant effect on costs, occupant satisfaction, well-being, safety, and comfort [84]. Therefore, the assessment of the building performance from occupant experience is an efficient process to mitigate adverse effects. POE is a prospective approach to assess building usage performance systematically from patients' and staffs' perspectives, that helps to determine ways to enhance building design and performance and also improve the productivity of occupants [85].

POE has identified by Vischer [86] as a case study way to examine how users evaluate the built environment, carried out either to fix difficulties during the operation of buildings or with a view for developing an awareness of building usage and design quality. Zuo et al., [87] define common POE processes in existing literature in three parts as planning, conducting, and applying. Figure 4 shows the POE processes, Retrieved by Zuo et al., [87]..

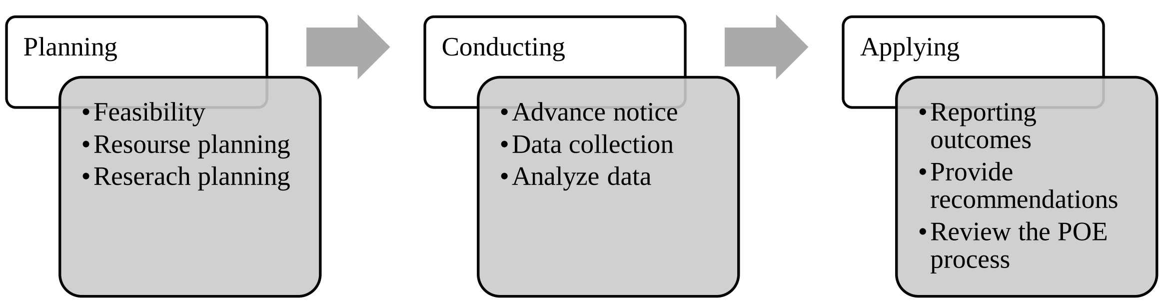


Figure 4: POE processes, retrieved from [87]

Shika et al., [88] indicated that a compatible approach and an action plan are both needed to accomplish sustainability goals that address needs and expectations of occupants in existing buildings. Because of the lack of sufficient empirical information about the sustainability performance of buildings, they have proposed a POE sustainability assessment framework for retrofitting, as shown in Figure 5.

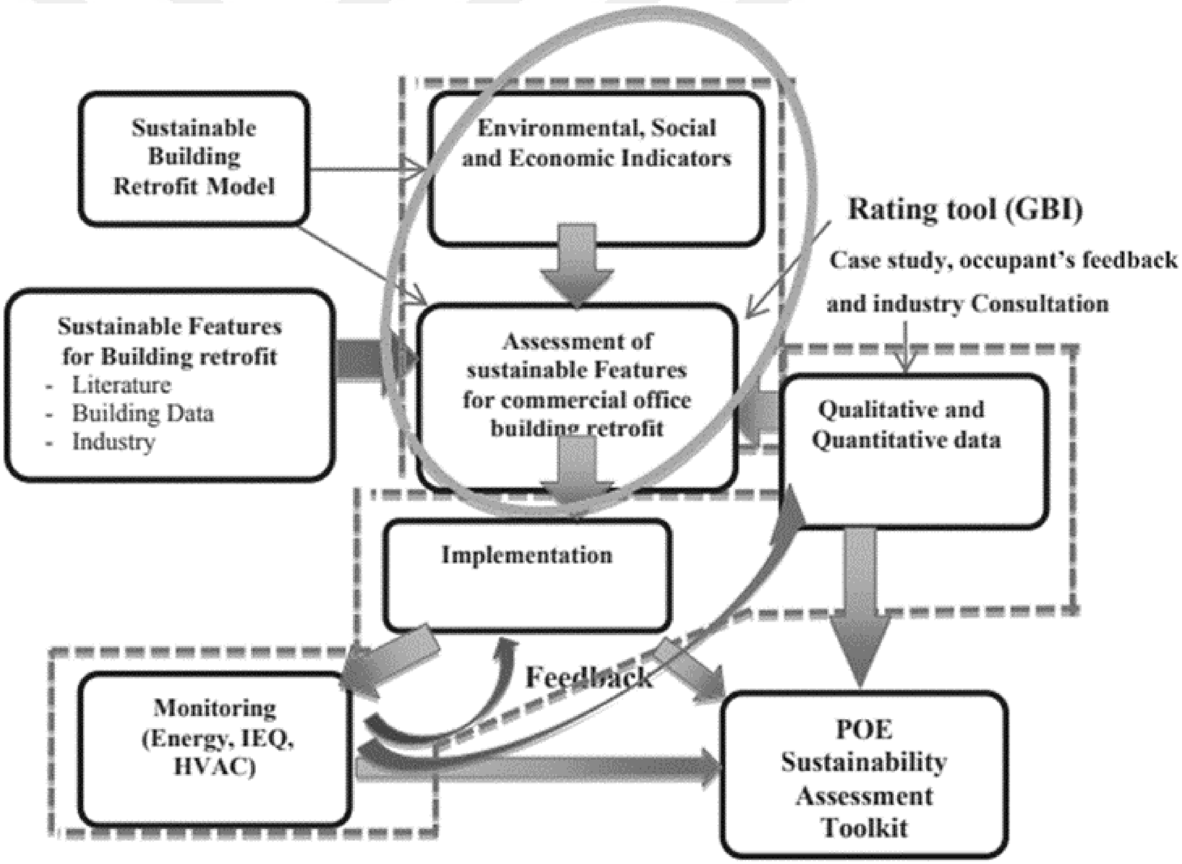


Figure 5: Conceptual framework of POE sustainability assessment [88]

Another POE framework is related the systematic building performance evaluation during operation and consists of analysis of the perception of the occupants [89]. This framework consists of four phases. (Shown in Figure 6).

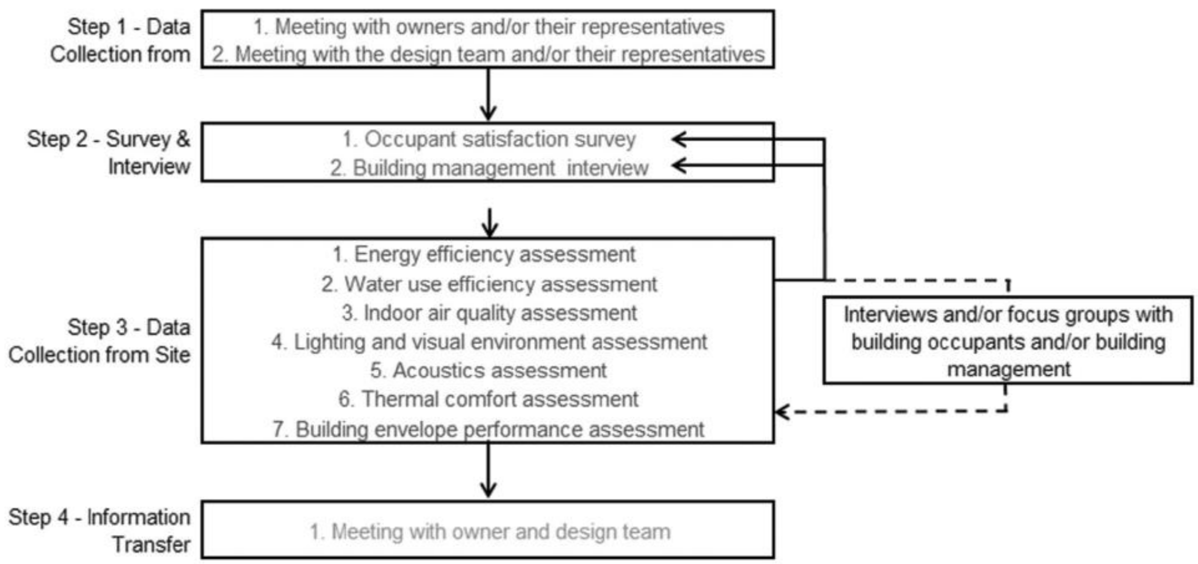


Figure 6: POE framework, retrieved from [89]

Healthcare Specific POE Tools

For green healthcare practice and certification tools, the experience of patients and staff, such as comfort, satisfaction, and effectiveness are significant means of evaluating the sustainability performance of the building. Based on occupant comfort and health, POE is one of the efficient tools to assess the buildings' performance by providing occupant feedback for buildings' design and construction [87].

In terms of building certification tools, LEED focuses on occupant well-being and satisfaction – the “Occupant Comfort Survey” credit is the issue related to occupant experience in the LEED Operation and Maintenance (LEED O+M) certifications [60]. Also, in BREEAM, there was a specific credit “Man 05 Aftercare” for the evidential requirements (related to POE implementations) in BREEAM New Construction. The credit depends on supporting the first year of the operation of the building to control the building performance by the design intent and building user’ requirements [90].In terms of another certification tool GREEN STAR, in GREEN STAR Performance certification type, there was a credit -Occupant Satisfaction Survey under Indoor Environmental Quality category. The fundamental objective of this credit is to encourage the evaluation of patients’ and staffs’ wellbeing and experience with their environments such as acoustics, thermal comfort, IEQ, and other comfort issues [91]. DGNB differs from other certification tools since it has “User Control” credits under a sociocultural and functional quality category. User Control credit offers to operate the IEQ possibility for building users [92].

To provide healthy living, reduce obesity, and prevent chronic disease, The Center for Healthcare Design (CHD) developed a tool, the “Population Health Clinic Evaluation Tool”, based on POE. The tool was developed with four significant aims, which are physical environment, social-economic factors, clinical care as well as healthy behaviors. Also, the tool assesses the five main spatial components of a typical outpatient health center that consists of the building – exterior, interior – overall, staff spaces, patient-clinician interactions as well as waiting – check-in [94].

Designing healthcare buildings requires complex approaches that lead to difficulties in measuring and evaluating them. The Achieving Excellence Design Evaluation Toolkit (AEDET) assesses the design by posing a series of clear, non-technical statements, encompassing the three significant areas of Impact, Build Quality, and Functionality. AEDET provides an analysis that defines the weaknesses and strengths of a design or an existing building [94].

Another POE tool for healthcare is A Staff and Patient Environment Calibration Tool (ASPECT), based on the comfort and satisfaction of staff and patients and the health outcomes of patients and the performance of staff. ASPECT assesses the design quality of patient as well as staff conditions in healthcare buildings. ASPECT is a tool directed explicitly towards achieving reaching excellence in design rather than taking guarantee compliance with guidance, regulation and legislation [95].

iv. Standards for Healthcare

Standards cover the quality of the process, the environmental conditions that must be taken into account, and also other factors that can impact each step of the process under discussion. When the quality of the process is taken into consideration, International Organizations for Standardization (ISO) plays a significant role in standardization. These standards were created to enable people to speak the same language, and it is still being developed (they are still developing) [97]. ISO is an independent and non-governmental international organization that has published

22649 International Standards and related documents, including almost each sector, from technology to food safety, to agriculture and healthcare [98].

To achieve sustainable healthcare buildings, ISO has developed different standards for healthcare; a few of them are ISO 9001, ISO 45001, and ISO 14001. ISO 9001 is a quality management system standard that helps ensure standardized levels of quality are applied for all organizations of the healthcare sector. The application of the ISO 9001 standard into healthcare facilities reduce inefficiencies and waste and provide cost savings while maintaining a focus on patient/client satisfaction [99]. Another standard based on healthcare is ISO 45001 which determines needs for an occupational health and safety (OH&S) management system that provides to enhance the safety and health of both employees and other personnel [100]. In terms of the environmental management system (EMS), ISO 14001 is a leading standard that supports a systematic framework to integrate environmental management practices by supporting the conservation of the environment, pollution prevention, waste minimization, as well as reduction of energy and materials consumption [101].

Moreover, there is another standardization, which is known as the European Committee for Standardization (CEN) that covers the National Standardization Bodies of 34 European countries. CEN contributes to the improvement of European Standards and other technical documents, which include different types of materials, products, processes as well as services [102]. CEN includes various standards for the healthcare sector; DIN EN 15224 is one of them. DIN EN 15224 is a quality management system for healthcare facilities consider the ISO 9001 standard [103]. The DIN EN 15224 standard provides both ISO 9001 advantages and also, comprehensive healthcare quality requirements. Additionally, it determines the main topics ranging from the efficacy and sustainability of healthcare to the reliability and safety of healthcare actions [103].

The fundamental objective of this part is to identify knowledge about the sustainability performance of green healthcare implementations and to explain the tools, guidelines, and standards that promote and evaluate sustainability. Thus, promoting and assessing sustainability in healthcare buildings by developing comprehensive tools, and standards, can be used as a strong reference for future green healthcare implementations.

CHAPTER III

III. GREEN RETROFITTING OF EXISTING HEALTHCARE BUILDINGS

This chapter has main four aims. The first one is to review the current status of existing healthcare buildings in the context of green retrofitting and to demonstrate the need for GREHB. The second objective is to gain a better understanding of green retrofitting practices and approaches in the healthcare environment. The third objective is to define the main drivers, benefits, and difficulties for green retrofitting in healthcare buildings. Moreover, the ultimate aim is to highlight the need for retrofit roadmaps and to explain the existing methodologies for retrofitting.

3.1. The Need for Green Retrofitting of Existing Healthcare Buildings

Hospitals or healthcare facilities around the world can be defined as an energy-intensive building type that contributes substantially to environmental impacts while accidentally leading to diseases and adverse health outcomes [46]. Consequently, healthcare buildings have significant scope in the building industry [103] in terms of healthcare-specific requirements. Typical healthcare buildings operate seven days a week and 24 hours a day and support care and treatment for people who are sick and vulnerable [104]. In this context, healthcare buildings require a stringent control of IAQ, diseases, medical equipment, and waste management [105] and also require the protection of patients and staff against hospital-acquired contaminations and occupational illnesses [106].

According to the U.S. Energy Information Administration statistics, healthcare consumes 8% of the total energy, including hospitals and medical offices [107]. Chung and Meltzer stated that U.S. healthcare buildings account for 8% of total greenhouse gas emissions (GHG) and 7% of total CO_2 emissions [108]. Also, the healthcare industry accounts for 5% of the total emissions, including buildings, transport, and the supply chain in England [109]. The energy consumption and emissions by healthcare buildings cause an increasing burden of illness such as cardiovascular, asthma, and other respiratory diseases [46]. Furthermore, healthcare buildings consume energy in the following proportions; 43% on lighting, 40% on water heating, 31% on space heating, office equipment, and 10 % on both cooking and cooling in its daily operations [110]. In America, the spending on healthcare reached $3.5 trillion which accounted for 17.9 percent of the Gross Domestic Product of the nation in 2017 [111]. Therefore, the healthcare industry can play a leadership role in providing healthy and sustainable outcomes by reducing its carbon footprint [46].

As a result of the continuous substantial environmental footprint of healthcare facilities, healthcare has been increasingly required to enhance its sustainability performance leading to applying sustainability strategies in the healthcare sector and constructing new green healthcare facilities [48]. Although green buildings present the next stage of buildings' evolution/development along with the development of new green buildings implementations, these steps alone are insufficient to reduce the harmful effects of existing ones [7].

Therefore, there is a need for GREHB that is curial to the improvement of the healthcare facility over time, including recycling, extending, reconfiguring, modifying, re-planning as well as contracting existing spaces [11]. In order to provide sustainability performance targets, green retrofitting practices helps to reduce CO_2 emissions, provide an opportunity for the healthcare facility to adapt to changes, and provide proper quality conditions [11]. In addition, Si [112] noted the retrofitting potential of existing non-domestic buildings and stressed the need to focus on the improvement of existing buildings. Ahmad [11] also stated that healthcare facilities should struggle against the difficulties arising from an aging and growing population, innovations in medical care well as care during the operation of daily activities. So, in terms of the harmful environmental impacts, retrofitting potential, and also, continuous operations of healthcare facilities, there is an urgent need for green retrofitting of existing healthcare facilities to reach desirable health outcomes and a healthy built environment.

3. 2. Green Retrofitting of Existing Healthcare Buildings

Destroying existing healthcare buildings and constructing new ones is not an appropriate way to achieve sustainable healthcare facilities and minimize the harmful outcomes of the healthcare industry on the built environment [10]. Nazri et al. [113] highlighted the importance that “existing buildings need to be retrofitted to be green.” Existing buildings give an exclusive opportunity to sustainably retrofit differently from the maintenance and necessary repairs that arise during their maintenance [114]. GREB is an efficient way to integrate and optimize the resources of humans, materials, finance, and technology [115].

Green retrofitting was defined by Abdullah [116] as a renovation of building systems and structure to improve efficiency, mitigate the consumption of resources, and increase the quality of indoor air. Similarly, Liang et al., [117] highlighted that the primary intention of green retrofitting could be determined as the reduction of carbon emissions as well as energy consumption with the advancement of a building’s fabric and systems. The USGBC identified retrofit as any type of upgrades of an existing facility that is partially or wholly occupied to increase environmental and energy performance, minimize water usage as well as enhance the quality and comfort of the space in terms of natural light and air quality [118], [112]. When energy, water, and materials get taken into consideration, an existing building’s retrofit has a considerable impact on enhancing the well-being as well as health of users, the building’s performance, and financial returns [119]. The green retrofitting of buildings not only provides favorable circumstances to reduce the high level of energy consumption but also assist the various retrofitting implementations, improve public healthcare and protection of environment and advance the awareness and dissemination of green retrofitting [120].

Tan et al., [121] concluded that green retrofit also suggests an alternative way to mitigate the impacts of GHG. To minimize the adverse environmental effects of existing healthcare buildings, is the one crucial, logical element that improves the energy efficiency, occupants' well-being, IEQ and reduces the green gas emissions and carbon footprints. Also, green retrofitting can be considered an efficient method to achieve the sustainability of existing facilities [122], [7].

Particularly, retrofitting in existing healthcare buildings needs careful attention in order to supply healthcare principles and occupant safety requirements, and also, this will help the healthcare sector to comply with new technologies [24]. From the healthcare perspective, the retrofitting of existing healthcare buildings poses significant difficulties in continuing the daily operations of healthcare facilities and maintaining patients safe. During the retrofitting of existing healthcare buildings, there is a need for early actions to control infections and occupants' safety to avoid patients' dissatisfaction and patient safety challenges [14]. So, during the retrofitting processes, especially in healthcare buildings, patient health and safety issues should be considered in order to enhance the success of the project.

Malkin [123] identified an actual retrofit requirement as “a fact-based, quantitatively oriented, benchmarked, energy efficiency retrofit with a clear analysis of payback on integrated multicomponent effort with performance guarantees.” Moreover, Mickaitytė et al., [120] highlighted the main results from building refurbishment; they are energy saving, increase comfort conditions, providing a suitable working environment, the expansion of life cycle of building, exploitation, economized and protection of environment.

Various green retrofitting practices can be applied for greening existing healthcare buildings, and the retrofit studies help to create knowledge on current practices which is significant in order to take essential steps and to enhance the current actions. Sun et al., [124] identified the strategies of green retrofitting as improving the air-conditioning system efficacy, improving lighting systems and controls, and improving buildings’ envelopes and roof systems.

Consequently, the primary considerations of existing retrofitting studies are based on “energy, HVAC, lighting, water, building envelope, seismic and interior design” retrofitting. The next part will review retrofitting options in detail.

Energy Retrofitting

Energy retrofitting was explained by Ryu [125] as the enhancement of existing buildings with energy-efficient equipment to provide energy protection from buildings' maintenance and operations. The fundamental benefit of major retrofitting projects is energy savings. Additionally, energy savings improve operational performance by lowering operation costs and also permitting funds to be deployed for main medical services like equipment and staffing. Energy retrofitting reduces not only energy consumption but also reduces the GHG, improves the indoor environment, and reduces energy cost while enhancing the care of patients and the health and productivity of occupants in hospital buildings. Energy retrofitting includes upgrading of lighting and HVAC systems and providing more sensitive control of the IEQ and an improved environment of care [126]. Natural Resources Canada [126] determined the major energy retrofit opportunities for hospitals as the staging project measures, existing building commissioning, lighting improvements, reduction of supplemental load, air distribution systems' development and also, heating and cooling upgrading.

Furthermore, Dunphy [127] indicated that buildings consume energy not only during their operations but also consume during their life cycle. Also, Dunphy [127] added that buildings can become energy efficient with consuming less energy in daily operations in this way the large proposition of life cycle energy can be mitigated. All in all, minimizing energy demand by energy retrofitting strategies has a critical influence on buildings' energy life cycle.

Mohammadpour et al., [128] have defined several energy conservations measures (ECMs) for healthcare facilities, which are grouped under mechanical systems, facilities, interiors and finishes, building envelopes, and electrical systems. Mechanical systems generally include heating, cooling, and ventilation upgrades, facilities' interiors and finishes include infiltration reductions, building envelopes include roof, wall, door, and window upgrades, and electrical systems include lighting upgrades. The implemented ECMs are shown in Figure 7 [128].

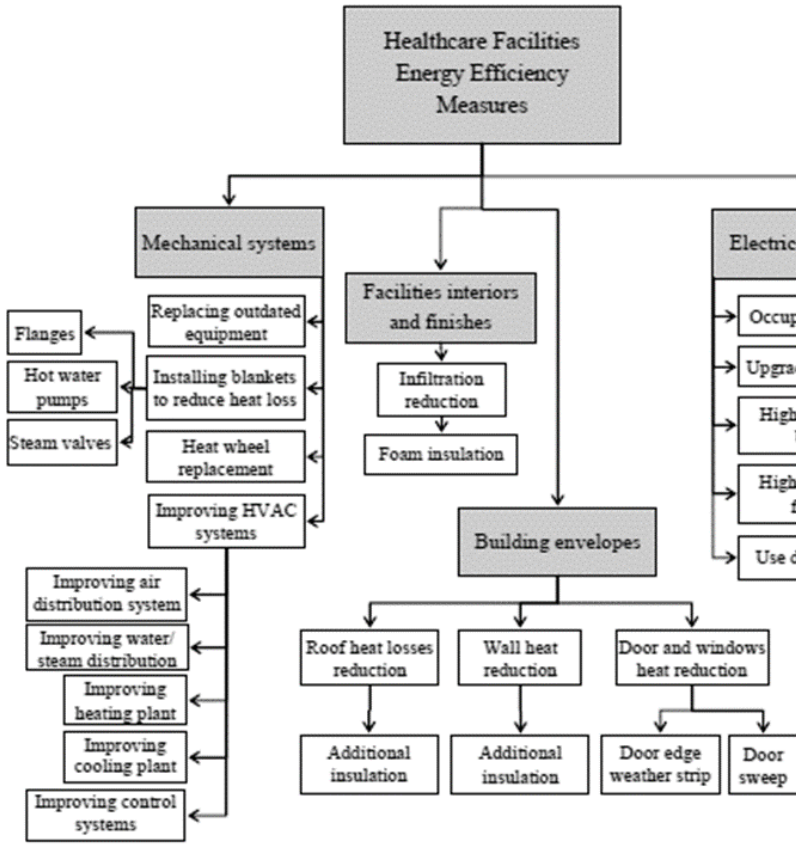


Figure 7: Healthcare facilities energy efficiency measures, retrieved from [128]

Buonomano et al., [129] reviewed the energy conservation techniques for hospital buildings and highlighted that hospital buildings generally have considerable differentiating features from other building types in terms of the usage (general, health center, psychiatric, etc.), the building envelope status, the constitution year, the level of insulation, the climatic zone, the age and maintenance level of the energy management as well as mechanical equipment.

HVAC Retrofitting

HVAC retrofitting is considered as a needed action for the comfort, health, and productivity of buildings' occupants by regulating temperature, humidity, quality, and air movement in healthcare buildings. HVAC system retrofitting includes ventilation and IAQ control that has a critical influence on the prevention of spreading of infections in the healthcare environment [126].Also, Yam et al., [130] specify similar opinions like [126] that reaching proper indoor ventilation and air quality is a significant contributory factor of minimizing the spread of airborne disease and different infections in healthcare facilities.

Moreover, Radwan et al., [132], with the reference on the study of a hospital in Egypt, investigated the energy efficiency by retrofitting an HVAC system for ventilation and by applying energy-efficient techniques and methods for reduction of energy consumption and CO_2 emissions. This study provides specific methods and information to provide knowledge in using energy management programs and energy efficiency methodologies for designers and managers of hospitals.

Lighting Retrofitting

In order to reach a high level of energy savings, reduce the costs of daily operations and maintenance, and provide short payback periods, cost-effective lighting technologies must be considered as one of the best solutions in hospitals [133]. In healthcare facilities especially, lighting has a crucial influence on occupants both biologically and emotionally. Notably, lighting strategies can improve the patient's experience and promote health and well-being. Additionally, from the perspective of doctors and nurses, they need a clean, bright light and clear with superior color rendering to make accurate diagnoses [126]. Furthermore, [134] emphases that supporting the lighting with an active color strategy in the healthcare environment that is accepted by patients and staff improves the well-being as well as health of patients and productivity of staff. Also, natural lighting should be integrated into lighting design strategies not only because it is helpful to occupants, but also since it is light delivered at no cost and in a form that most people prefer [126].

Water Retrofitting

In hospitals, water retrofitting reduces water consumption and realizes water-utility costs savings. A combination of behavioral and technological methods has a substantial impact on reaching considerable savings.

Furthermore, healthcare buildings are one of the primary users of water in daily operations [136]. Additionally, Priyalal1 et al., [136] have stated that healthcare facilities need special consideration for water management and defined water management as consuming water effectively without obstructing the functions of the facility. Thus, water management has a critical position in decreasing the high usage of water in the healthcare environment. During the daily practice of healthcare facilities, health services strive to protect water by providing a comprehensive water management program. [135].

Building Envelope Retrofitting

Building envelope retrofitting includes the retrofitting of the roof, walls, foundation, windows, and doors to prevent unwanted heat gains and losses and water impermeability. Upgrading windows has great impacts on operating costs, the productivity of staff, well-being and health of users [126]. Retrofitting of windows systems not only has a strong impact on the building envelope and interior design but also is a significant parameter to decrease energy usage and peak electricity demand. For instance, the selection of windows minimizes heat loss and window emissivity, controls solar heat gain, and maximizes the visible light transmittance [126]. Silenzi et al., [137] investigated the best retrofit action strategies to reduce energy consumption by using hourly simulations of hospital buildings with different combinations of VIP facades, smart windows, and LED lighting systems.

Roofs of buildings are seen as a critical part of heating loss and gain, so the roof isolation is the best retrofitting action to reduce heat loss and gain [126]. Jha and Bhattacharjee [138] developed a tool for energy efficient roof retrofitting that provides an opportunity to select the best roof retrofitting action. While they are developing a roof-retrofitting tool, they throw fresh light on a subject to enhance the energy efficiency of roofs. This study is significant to users in deciding the right materials and actions achieving energy-efficiency in roof retrofitting. Obviously, green roof systems are one of the roof retrofitting actions. In their research, Santamouris et al., [139] examined the environmental and energy efficiency of green roof systems in Athens by investigating the performance of the green roofs by using an energy performance assessment system. Eventually, the results of the examination of the energy performance of the green roof system demonstrated that using green roof systems leads to considerable energy efficiency in buildings. Another approach in building envelope retrofitting is wall retrofitting options, which include replacing the cladding, multiple sealing, adding insulation under the cladding approaches [140]. A study conducted by Al-Ragom [141] illustrated that the isolation of wall and roof systems, changing of window glazing systems, and decreasing the windows' areas contributed to accomplish annual consumption savings in arid and hot climates.

El-Darwish and Gomaa [142]'s research findings determined some of the critical measures for building envelope retrofitting such as insulation of external walls, selection of window glazing type, providing of airtightness and solar shading. Their findings showed that [142], implementation of these retrofitting methods mitigates the energy usage by 33%. Also, Ascione et al., [143] studied the energy, economic as well as environmental impacts of building envelope retrofitting for healthcare buildings and indicated that the cooling and heating loads are essential for the building envelope in the aspects of energy transfer such as transmission, radiation, and infiltration. As a result, previous research indicates that the retrofitting of the building envelope allows more stable indoor quality and reduction in energy consumption.

Seismic Retrofitting

Destructive earthquakes have caused loss of lives and economic losses worldwide over the last two decades. Under these circumstances, comprehensive seismic building regulations as well as codes have been developed in practically every country in the world [144]. Masi et al., [145] have indicated that there are various buildings in the world which were designed without seismic risk consideration, which are located in seismic areas. So, in order to define seismic risk mitigation, they developed a seismic risk reduction methodology for public buildings [145]. Sutcu et al., [144] highlighted the importance of the improvement of seismic performance of buildings by implementing seismic retrofitting practices in their study of the retrofitting of existing RC frames.

Ferraioli et al., [12] showed that seismic isolation retrofitting of hospital buildings allow the continuing daily activities of hospitals to proceed even after powerful earthquakes by focusing on a case study building.

Furthermore, Hermawan et al., [146] demonstrated that the decision-making process under complex situations such as earthquakes has a huge impact on successful hospital retrofit projects with the retrofitting in the middle of project execution that provides awareness, education, and consistency of stakeholders.

Miniati et al., [147] enhanced a decision support system for healthcare facilities' seismic risk management that can reduce the seismic impact on hospitals. According to a case study conducted by Matteis and Ferraioli [148], it is proved that the integration of metal shear panels into healthcare structures is an effective approach to reach seismic improvement. Therefore, much research has indicated that the implementation of seismic retrofitting strategies is essential to mitigate seismic impacts and damage during strong earthquakes and improve the safety of healthcare structures.

Interior Design Retrofitting

Improvements in the interior design of existing healthcare facilities are one of the effective ways to realize the retrofitting actions in building performance in terms of occupant comfort. Retrofitting of healthcare facilities based on the development of a hospital's visual environment allows occupants' health and well-being to be enhanced. Dalke et al., [134] highlighted the influence of color and lighting refurbishment of hospital buildings that resulted in a reduction of stress level and an improvement in recovery rates and well-being of occupants. Additionally, appropriate selection and implementation of color strategies in textiles, furniture, and walls create a calming environment that has a strong and positive influence on occupant psychology. Also, interior design practices by implementing different architectural design strategies provide easy wayfinding in terms of accessibility into the building. Thus, the quality of the exterior and interior appearance has a strong influence on improving the morale of occupants of healthcare facilities [134].

Defining and designing the appropriate door openings, correct placement of accessories, or defining and designing the appropriate orientation of furniture has positive outcomes in terms of patients and staff. Huisman et al., [149] showed that designing of physical environments like identical rooms, single-patient rooms, indoor quality as well as technical equipment has positive health outcomes on the healing process and the well-being of occupants. Thus, retrofitting of healthcare environment design can be seen as one of the effective contributors to reach a better, more convenient indoor environment for patients and staff.

Consequently, this section explained the green retrofitting practices and approaches in the healthcare environment. The GREHB is essential to enhance occupants' health and well-being and to improve healthcare building sustainability performance. This can be achieved with various practices which are mainly based on enhancing energy efficiency and patients' health and safety.

3. 3. Drivers, Benefits and Barriers to Green Retrofitting in Existing Healthcare Buildings

It is contestable that green retrofitting of existing healthcare facilities has great potential to reduce environmental damage. The identification of main drivers, benefits, and barriers of retrofitting healthcare buildings is essential to enhance buildings sustainability performance and to understand the dynamics of the retrofitting process before focusing on the CSFs.

Drivers

Based on previous research, drivers of green retrofitting of healthcare facilities are the main contributors to overcome the negative impacts on the built environment. Existing literature indicates that there are various studies on drivers for green retrofitting. Sheth et al., [150] defined the sustainability drivers for healthcare facilities into three aspects; they are construction drivers (waste reduction, energy conservation, materials, IEQ, etc.), administrative drivers (education, performance-based standards, resource conservation etc.) and also, legislative drivers (policies and regulations, partnership project stakeholders etc.). Also, Sheth et al., [151] identified the main drivers for refurbishment of healthcare facilities as users' drivers (new operations, privacy issues, patient room improvement, development of outpatient areas etc.), construction drivers (the age of the building, maintenance and operational costs, seismic status of the structure, energy consumption etc.) and future drivers (policies and regulations, competition, new technologies etc.). Policies and regulations are one of the main drivers that set the energy efficiency needs for green retrofitting and also, different retrofit technologies in order to promote green retrofit projects [118].

Furthermore, Low et al., [17] emphasized the main drivers for greening new and existing buildings as governmental corporate social responsibility, legislation/incentives, overseas competition/influence, rising energy bills, competent team members, marketing/branding motivation, improving the well-being of employees, local competition as well as return on investments (ROI).

Other pioneering drivers determined by Aktas and Ozorhon [152], are reduction of operation costs, high return on investment, competitiveness, high occupant satisfaction level, increasing environmental awareness and occupant comfort, water, and energy conservation. Therefore, the existing literature has shown that there are important drivers for green retrofitting. The most-reported drivers in existing literature are demonstrated in Table 6.

Table 6: Drivers to GREHB

Drivers	**References**
Government regulations and policies	Low et al., [17]; Ma et al., [118]; Sheth et al., [150]; Sheth et al., [151]; Perrett [153]; Britnell and Dixon [154]; Wilson [155]; Darko et al., [156]; Li et al., [157]
Reduced costs/ financial gain	Low et al.,[17]; Sheth et al., [151]; Aktas and Ozorhon [152]; Perrett [153]; Britnell and Dixon [154]; Darko et al., [156]; Bertone et al., [158]; Polzin et al., [159]
Energy conservation	Sheth et al., [150]; Sheth et al., [151]; Aktas and Ozorhon [152]; Darko et al., [156]; Gundogan [160]
Knowledge, skills, and awareness	Aktas and Ozorhon [152]; Darko et al., [156]; Li et al., [157]; Polzin et al., [159]
Improved health and well-being and satisfaction	Low et al.,[17]; Aktas and Ozorhon., [152]; Darko et al., [156]; Lomas and Giridharan [161]
Competition	Low et al.,[17]; Sheth et al., [151]; Aktas and Ozorhon [152]; Gundogan [160]
Improve thermal comfort/performance	Lomas and Giridharan [161]; El-Maghlany et al., [162]; Lan et al., [163]
Rising energy costs'	Low et al.,[17]; Perrett [153]
Development of schemes/tools	Perrett [153]; Li et al., [157]; Polzin et al., [159]
Marketability	Sheth et al., [151]; Perrett [153]; Darko et al., [156]
Water conservation	Aktas and Ozorhon [152]; Darko et al., [156]; Gundogan [160]
Improved IEQ	Sheth et al., [150]; Darko et al., [156]; Gundogan [160]
Improved comfort	Aktas and Ozorhon [152]; Britnell and Dixon [154]; Gundogan [160]
Education and training	Sheth et al., [150]; Darko et al., [156]
Corporate image, culture, and vision	Low et al., [17]; Darko et al., [156]
Improved occupants' productivity	Darko et al., [156]; Gundogan [160]
Corporate social responsibility	Low et al., [17]; Lomas and Giridharan [161]
Environmental protection	Darko et al., [156]
Reduced payback period	Darko et al. [156]
Waste reduction	Sheth et al. [150]
Quality of care	Sheth et al. [151]
Competent team members	Low et al. [17]
Incentives	Britnell and Dixon [154]
Infection control	Sheth et al. [151]
Building age	Sheth et al. [151]

Benefits

Many studies have focused on the benefits of GREHB in recent years. Tan et al. [121] identified the benefits of green retrofitting as both reduced energy consumption and GHG. Further, case studies on Children's Hospitals conducted by Enache-Pommer and Horman [15], described the benefits of green retrofitting defined as reduced water as well as energy usage that increased the productivity of employee and reduced the cost of life cycle. Furthermore, Yu et al., [164], divides benefits into two groups as economic and financial and intangible benefits that include savings in operating costs and a higher net income to the building owners. Also, there are intangible benefits that include improving the company's brand image, improving IEQ, and reducing symptoms of users of green buildings [164].

Chen [18]', benefits of green retrofitting includes;

- minimized operating costs
- higher return on investment and higher rental income
- lower tenant churn and vacancy rates, opening the building to new tenant markets
- the higher overall capital value of the building
- minimized environmental footprint and GHG
- enhanced IEQ
- money saved investing in energy infrastructure
- futureproofing against tenant demands and government regulations

- improved corporate image
- making the building more attractive to investors

Previous studies showed that green retrofitting has crucial benefits in the perspective of a building's sustainability performance and occupants. The most reported benefits in existing literature are demonstrated in Table 7.

Table 7: Benefits to GREHB

Benefits	**References**
Achieved energy savings/Reduced energy consumption	Mickaitytė et al., [120]; Buonomano et al., [129]; Short et al., [131]; Radwan et al., [132]; Silenzi et al., [137]; Ascione et al., [143]; Bertone et al., [158]; El-Maghlany et al., [162]; Moghimi et al., [166]; Chiang et al., [167]; Kim et al., [168]; Silenzi et al., [169]; Keeton [170]; Staljanssens et al., [171]; Khairi et al., [172]; Short et al., [173]; Pavković et al., [174]; Principi et al., [175]; Carbonari et al., [176]; Ascione et al., [177]; Taleb [178]; Bertone et al., [188]; Darko et al., [189]; Tan et al., [190]
Reduced $C0_2$ emissions/GHG	Chen [18]; Radwan et al., [132]; Bertone et al., [158]; Lomas & Giridharan, [161]; Khairi et al., [172]; Pavković et al., [174]; Taseli and Kilkis [179]; Bertone et al., [188]; Darko et al., [189]; Tan et al., [190]
Achieved cost savings/lower costs	Chen [18]; Yam et al., [130]; Radwan et al., [132]; Silenzi et al., [137]; Bertone et al., [158]; Yu et al., [164]; Moghimi et al., [166];Bertone et al., [188]; Darko et al., [189]
Improved IEQ	Chen [18]; Yu et al., [164]; Khairi et al., [172]; Darko et al., [189]
	Yam et al., [130]; El-Maghlany et al., [162]; Lan et al., [163]; Ascione et al., [177]
Improved health and well-being	Azizi, [35]; Buffoli et al., [36]; Karliner and Guenther [37]; Dalke et al., [134]; Keeton [170]; Ellis et al., [180]; Darko et al., [189]
Improved patient recovery/healing process	Wagner [31]; Burpee & McDade [53]; Buonomano et al., [129];Dalke et al., [134]; Nimlyat et al., [181];
Improved seismic performance of building/seismic safety	Masi et al., [145]; Carbonari et al., [176]; Sorace and Terenzi [182]; Asgarian and McClure [183]; Ferraioli and Mandara [184]
Reduced water consumption	Bertone et al., [158]; Chiang et al., [167]; Rice et al., [185]; Bertone et al., [188]
Reduced the staff's/stakeholder's levels of productivity	Buonomano et al., [129]; Khairi et al., [172]; Nimlyat et al., [181]; Darko et al., [189]
Improved thermal comfort/ performance	Buonomano et al., [129]; Lomas & Giridharan, [161]; El-Maghlany et al., [162]; Darko et al., [189]
Reduced comfort level/ satisfaction	Mickaityte et al., [120]; Buonomano et al., [129]
Quality improvement of care	Hicks et al., [186]; Payne and May [187]; Melo [191]
Improving the company's brand image	Chen [18]; Yu et al., [164]; Darko et al., [189]

Barriers

Recent literature on barriers to green retrofitting practice of healthcare buildings classify the barriers of green retrofitting into different categories. Alam et al., [192] identified the main barriers into four different criteria, which are economic, knowledge, regularity as well as social. Economic barriers include high upfront costs, minimize cost, priorities in investments, split incentives, lack of finance, payback expectations, price signals, uncertainties over financial gain, materiality as well as lack of attention. Regulatory barriers include fragmented markets, institutional, structural, and multi-stakeholder issues, and the government not acting as an active driver. Knowledge barriers were determined as a absence of awareness and information, absence of motivation, absence of awareness of savings potential, knowledge and skills related to building professionals, confusion in choosing the best option, and misperceptions regarding energy efficiency. The social barrier was identified as the interruption to building operations [192].

Jagarajan et al., [7] have identified main barriers, challenges, problems or obstacles affecting successful green retrofit projects under nine different topics as policy support, green building professionals, financial resources, green development quantification, internal leadership, communication, green material, green awareness as well as technology. Another study determines the main barriers for healthcare environments as organizational barriers, economic barriers, physical/operational barriers and regulatory barriers [193].

In addition to the aforementioned barriers, Ma et al., [118] highlighted other factors of uncertainty which can be a challenge for the retrofit action of existing healthcare buildings. Also, Wilson and Kishk [13] stated the unique characteristics of healthcare facilities that can be turned into a challenge. For example, Sheth et al., [10] have indicated that there can be healthcare specific challenges because of design, location, design, goals, scope of work, objectives depending on the project. Compared to the construction of new facilities, refurbishment is a challenging approach in terms of structure, form, and orientation of existing buildings [10].

Further, Kamath et al., [38] illustrated, that the healthcare-specific barriers can be identified as compliance with regulatory requirements, operational hours, meeting the needs of licensing and accreditation agencies, rates of ventilation, hospital infection control, life cycle of hospital buildings, chemical use: high-volume waste stream, intense water, and energy use, the myth of higher cost, lack of green hospital practices being mandatory, and lack of pull from customers. To sum up, studies demonstrated that there are significant factors that affect the GREHB. The most-reported barriers in the existing literature are presented in Table 8. Identified drivers, benefits and barriers in this section have a strong influence on achieving sustainable healthcare buildings and the applications of green retrofitting in terms of realizing economic, environmental, social, and managerial targets.

Table 8: Barriers to GREHB

Barriers	References
High cost	Jagarajan et al., [7]; Chen, [18]; Baer [114]; Silenzi et al., [137]; Gundogan [160]; Alam et al., [192]; Wang et al., [194]; Woo et al., [195]; Mohammadpour et al., [196]; Darko et al., [198]; Afshari et al., [200]; Ahmad et al., [262]; Shen et al., [264]
Lack of information, education, knowledge and awareness and expertise	Jagarajan et al., [7]; Chen,[18]; Baer [114]; Dalke et al., [134]; Hermawan et al., [146]; Gundogan [160]; Bertone et al., [188]; Alam et al., [192]; Wang et al., [194]; Darko et al., [198]; Afshari et al., [200]; Ahmad et al., [262]
Lack of governmental regulations and policies	Jagarajan et al., [7]; Bertone et al., [188]; Alam et al., [192]; Wang et al., [194]; Darko et al., [198]; Afshari et al., [200]; Ahmad et al., [262]; Shen et al., [264]
Risks and uncertainty	Chen [18]; Masi et al., [145]; Alam et al., [192]; Wang et al., [194]; Darko et al., [198]; Afshari et al., [200]; Ahmad et al., [262]
Lack of experienced stakeholders	Jagarajan et al., [7]; Chen, [18]; Gundogan [160]; Bertone et al., [188]; Alam et al., [192]; Wang et al., [194]; Ahmad et al., [262]
Lack of incentives/support	Jagarajan et al., [7]; Gundogan [160]; Wang et al., [194]; Darko et al., [198]; Afshari et al., [200]; Ahmad et al., [262]
Lack of finance/limited budget	Bertone et al., [188]; Melo [191]; Alam et al., [192]; Wang et al., [194]
Lack of green materials/resources	Jagarajan et al., [7]; Gundogan [160]; Darko et al., [198]; Afshari et al., [200]
Lack of interests	Alam et al., [192]; Darko et al., [198]; Afshari et al., [200];
Lack of communication and collaboration among project stakeholders	Jagarajan et al., [7]; Darko et al., [198]; Afshari et al., [200]; Ahmad et al., [262]
Lack of inadequate certification schemas/tools/codes/standards	Hermawan et al., [146]; Mohammadpour et al., [197]; Darko et al., [198]
Healthcare specific barriers	Wilson and Kishk [13]; Kamath et al., [19]; Sheth et al., [104]
Lack of internal coordination and leadership	Jagarajan et al., [7]; Alam et al., [192]
Lack of integrated design methods	Gundogan [160]; Darko et al., [198]
Project location	Sheth et al., [10]; Bertone et al., [188]; Darko et al., [198]; Ahmad et al., [262]
Age of the building	Carbonari et al., [176]; Alam et al.,[192]; Ahmad et al., [262]
Patient population	Melo [191]; Rosenbaum et al., [199]
Project complexity	Darko et al. [198]
Long payback period	Wang et al., [194]; Ahmad et al., [262]; Shen et al., [264]

3.4. Retrofitting Methodologies/Approaches

Healthcare providers, project managers, stakeholders, and clients of healthcare projects need a roadmap to have green retrofitted healthcare projects successfully implemented. Bertone et al., [188] have identified the critical lines of a successful retrofitting project as building efficiency assessment, selection of the best retrofit option, procurement, financing, and post-retrofit measurement, and verification (M&V) (Shown in Figure 8). Bertone et al., [188] identified a successful retrofit project as a bridge, so each component mentioned above should be completed to accomplish a retrofit project.

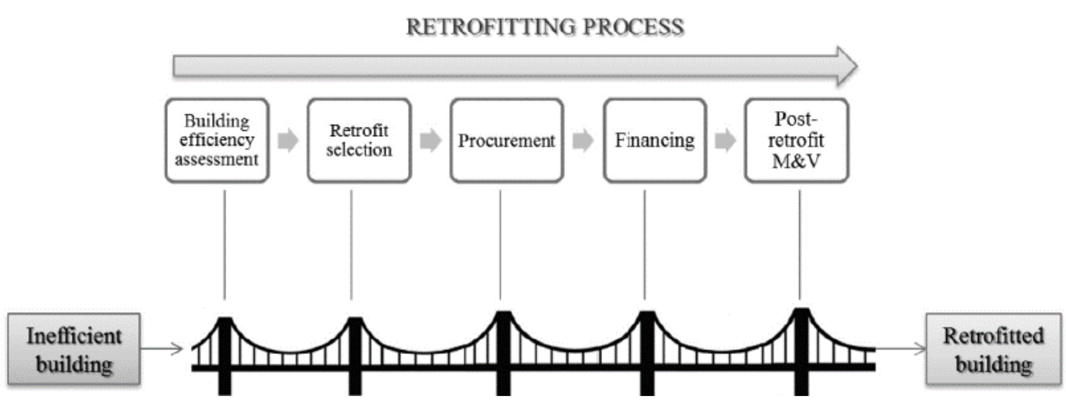


Figure 8: The key components of building retrofitting project [188]

Ma et al., [118] have recommended an approach to sustainable building retrofits based on development on project pre-retrofit and setup surveys, energy auditing and performance assessment, identification of retrofit options, site implementation and commissioning, and validation and verification components

(Shown in Figure 9). This approach could be used for retrofitting any buildings.

- The project setup and pre-retrofit survey phase includes the defined scope of work, setting project targets, determination of available resources, and pre-retrofit surveys.
- The energy auditing and performance assessment phase includes an understanding of building energy data, selection of key performance indicators, and building energy auditing and performance assessment and diagnostics.
- Identification of retrofit options includes energy savings estimation, economic analyses, risk assessment and prioritize retrofit options.
- Site implementation and commissioning include site implementations, and test and commissioning (T&C).
- The validation and verification phase include project post measurement and verification (M&V) and post-occupancy survey [118].

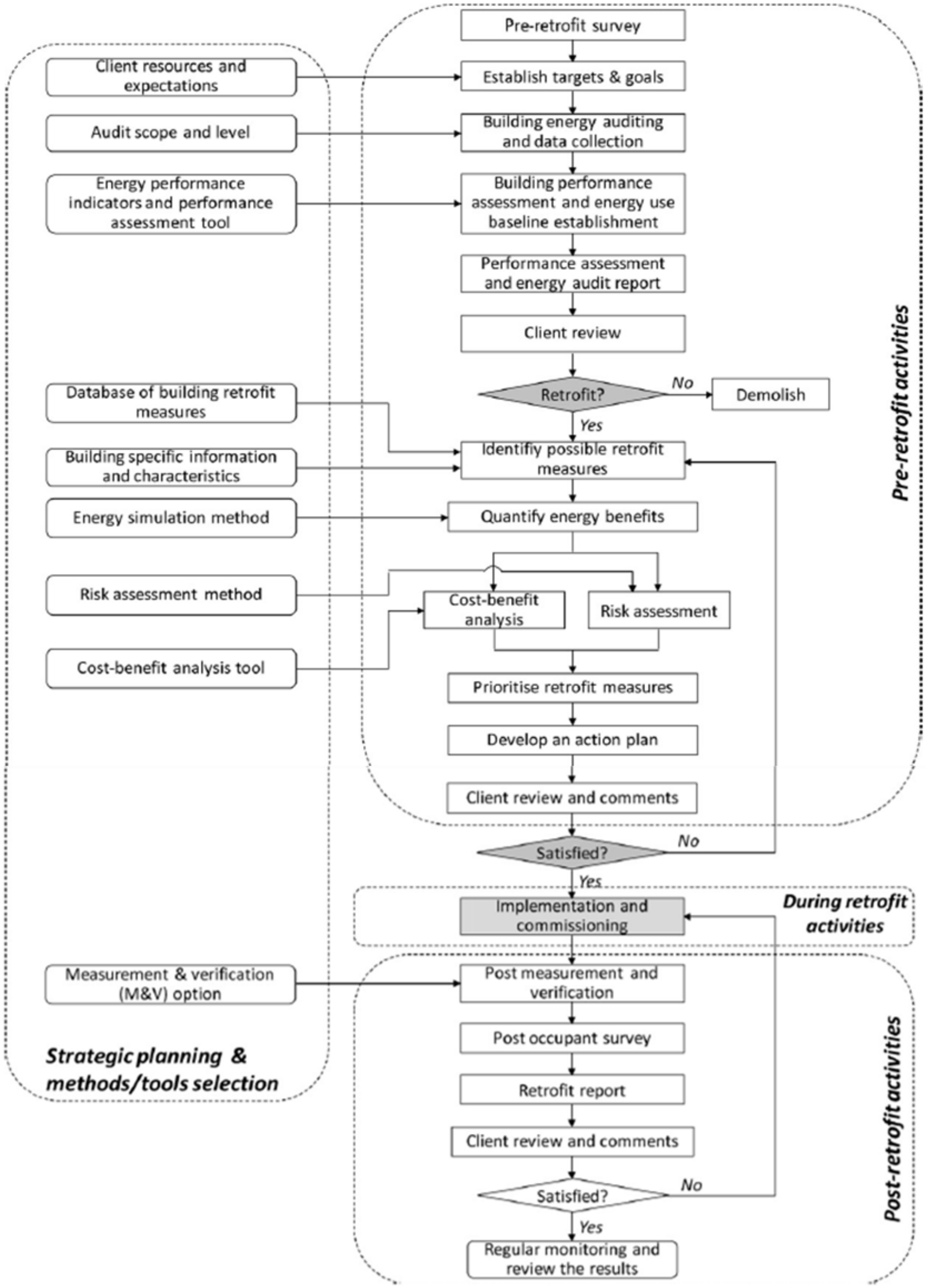


Figure 9: A systematic approach to sustainable building retrofits [118]

Furthermore, Luther and Rajagopalan [201] have proposed a pre-retrofitting methodology that was divided into four categories as stakeholder commitment, including the development of building performance, a building integrity audit, building operation, and building improvement. The methodology is based on defining energy waste first, reducing the electrical demand, and then retrofitting for energy-efficiency. Furthermore, a "building integrity audit" provides the categorization of three major energy consumers that are the determination of waste, missed opportunities, and rescheduling the operation of equipment use [201]. The proposed methodology is shown in Figure 10.

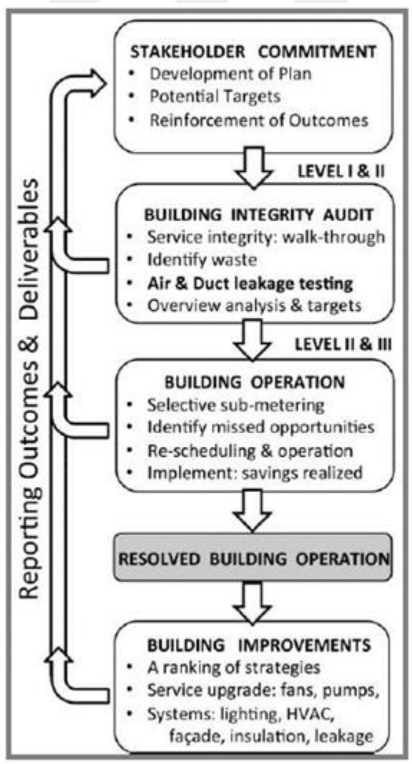


Figure 10: A proposed methodology to energy retrofitting [201]

Mickaityte et al., [120] have recommended a sustainable building refurbishment concept model, which includes social, economic, ecological, architectural, cultural as well as technical dimensions, which have a strong influence on general refurbishment efficiency. This concept model proposes the implementation of the aforementioned dimensions with a particular focus on health of public, efficient energy use and rational resource use, environment protection, and affordability. Sustainable building refurbishment includes information collection, decision modeling, solution selection, and implementation phases [120]. The conceptual model is given in Figure 11.

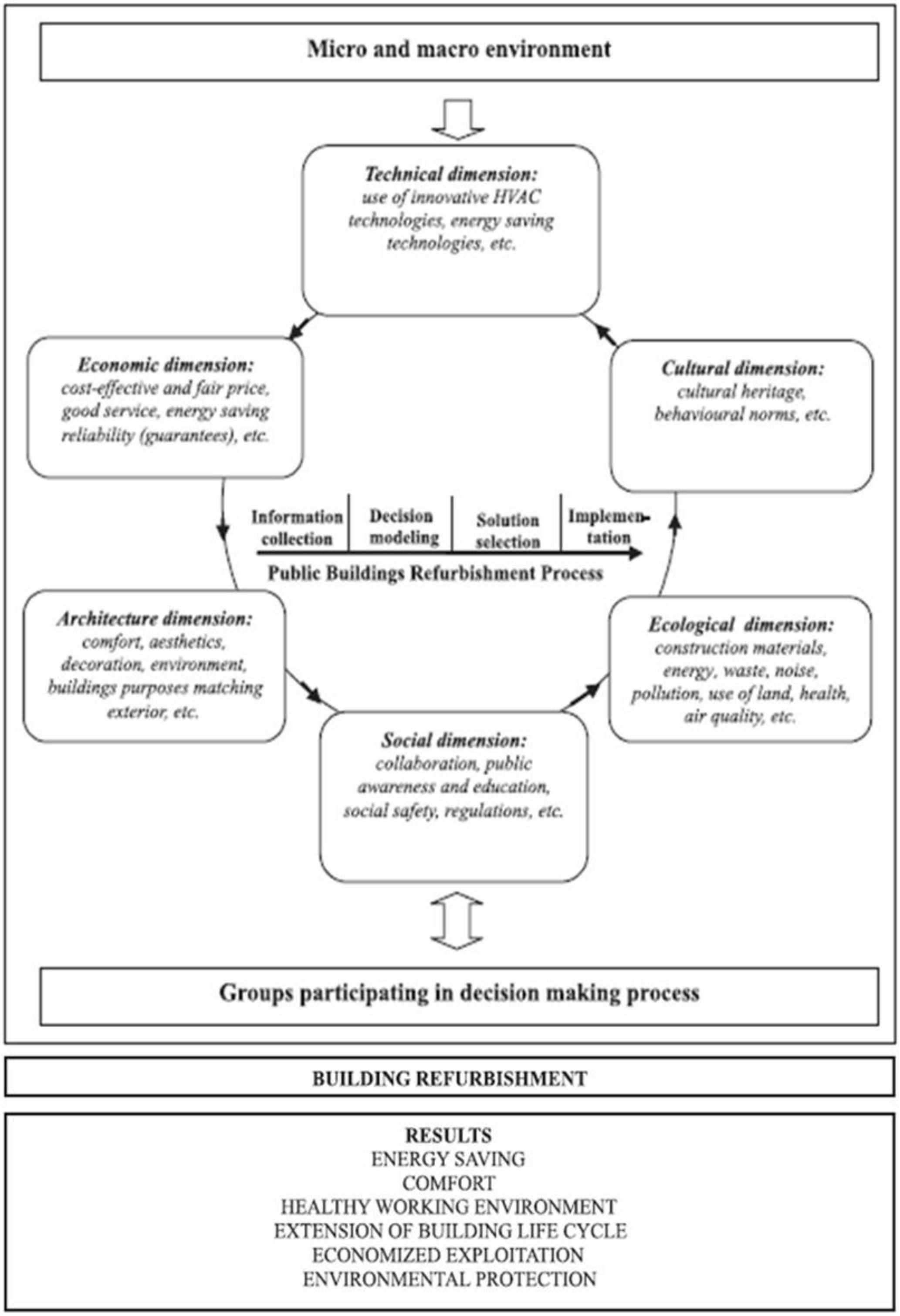
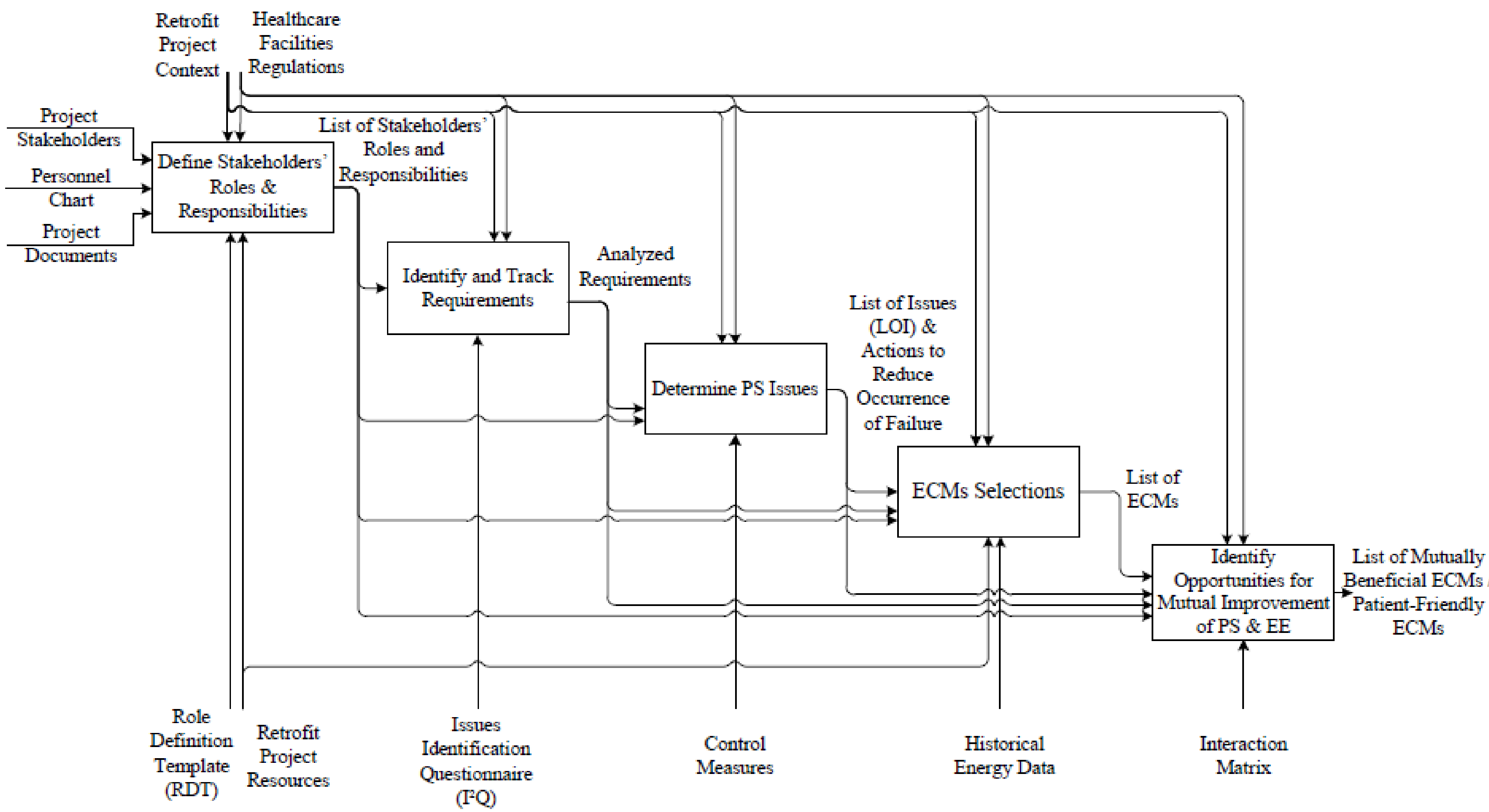


Figure 11: The concept model of sustainable building refurbishment [120]

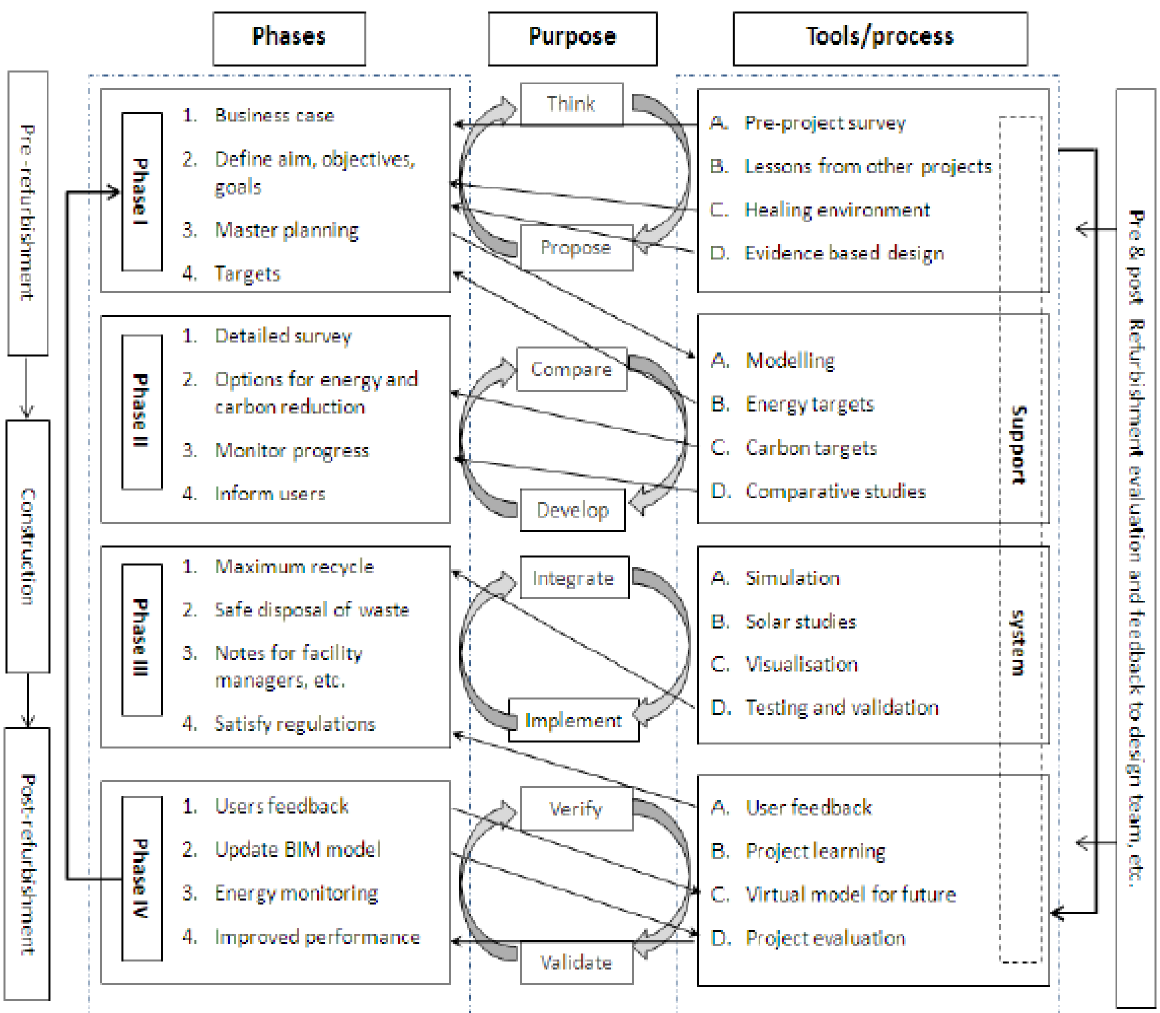
Additionally, in terms of a healthcare perspective, significant studies about retrofit methodologies especially for healthcare buildings exist in the literature. Mohammadpour [14] studied on the retrofitting of healthcare buildings based on patient safety and energy efficiency issues. They developed the Patient Safety and EnergyEfficiency (PATSiE) Framework in order to improve safety of patients and energy efficiency of existing healthcare facilities. PATSiE consists of systematic steps respectively: Define Stakeholders' Roles and Responsibilities, Identify and Track Requirements, Determine PS (Patient Safety) Issues, ECMs Selection, and Identify Opportunities for the Mutual Improvement of PS & EE (Energy Efficiency). The PATSiE framework is shown in Figure 12.

Figure 12: PATSiE framework retrieved from [14]



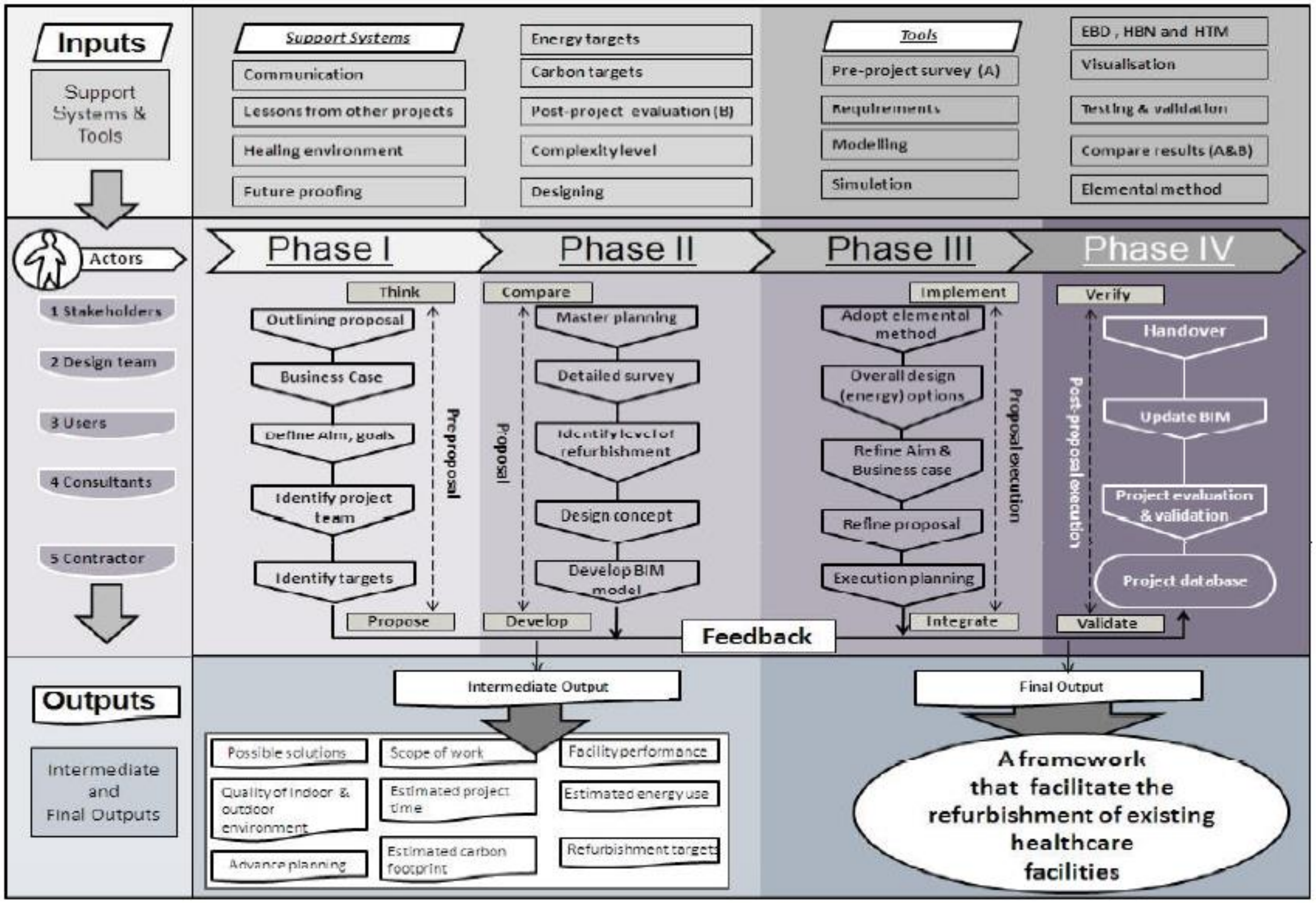
Likewise, Sheth et al., [10] proposed a framework for the refurbishment of healthcare facilities with an energy focus with other possible construction considerations. The framework includes three primary refurbishment processes, respectively: pre refurbishment, refurbishment, and post refurbishment. Also, to gain better understanding, the conceptual framework was divided into three columns. Figure 13 demonstrates the developed framework for refurbishment of healthcare facilities.

Figure 13: Framework for refurbishment of healthcare facilities [10]



Moreover, Sheth [67] proposed A Healthcare Energy and Refurbishment (HEaR) Framework to integrate existing approaches for refurbishment of exiting healthcare buildings. That framework consists of four parts including pre-proposal (think and propose), proposal (compare and develop), proposal execution (implement and integrate), and post-proposal execution (verify and validate). The framework also covers the supporting systems, tools and actors which will have a critical role in the refurbishment process of existing healthcare facilities. The conceptual framework is given in Figure 14.

Figure 14: A healthcare energy and refurbishment (HEaR) framework [67]



Besides sustainable retrofitting methodologies at building level, there is also a neighborhood level retrofitting project that is developed as an integrated retrofit design methodology (IDM) for NewTREND project. This methodology emphasizes the importance of stakeholder integration in retrofitting projects and aims to provide a guideline for all involved stakeholders in finding the most effective energy retrofitting solutions in neighborhood retrofitting projects concerning energy and cost-efficiency and their overall sustainability performance. The IDM created a method that integrates stakeholders in the design process and linked them to the ten different project phases which are initiation phase, the preparation phase, diagnosis phase, strategic definition, concept phase, decision-making phase, design development and tendering phase, construction phase, handover and closeout phase, and the in-use phase [202] (Shown in Appendix A).

All in all, in the existing literature, there are various retrofitting methodologies with different focuses such as energy efficiency, stakeholders, citizens' healthcare, and patient safety focuses. Despite the different concerns, it can be stated that in all retrofitting methodologies, the identified stages as part of the retrofitting methodologies lead towards retrofitting progress and successful operations in retrofitting of exiting healthcare buildings.

Identification of the roadmaps to reach successful implementation and operation of retrofit projects helps to understand the retrofitting approaches in different phases and creates awareness for retrofitting methods. Therefore, the retrofit stages determined from the researchers who investigated the retrofit stages for the projects [10], [67], [118], [120], [188] and [201]; the stages of the retrofit project were identified as pre-retrofit, retrofit, and post-retrofit stages. Table 9 presents the retrofit stage of existing healthcare buildings.

Table 9: The retrofit stages of existing healthcare buildings

Stages	References		References
Pre-retrofit	Sheth et al., [10]; Ma et al., [118]	Project setup and Pre-retrofit survey	Ma et al., [118]; Sheth et al., [10]; Sheth [67]
		Define targets and goals	Ma et al., [118]; Sheth et al., [10]; Sheth [67]
		Building efficiency/ performance assessment	Ma et al., [118]; Bertone et al., [188]; Luther and Rajagopalan [201]
		Selection of retrofit options	Ma et al., [118]; Mickaityte et al., [120]; Bertone et al., [188]; Luther and Rajagopalan [201]
		Define Stakeholders' Roles and Responsibilities	Mohammadpour [14]; Sheth [67]
		Determine PS (Patient Safety) Issues	Mohammadpour [14]
Retrofit	Ma et al., [118]	Implementation of retrofit project	Ma et al., [118]; Mickaityte et al., [120]; Bertone et al., [188]; Sheth [67]
Post-retrofit	Sheth et al., [10]; Ma et al., [118]; Bertone et al., [188]	Measurement and verification (M&V)	Ma et al., [118]; Bertone et al., [188]
		Post Occupancy Survey	Ma et al., [118]

CHAPTER IV

IV. RESEARCH METHODOLOGY

In this thesis, it is critical to examine the findings of the previous researches, which are relevant to the thesis topic for providing comprehensiveness. A “mixed-method,” approach, which consists of a combination of quantitative and qualitative methods [203], was used to identify the CSFs for green retrofitting in the thesis methodology. In this context, the research began with a structured literature review for deriving a priori list of CSFs of greening existing healthcare buildings. Secondly, a questionnaire survey was prepared to explore the CSFs for GREHB. In the questionnaire survey, the respondents were asked to evaluate the importance of the pre-determined CSFs of GREHB via sending an e-mail. Considering the reviewed literature and the list of CSFs obtained from survey results, a priori conceptual framework for CSFs of GREHB was developed. Finally, a survey was conducted for ensuring the validity of the developed framework. Figure 15 demonstrates the research methodology of this thesis.

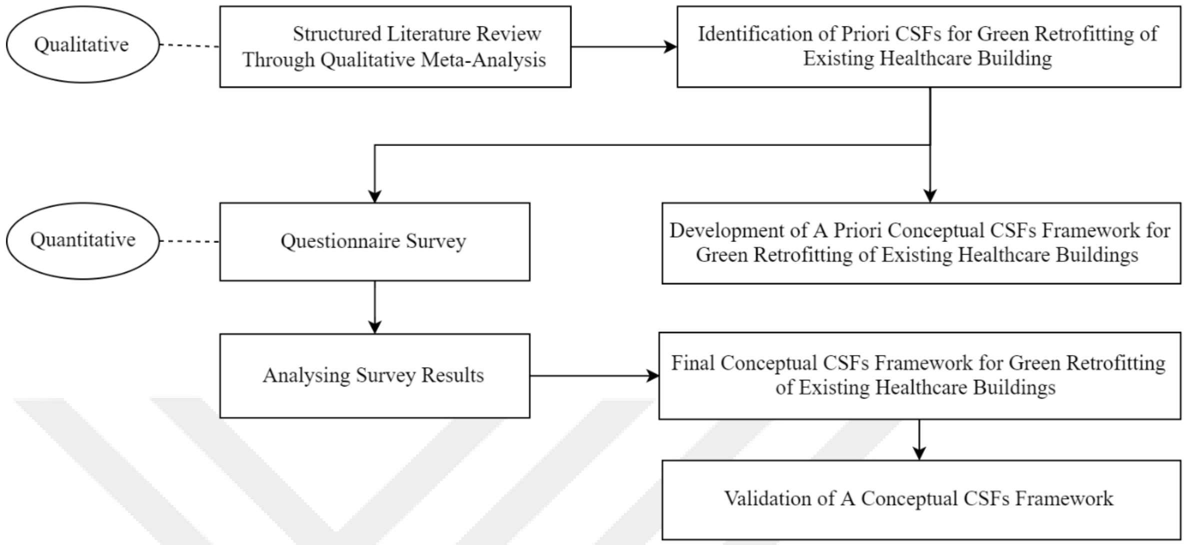


Figure 15: Research methodology of this thesis

4.1. Structured Literature Review through Qualitative Meta-Analysis

A structured literature review is known as a research procedure of study to classify and critically evaluate relevant research.

[204]. The qualitative meta-analysis method was used to conceptualize and synthesize the current literature of CSFs for the GREHB [204]. Qualitative synthesis is a method of scientific investigation aimed at systematically reviewing and formally integrating the findings in reports of completed qualitative studies. The qualitative research synthesis is known as qualitative meta-analysis or qualitative meta-synthesis in the existing literature [205].

Designing the search strategy is the curial part of any study. Hence, for retrieving relevant articles for this study, a systematic search of existing literature was conducted by using Scopus and Web of Science (WoS) databases. The keywords for searching were defined as “critical success factors (CSFs),” hospital,” “healthcare,” “retrofit*,” “green*,” “refurbishment” and “sustainability” that were searched for in the title, abstract and keyword sections of selected databases. “Searching” was done with various combinations of the chosen keywords to identify CSFs of existing healthcare buildings’ retrofit (searched 06.11.2019). Table 10 shows all keywords and combinations that were used in these searches.

Table 10: Keywords for database searches

Database Searches Searched: abstract, title and keyword	
Cluster 1	**Cluster 3**
CSFs AND retrofit*	CSFs AND green* AND healthcare
CSFs AND refurbishment	CSFs AND green* AND hospital
CSFs AND green*	CSFs AND green* AND retrofit*
CSFs AND sustainability	CSFs AND green* AND refurbishment
Cluster 2	**Cluster 4**
CSFs AND sustainability AND healthcare	CSFs AND retrofit* AND healthcare
CSFs AND sustainability AND hospital	CSFs AND retrofit* AND hospital
CSFs AND sustainability AND retrofit*	**Cluster 5**
CSFs AND sustainability AND refurbishment	CSFs AND refurbishment AND healthcare
CSFs AND sustainability AND green*	CSFs AND refurbishment AND hospital

The search was conducted in the “title, abstract, and keywords” sections of Scopus and WoS with a chosen time limit as “published all years to present.”

The search results demonstrated that 851 articles were found which involved at least one of the keywords. The determination of relevant papers was done in four steps. The Prisma Flow Diagram shows the process followed for the identification of the CSFs (Shown in Table 11).

Step 1: In the first step, 851 papers were identified through Scopus and Web of Science database searching.

Step 2: 851 papers were arranged in alphabetical order, and the articles with the same name were extracted. As a result of the elimination process, 485 papers were found. Through the screening of abstracts, titles, and keywords of 485 papers’ names, a total of 90 papers were found relevant for defined keywords.

Step 3: With an in-depth review of the full text of a selected 90 papers, 48 papers were found as relevant for this study.

Step 4: Investigating the selected relevant papers, only 38 papers were included for the identification of CSFs.

Table 11: The prisma flow diagram for the identification of the CSFs

Identification	Records identified through Scopus and Web of Science database searching (n =851)
Screening	Records after duplicates removed (n = 485) Records screened abstract-title-keywords (n = 90)
Screening	Full-text articles assessed for eligibility (n = 90)
Included	Articles included in the analysis (n = 38)

4.2. Questionnaire Survey-CSFs

The quantitative part of this thesis consists of conducting a questionnaire survey method which was already chosen by most researchers for the identification of CSFs., [206], [17]. The questionnaire is the most frequently used mode of observation method to collect original data and describe a population too large to observe directly. To conduct a questionnaire, the researcher defines a sample of respondents and carries out a designed questionnaire to each person in the sample [207]. Thus, considering existing studies on the investigation of CSFs of green retrofitting, to define the CSFs for GREHB, the questionnaire survey method was chosen for this thesis.

4.2.1. Sampling Strategy

A carefully constructed probability sampling consists of a group of participants that are identified to reflect the characteristics of a large population. In this way, a well-structured questionnaire can be provided to all participants with standardized questions, and the same data can be produced from all participants [207].

The determination of the population and sampling usually requires decisions in four topics; where the sample is to be taken, what type of sample will be created, the sample size, and the number of acceptable responses [208].

The target population was selected as professionals and academicians who have experience in "green buildings" and "sustainability" in Turkey. The Researcher Information System (ARBİS) [209], LEED Accredited Professional (AP) [60], and BREEAM Assessor databases [69] were used to determine professionals and academics. ARBİS is the researcher database of Turkey, developed by TÜBİTAK [209]. For identifying the researchers' sample from this generated population, "green buildings" and "sustainability" keywords were used. The lists of members in ARBİS, in LEED and in BREEAM demonstrated that, the total population of the sample who were an expert on green building or sustainability practices, were 190 people [60], [69], [209].

One of the most critical issues of the sampling process is the determination of the number of units to be sampled and the sample volume. As the sample volume increases, the calculated value of the sample statistics approaches the parameter values, thus the range of change of possible sample statistics is distributed, and the standard of error decreases, and hence, the accuracy increases [210].

The sample size for this research was calculated using the formulas which are given by Kish [211], including (1), (2), and (3).

$$n = \frac{n'}{(1+\frac{n'}{N})} \tag{1}$$

$$n' = \frac{S^2}{V^2} \tag{2}$$

$$S^2 = (p)(1-p) \tag{3}$$

n: sample size

N: total population= 190

V: standard error in sample distribution = 0.05

S: maximum standard deviation within the population (Total errors=0.10, (%) 95% confidence level)

p: representation of the selected sample in the total population

With the help of the formulas given in (1), (2) and (3), the sample size required for the survey study is calculated as n = 65.

The CI also has a poor reputation for known low response rates in surveys. 20% -40% is accepted as the norm [212]. Therefore, this fact should be taken into consideration in the sample size to which the questionnaire will be sent.

4.2.2. Survey Development and Pilot Study

The structured literature review contributed to the investigation of the CSFs of GREHB and the development of the questionnaire survey. The questionnaire included four parts.

Part I is an introductory section that describes the aims and objectives of this research and explains the questionnaire's structure. Part II consists of the questions which are related to the background information of the respondents, including job and years of experience. Part III consists of the questions of CSFs of GREHB, and in this part, professionals and academics were asked to assess the importance of CSFs by using a five-point Likert scale ranking. In this part, number 1 represents "not important," number 2 represents "slightly important," number 3 represents "important." number 4 represents "very important," and number 5 represents "extremely important" (Shown in Table 12.)

Table 12: Importance of variables

Rating	Importance of Variables
1	Not Important
2	Slightly Important
3	Important
4	Very Important
5	Extremely Important

The Likert scale is mainly used in questionnaires to obtain a respondent's preferences or rate of agreement with a statement or set of statements [213]. The Likert scale was selected to conduct this research since the use of this method has become popular in both CSFs, green building, green healthcare, and retrofitting studies (see, in example [206], [18], [11], [194]).

Part IV is the suggestion part. In this part, the participants were asked whether there are any CSFs apart from for the CSFs suggestions described above in the GREHB.

In order to test the appropriateness, validity, and reliability of the questionnaire before the survey, a pilot study was managed. The pilot study consisted of the four academics and a postgraduate researcher who have a background in green buildings, green healthcare, and green retrofitting topics. Approximately 25 minutes were sufficient to complete the questionnaire. Based on feedback from the participants of the pilot study, the questionnaire was developed into the final version. The questionnaire is given in Appendix B.

Also, to conduct this questionnaire, permission was taken from the ethical committee. The decision of the ethics committee is given in Appendix C.

4.2.3. Data Collection and Analysis

This part demonstrates how data was obtained from the questionnaire. The questionnaire was sent via e-mail to a total of 190 respondents who are listed in ARBİS, LEED, and BREEAM. A fifteen days period was given to complete the questionnaire. At the end of the duration, 12 respondents answered the questionnaire. Due to the low response rate, respondents were asked to complete the questionnaire again. This step was repeated two more times. As a result of the data collection steps, 46 valid replies were obtained from the respondents.

Based on data obtained from the questionnaire, the results were analyzed statistically by using the IBM SPSS Statistic 20 (Statistical Package for the Social Sciences). Additionally, the MS Office Excel 2018 program was used to obtain visually smooth graphics and charts. Descriptive and inferential statistics were used for the data obtained from the survey such as arithmetic mean, standard deviation and coefficient of variation. Starting from descriptive statistics, a series of statistical analysis procedures such as Cronbach Alphas criteria were used to test the reliability of the scales. Statistical procedures and the data obtained in the questionnaire are explained in detail in Chapter VI – Results.

4.3. Development of a Conceptual CSFs Framework for Green Retrofitting of Existing Healthcare Buildings

The development process of a conceptual CSFs framework for GREHB has three consecutive steps. The first action is a structured literature review, the second step is to conduct a questionnaire survey, and the third one is the evaluation and validation of the developed framework. The development of the framework includes mixed methods; these consist of qualitative and quantitative methods and inductive inferences.

Step 1: The Structured Literature Review

The conceptualization of the CSFs framework for green retrofitting of healthcare buildings is one of the critical parts of this thesis. Firstly, a structured literature review was conducted to develop an initial CSFs framework for GREHB. As a result of the reviewed literature, CSFs were identified to develop the conceptual framework. To classify the obtained CSFs for framework development, the normative refinement process was used. The main CSFs dimensions were taken from the researchers who made the framework in the literature namely, [112], [83], [120], [17], [16], [214], [215], [216]. Table 13 represents all dimensions obtained from existing literature.

Table 13: Main CSFs dimensions in existing literature

Main Dimensions	References								
	[83]	[120]	[17]	[112]	[242]	[247]	[168]	[233]	[16]
Economic	x	x		x					
Environmental	x			x		x			
Social	x	x		x					
Technical		x		x		x			
Cultural		x							
Architectural		x							
Ecological		x							
Pre-Project-Related Factors			x						
Project Management-Related Factors			x						
Client-Related Factors			x						
Project Team-Related Factors			x			x			
External Factors			x		x				x
Project-Self Factors					x				
Leadership & Team Factors					x				
SD Factors					x				
Financing Factors					x				
Contracting Factors					x				
Partnership Factors					x				
Project Process Factors					x		x		
Communication Factors						x			
Organizational Factors						x			
Project Success						x			
People							x		
Technological							x		
Governance Success Factors								x	
Project Management									x
Interactive Processes									x
Project Related Factor									x
Human Related Factor									x
Contractual Arrangements									x
Knowledge and Innovation of SD									x
Project Procedures									x
Implementation of SD Strategy									x

Nine main dimensions were identified for this study as Economic, Environmental, Socio-cultural, Technical, Managerial/ Organizational, Human, Technological, Political, and Project dimensions.

As a result of the normative refinement process, the framework was proposed at three levels; Level 1, Level 2 and Level 3.

The identified nine main dimensions were determined as Level 1. In Level 2, the CSFs were identified as the sub factors of the main nine dimensions. For developing a more comprehensive framework, Level 3 was identified as a level which consists of more specific CSFs for GREHB.

Therefore, a priori conceptual CSFs framework for GREHB was proposed, that includes all CSFs related to the green retrofitting. The conceptual CSFs framework and main dimensions will be explained in detail in Chapter 5.3. A Conceptual Framework CSFs for Green Retrofitting of Existing Healthcare Buildings.

Step 2: Questionnaire Survey

The second step in developing the conceptual framework is to conduct the survey. The respondents were asked to evaluate the significance of CSFs in green retrofitting processes of existing healthcare facilities on a 5-point Likert scale. The mean values of CSFs were calculated and ranked the CSFs for revising the proposed conceptual framework. CSFs with a score of “3= Important” or higher on the scale were identified as critical factors affecting the success of the GREHB.

Hence, CSFs under the score of 3, were excluded from the proposed conceptual framework. As a result, a proposed conceptual framework was refined according to the results of the survey. The revised conceptual framework is given at the end of Chapter 6.5. Final Conceptual CSFs Framework for Green Retrofitting of Existing Healthcare Buildings.

Step 3: Validation of the Conceptual CSFs Framework for Green Retrofitting of Existing Healthcare Buildings

The validation is a significant step for the development of the proposed conceptual framework. The examination of validity reveals whether the conceptual framework was valid, usable, relevant and comprehensive for improving the performance of existing healthcare buildings. These validation criteria were determined according to existing studies [11, 67, 155, 267]. The determined validation criteria for the framework are shown in Table 14.

Table 14: The validation criteria for framework

Characteristics of Framework	References
Valid	[11]; [267]
Usable	[11]; [155]; [267]
Relevant	[267]
Comprehensive	[67]

Validation Survey Development, Data Collection and Analysis

For the validation of the developed conceptual framework, a survey based on a 5-points Likert scale was conducted by taking expert opinions via e-mail. 4 professionals from the industry and 4 practitioners were selected to evaluate the validation criteria for the conceptual CSFs framework for GREHB. The questionnaire survey for validation is given in Appendix F.

The results of the validation survey were analyzed statistically by using the IBM SPSS Statistic 20 and MS Office Excel 2018 programs. Descriptive and inferential statistics such as arithmetic mean, mode, median, standard deviation, and coefficient of variation were used to evaluate the data obtained from the questionnaire. In addition to descriptive statistics, a series of statistical analysis methods such as the Cronbach Alphas criteria were used. The results of the validation survey of the framework and the statistical methods used are explained in detail in Chapter 6.6. Validation of the Framework.

CHAPTER V

V. CRITICAL SUCCESS FACTORS OF GREEN RETROFITTING OF EXISTING HEALTHCARE BUILDINGS

5.1. Critical Success Factors (CSFs)

The terminology of CSFs, was determined in the context of management of information systems by Rockart [217] as the few key areas where "things must go right" for the business to flourish and areas of activity that should obtain constant and careful attention from management. Additionally, he indicated that CSFs include the key elements to reach excellent performance in which to guarantee the attainment of project goals [217]. After Rockart's CSFs consideration, the definition of CSFs was developed by many researchers in different contexts. Toor and Ogunlana [218] indicated that recently, CSFs studies had been conducted in different sectors including information technology (IT), industrial systems, construction, process engineering, business development, and operations management. This section examines recent literature on CSFs of GREB.

The success of a project defined as the meeting the specific expectations and goals for a given stakeholder by Sanvido et al., [219], Alias et al., [220] defines CSFs as inputs to project management practice, which can contribute directly or indirectly to success of the project. Similarly, Patel et al., [221] identify the CSFs as an element of the project management process, which is necessary to achieve a project's goals. Moreover, Sanvido et al., [219] emphasized that each project has specific CSFs which change from project to project depending on participants, project size, the scope of services, the sophistication of the owner related to the design of facilities, technological implications, and a variety of other factors. Hence, focusing on CSFs is a prospective way to enhance the effectiveness and efficiency of project performance [222].

Shen et al., [206] defined the CSFs for green buildings' performance as the integration of the project team, the competence of project participants, technical and management innovation, the competence of individual project participants, project characteristics, the competence of individual project participants as well as the project team. Also, he underlines that to enhance affordable and sustainable products, all stakeholders of projects should improve their competences by the use of technical and management innovation [206]. Obviously, with improved competencies of stakeholders, green buildings can become more available and attractive to the community.

Similarly, in their other research Shen et al., [264] identified 17 CSFs by focusing on the green building industry in Thailand. Competency of stakeholders is the remarkable factor again and the most vital top four factors were determined as the competence of the GB consultant, the competence of the designer, the competence of project teams, and the competence of the contractor.

In another research conducted by Dos Santos & Jabbour [215] 14 CSF in order to manage the green building projects grouped into four criteria as; cost, project management, technology, and human resources, and building codes and green building rating systems. It is revealed that for successful project management, effective collaboration, early involvement in the project, and commitment of all participants are the most CSFs.

Moreover, in the context of retrofitting, Ma et al., [118] considered the key factors which affect success as including regulations, and policies, retrofit technologies, client resources and expectations, human factors, building-specific information, as well as other uncertainty factors. For setting minimum energy efficiency requirements for retrofitting of existing buildings, policies and regulations have a strong influence on projects' energy performance. Also, client expectations and resources which define the scope and aims of the project are vital. Using retrofit technologies has a critical impact on project success in the achievement of energy efficiency and sustainability in the retrofitting projects. Notably, project characteristics such as geographic location, occupancy schedule, building type, age size, , etc. are the determinant factors that affect the success of existing building retrofitting. Occupant satisfaction and comfort criteria are the important aspects related to occupants and patients that has to be met by effective retrofitting. Also, the forecasting of uncertainty factors is vital to define the best retrofit action to reach successful building retrofitting performance [118].

Hosseini et al., [263], determined 27 CSFs for the integration of sustainability into project management applications for developing countries under three different categories, respectively: Technical Competences (TC), Behavioral Competences (BC), and Contextual Competences (CC).

Sfakianaki [266]' categorized 35 CSFs under five different categories for sustainable construction namely: environmental, economic, social, design and techniques, and implementation, policy, and regulation factors.

Low et al., [17] identified 28 CFSs for the construction of buildings that are new and to be retrofitted in Singapore. These 28 CSFs were classified under five main categories, including project management-related factors, client-related factors, pre-project-related factors, project team-related factors as well as external factors and top-ranked CSFs were determined as top management support, effective planning and control, building owner's involvement, cost management, the responsiveness of building owners, clear scope and priorities of stakeholders, and legislation [17].

In a research conducted in China by Xu et al., [214], 28 CSFs of energy performance contracting (EPC) for sustainable Building Energy Efficiency Retrofits (BEER) in hotel buildings were classified into eight different dimensions respectively as partnership factors, leadership and team factors, project-self factors, SD factors, financing factors, external factors, contracting factors, and project process factors.

Dos Santos & Jabbour [215] focused on two Brazilian hospitals as a case study with a special focus on the adoption of energy efficiency actions and identified 12 CSFs namely, commitment to the environment, top management support, employee empowerment, green process design, environmental management systems information management, adoption of advanced green management practices, , supplier management, employee rewards, teamwork, review and improvement and environmental training.

Obviously, there is a direct relationship between the performance of buildings and the project's success potential [225]. Ishak et al., [225], indicated that refurbishment actions aim to improve a building's environmental performance. Also, refurbishment projects need special considerations that differ from new construction projects. Ishak et al., [225] categorized CSFs for refurbishment projects as internal factors, external factors, and additional factors based on project characteristics. Internal factors consist of project management, top management, and project team factors. External factors include environmental, economic, technological social, and policy factors.

The success of GREB' projects is strongly associated with stakeholders. Liang et al., [226] identified CSFs for green retrofitting projects in China as economics, building information, and environment, technology, sociocultural, standard and policy with a special focus on stakeholders' influence on the success.

In their structured review of literature, Jagarajan et al., [7] classified CSFs for sustainable retrofitting of existing buildings into nine main aspects namely, interactive processes, project management, human-related factors, project-related factors, contractual arrangements, external factors, knowledge, and innovation of SD, project procedures, as well as implementation of SD strategy. Moreover, Jagarajan et al., [16] defined eight main criteria as financial resources, green building professionals, green awareness, policy support, green development quantification, communication, technology, internal leadership and green material which have a significant impact on successful green retrofit project practices.

However, Zainol et al., [19] concentrated on green building operations and maintenance problems and placed 15 CSFs into five different categories, including environmental and biological effects, technical defects, social and cultural problems, managerial problems, political as well as legal factors.

In essence, the concern for reaching and implementing successful green retrofitting projects has led to conducting various CFSs studies by researchers in terms of raising awareness about green retrofitting projects. Table 15 compiles CSFs from the structured literature review of this thesis.

Table 15: CSFs from the structured literature review

	CSFs of GREHB	References
1	Ability to alter process and product for reducing the impact on natural resources	Kannan, [239]
2	Accessibility	Kannan, [239]
3	Accurate measurement and verification (M&V)	Xu & Chan, [214]; Shang, et al., [227]; Xu, et al., [242]
4	Acoustic comfort	Kamaruzzaman et al., [4]
5	Adequate financial resources	Jagarajan, et al., [7]; Aktas, & Ozorhon, [152]; Venkataraman & Cheng, [165]; Ahmad et al., [262]; Li et al., [265]
6	Advanced environmental management systems	dos Santos & Jabbour, [215]
7	Agile project processes	Mavi & Standing, [231]
8	Availability of green material	Jagarajan, et al., [7]
9	Availability of resources	Low, et al.,[17]; dos Santos & Jabbour, [215]; Akbari, et al., [228]; Mavi & Standing, [231]
10	Availability of technology	Jagarajan, et al., [7]; Xu & Chan, [242]
11	Available financing market and financial schema	Xu, et al., [214]; Xu & Chan, [242]; Ahmad et al., [262]
12	Avoid using harmful materials	Kannan, [239]
13	Awareness of financing institutes	Shang, et al., [227]
14	Awareness of green building technologies and environmental issues	Jagarajan, et al., [7]; Mavi & Standing, [231]; Chan, et al., [234]
15	Building age	Xu, et al., [214]; Ahmad et al., [262]
16	Building amenities	Kamaruzzaman et al., [4]
17	Building Design (Architectural)	Castro, et al., [268]
18	Building owners retrofit expertise	Jagarajan, et al., [7]
19	Change management	Low, et al., [17]
20	Clear criteria and standards	Liang, et al., [226]; Liang, et al., [229]
21	Clear project goals/ objectives /scope and project vision priorities of stakeholder	Jagarajan, et al., [7]; Low, et al., [17]; Kim, et al., [168]; Liang, et al., [226]; Liang, et al., [229]; Shang, et al., [227]; Banihashemi, et al., [230]; Hosseini et al., [263]; Li et al., [265]
22	Clear written lines of responsibility	Low, et al., [17]
23	Client commitment	Jagarajan, et al., [16]; Aktas & Ozorhon, [152]; Banihashemi, et al, [230]; Ponniah, et al., [237]; Hosseini et al., [263]
24	Client competency	Jagarajan, et al., [16]; Ponniah, et al., [237]
25	Collaborative design and automation	Liang, et al., [226]; Liang, et al., [229]
26	Commitment of stakeholders	Venkataraman & Cheng, [165]; Li, et al., [216]; Banihashemi, et al, [230]; Hosseini et al., [263]
27	Communication/ cooperation/ collaboration/ coordination/ motivation of stakeholders	Jagarajan, et al., [7]; Venkataraman & Cheng, [165]; Kim, et al., [168]; Shen, et al., [206]; Xu, et al., [214]; Li, et al., [216]; Liang, et al., [226]; Shang, et al., [227]; Akbari, et al., [228]; Liang, et al., [229]; Mavi & Standing, [231]; Shen, et al., [232]; Xu & Chan, [242]; Chung, et al., [243]; Maqbool & Sudong, [247]; Ahmad et al., [262]; Shen et al., [264]; Li et al., [265]; Sfakianaki [266]

Table 15: CSFs from the structured literature review

CSFs of GREHB		References
28	Community engagement	Venkataraman & Cheng, [165]
29	Compatibility	Wang et al., [194]
30	Competent project manager	Jagarajan, et al., [7]; Shen, et al., [206]; Mavi & Standing, [231]; Ahmad et al., [262]; Shen et al., [264]
31	Complexity and maturity of the technology	Liang, et al., [226]; Liang, et al., [229]
32	Continuous performance measurement	Mavi & Standing, [231]; Wee & Quazi, [249]
33	Contract management	Xu, et al., [214]; Xu, et al., [223]; Xu & Chan, [242]
34	Cost	Kamaruzzaman et al., [4]; Liang, et al., [226]; Liang, et al., [229]; Ahmad et al., [262]
35	Cultural	Kamaruzzaman et al., [4]
36	Cultural tradition	Liang, et al., [226]; Liang, et al., [229]
37	Deficiency of performance data about retrofitted existing buildings	Jagarajan, et al., [7]
38	Delivery reliability and on time reliability	Kannan, [239]
39	Design compatible with cultural values	Kamaruzzaman et al., [4]
40	Design for Disassembly (DFD)	dos Santos & Jabbour, [215]
41	Design, construction	Chung, et al., [243]
42	Dispute management	Low et al., [17]
43	Durability	Kamaruzzaman et al., [4]; Sfakianaki [266]
44	Early involvement of project participants and right project team	Venkataraman & Cheng, [165]; Ahmad et al., [262]; Shen et al., [264]
45	Ease of receiving uniform tax and regulatory incentives	Jagarajan, et al., [7]
46	Economic	Ishak, et al., [225]; Kamaruzzaman et al., [4]; Sfakianaki [266]
47	Economic environment	Shen, et al., [206]; Xu, et al., [214]; Xu & Chan, [242]; Ahmad et al., [262]; Shen et al., [264]
48	Effective consultation with key stakeholders	Mavi & Standing, [231]
49	Effective environmental compliance and auditing program	Venkataraman & Cheng, [18]; Li, et al., [216]
50	Effective feedback and troubleshooting	Venkataraman & Cheng, [18]; Li, et al., [216]
51	Effective health and safety protocols	Banihashemi, et al., [230]
52	Efficiency (optimum performance and energy saving (building envelope, mechanical and electrical systems, facilities interior and finishes)	Kamaruzzaman et al., [4]; Mohammadpour et al., [128], Ishak, et al., [225]
53	Efficient use of material (over its life cycle)	Kamaruzzaman et al., [4]
54	Employee empowerment and motivation	dos Santos & Jabbour, [215]; Li, et al., [216]; Maqbool & Sudong, [247]
55	Enacting required policies in supporting sustainability principles in construction projects by governmental and professional bodies	Banihashemi, et al., [230]
56	End user-imposed restrictions	Mavi & Standing, [231]
57	Energy performance (HVAC, lighting, lift etc.)	Kamaruzzaman et al., [4]
58	Energy specialist	Jagarajan, et al., [7]

Table 15: CSFs from the structured literature review

CSFs of GREHB		References
59	Engineering expertise	Chung, et al.,[243]
60	Environmental	Jagarajan, et al., [16]; Low, et al., [17]; Ishak, et al., [225]; Maqbool & Sudong, [247]; Sfakianaki [266]
61	Environmental commitment and policy of all stakeholders	Kannan, [239]
62	Environmental protection measures in project design	Akbari, et al., [228]; Kannan, [239]
63	Equity labour sources and non-discrimination	Kannan, [239]
64	Existence of environmental certifications of suppliers	Kannan, [239]
65	Existence of green building codes and regulations	Chan, et al., [234]
66	Existing building environment and condition	Liang, et al., [226]; Liang, et al., [229]
67	Existing building evaluation	Liang, et al., [226]; Liang, et al., [229]
68	Existing facilities condition	Liang, et al., [226]; Liang, et al., [229]
69	Experience of consultants	Aktas & Ozorhon, [152]
70	Experience of contractors	Jagarajan, et al., [7]; Aktas & Ozorhon, [152]
71	Experience of design team	Jagarajan, et al., [7]; Aktas & Ozorhon, [152]
72	Experience sharing and education	Liang, et al., [226]; Liang, et al., [229]
73	Feasibility	Akbari, et al., [228]
74	Financial capability of suppliers	Kannan, [239]
75	Financial incentives and funds	Jagarajan, et al., [7]; Jagarajan, et al., [16]; Akbari, et al., [228]
76	Financing and task policy	Shang, et al., [227]
77	Flexibility and adaptability	Kamaruzzaman et al., [4]; Kannan, [239]
78	Flexible working arrangements	Kannan, [239]
79	Fluctuation of the price of green materials	Jagarajan, et al., [7]
80	Foreign exchange rate	Kannan, [239]
81	Good planning and scheduling methods	Mavi & Standing, [231]
82	Good relationships among participants, trust and partnership	Shen, et al., [206]; Mavi & Standing, [231]; Maqbool & Sudong, [247]; Shen et al., [264]
83	Government program and policies	Liang, et al., [226]; Liang, et al., [229]
84	Green building skills/training and sustainability knowledge	Jagarajan, et al., [7]; Kannan, [239]
85	Green process design	dos Santos & Jabbour, [215]
86	Green purchasing capabilities	Kannan, [239]
87	Green technology capabilities	Kannan, [239]
88	HHF's sustainability behavior	Wang et al., [194]
89	HSE Management	Akbari, et al., [228]
90	Human Related	Jagarajan, et al. [16]
91	Impact of the project on land value and local economy	Kamaruzzaman et al., [4]
92	Implementation of vigorous procedures	Tucker, et al., [241]

Table 15: CSFs from the structured literature review

CSFs of GREHB		References
93	Improved employee productivity and performance	Jagarajan, et al., [7]; Liang et al., [229]
94	Improved health and safety	Akbari, et al., [228]; Kannan, [239]
95	Improved indoor environmental quality	Kamaruzzaman et al., [4]; Chung, et al., [243]; Sfakianaki [266]
96	Improved occupant'/employees' satisfaction	Aktas & Ozorhon, [152]; Akbari, S. et al., [228]
97	Improved occupants' health and wellbeing	Xu, et al., [214]; Liang et al., [229]; Sfakianaki [266]
98	Improved social reputation	Low et al., [17]; Aktas & Ozorhon, [152]
99	Incentives	Chan, et al., [234]
100	Indoor air quality	Kamaruzzaman et al., [4]; Sfakianaki [266]
101	Information management	dos Santos & Jabbour, [215]; Wee & Quazi, [249]
102	Information technologies and computerization level	Liang, et al., [226]; Liang, et al., [229]
103	Initial capital cost of green buildings	Jagarajan, et al., [7]; Sfakianaki [266]
104	Innovation	Kamaruzzaman et al., [4]; Jagarajan, et al., [16]; Venkataraman & Cheng, [165]; Li, et al., [216]; Li et al., [265]
105	Innovative financing methods	Li, et al., [216]
106	Innovative management approaches	Li, et al., [216]; Venkataraman & Cheng, [165]
107	Installation	Venkataraman & Cheng, [18]; Aktas & Ozorhon, [152]
108	Installation/Equipment	Jagarajan, et al., [7]
109	Interest rate	Liang, et al., [226]; Liang, et al., [229]
110	Interruptions in operations	Liang, et al., [226]; Liang, et al., [229]
111	In-use environmental performance/ during retrofit process	Mavi & Standing, [231]
112	Investigation and adaptation of the correct approach	Tucker, et al., [241]
113	Investment and involvement from the government and private companies in the green building movement	Jagarajan, et al., [7]
114	Investment cost (Material, labor, commissioning fee)	Shang, et al., [227]
115	Involvement of green building professional throughout the project lifecycle	Venkataraman & Cheng, [165]; Mavi & Standing, [231]
116	Leadership	Jagarajan, et al., [7]; Aktas & Ozorhon, [152]; dos Santos & Jabbour, [215]; Akbari, et al.,[228]; Zhao, et al., [236]; Maqbool & Sudong, [247]
117	Leveraging the technology	Kim, et al., [168]
118	Life cycle analysis	dos Santos & Jabbour, [215]
119	Life-cycle management	Mavi & Standing, [231]
120	Maintain long-term relationships and alliances	Kannan, [239]
121	Maintainability	Liang, et al., [226]; Liang, et al., [229]
122	Management with social responsibilities	Abdullah et al., [224]
123	Managerial/ Organizational	Maqbool & Sudong, [247]
124	Market regulatory environment	Shang, et al., [227]
125	Material	Kamaruzzaman et al., [4]

Table 15: CSFs from the structured literature review

CSFs of GREHB		References
126	Material and equipment selection	Jagarajan, et al. [16]; Shen, et al., [206]; Li, et al., [216]; Chung, et al., [243]
127	Met plant quality standards	Mavi & Standing, [231]
128	Minimal scope change	Mavi & Standing, [231]
129	Occupancy type	Liang, et al., [226]; Liang, et al., [229]
130	Operation & Maintenance cost after making improvements	Aktas & Ozorhon, [152]; Shang, et al., [227]
131	Operational	Wang et al., [194], Pietzsch et al., [246]
132	Organizational structure/ factors	Xu, et al., [214]; Shang, et al.,[227]; Mavi, R.K. & Standing, C., [231]; Xu & Chan, [242]
133	Organizing capacity and task orientation	Xu & Chan, [242]; Maqbool & Sudong, [247]
134	Overall health and safety measures	Akbari, et al., [228]
135	Owner expectation	Aktas & Ozorhon, [152]
136	Owners-clients awareness on sustainable development	Jagarajan, et al., [7]; Xu, et al., [214]; Shang, et al., [227]; Xu & Chan, [242]
137	Partnering agreements and factors	Low, et al., [17]; Xu, et al., [214]
138	Payback period	Wang et al., [194]; Ahmad et al., [262]
139	Penalties and punishments for unethical behaviour	Kannan, [239]
140	Performance evaluation/appraisal	Tucker, et al., [241]
141	Planning, monitoring and control	Jagarajan, et al., [16]; Low, S.P. et al., [17]; Xu, et al., [214]; Xu, P et al.,[223]; Xu & Chan, [242]
142	Policies	Jagarajan, et al., [7]; Xu, et al., [214]; Liang, et al., [226]; Shang, et al., [227]; Liang, et al., [229]; Razman et al., [233]; Li et al., [265]
143	Policy support	Jagarajan, et al., [7]; Xu, et al., [214]; Shen, et al., [232]; Razman et al., [233]; Xu & Chan, [242]
144	Political	Jagarajan, et al., [16]; Ishak, et al., [225]
145	Pollution control	Kamaruzzaman et al., [4]; Kannan, [239]; Sfakianaki [266]
146	Procurement and tendering	Jagarajan, et al. [16]; Tucker, et al., [241]; Sfakianaki [266]
147	Procurement standard	Kannan, [239]
148	Product responsibility	Kannan, [239]
149	Professional experience and competencies	
150	Professional/technical knowledge and expertise in GBTs	Li, et al., [216]; Chan, et al., [234]
151	Profit distribution among stakeholders	Liang, et al., [226]; Liang, et al., [229]
152	Profitability	Jagarajan, et al., [16]
153	Project	Xu, et al., [214]; Ishak, et al., [225]
154	Project and construction management	Kamaruzzaman et al., [4]; Jagarajan, et al., [16]; Xu & Chan, [242]; Ishak, et al., [225]; Liang, et al., [226]; Liang, et al., [229]
155	Project brief and design	Kamaruzzaman et al., [4]
156	Project characteristics	Shen, et al., [232]
157	Project complexity	Mavi & Standing, [231]
158	Project financing- financial status	Xu, et al., [214]; Xu & Chan, [242]

Table 15: CSFs from the structured literature review

CSFs of GREHB		References
159	Project manager commitment	Jagarajan, et al., [7]
160	Project processes	Xu, et al., [214]; Xu, et al., [223]
161	Project risk and liability management	Mavi & Standing, [231]
162	Project type and size	Shen, et al., [206]; Mavi & Standing, [231]; Ahmad et al., [262]; Shen et al., [264]
163	Promote green innovation	Pietzsch, et al., [246]
164	Public green awareness and behavior	Chan et al., [235]; Pietzsch, et al., [246]
165	Public open space	Kamaruzzaman et al., [4]
166	Public utility and comfort	Mavi & Standing, [231]
167	Quality	Low, et al., [17]; Tucker, et al., [241]
168	Quality of services	Kamaruzzaman et al., [4]
169	Quality testing	Maqbool & Sudong, [247]
170	Realistic expectations and objectives	Mavi & Standing, [231]; Maqbool & Sudong, [247]
171	Reduce ambiguity and maximize stability	Maqbool & Sudong, [247]
172	Reduced consumption of material for reuse, recycle, and recovery of material	Kannan, [239]
173	Reduced life cycle cost	Kamaruzzaman et al., [4]
174	Reducing contamination level	Kamaruzzaman et al., [4]
175	Reducing technical uncertainty	Maqbool & Sudong, [247]
176	Reduction of CO2 emission	Kamaruzzaman et al., [4]; Aktas & Ozorhon, [152]; Akbari, et al., [228]; Sfakianaki [266]
177	Reduction of electricity and gas consumption	Aktas & Ozorhon, [152]
178	Reduction of energy consumption/ energy saving/efficiency	Shang, et al., [227]; Akbari, et al., [228]; Mavi & Standing, [231]; Kannan, [239]; Sfakianaki [266]
179	Reduction of greenhouse gas emission	Jagarajan, et al., [7]; Jagarajan, et al., [16]
180	Reduction of water consumption/ conservation	Kamaruzzaman et al., [4]; Aktas & Ozorhon, [152]; Mavi & Standing, [231]
181	Regulations/legislation	Low, et al., [17]; Li et al., [265]
182	Reliability	Kamaruzzaman et al., [4]
183	Renewable energy technologies	Kamaruzzaman et al., [4]
184	Responsible source of material	Kamaruzzaman et al., [4]
185	Retrofit readiness and new environmental technologies level of owners	Jagarajan, et al., [7]
186	Return on predictable ROI investment needs	Jagarajan, et al., [7]
187	Review and improvement and feedback	Li, et al., [216]
188	Site and location limitation	Xu, et al., [214]; Ahmad et al., [262]
189	Skilled workers and high-quality workmanship	Banihashemi, et al., [230]; Shen, et al., [232]; Hosseini et al., [263]
190	Social	Kamaruzzaman et al., [4]

Table 15: CSFs from the structured literature review

CSFs of GREHB		References
191	Socio- Cultural	Xu et al., [214]; Kamaruzzaman et al., [4] Ishak, et al., [225]; Jagarajan et al., 2015;
192	Socio-political environment	Shen et al., [206]; Ahmad et al., [262]; Shen et al., [264]
193	Stakeholder integration	Jagarajan et al., [16]; Chung et al., [243]; Shen et al., [206]
194	Stakeholders experience/competency and know-how	Jagarajan et al., [16]; Low et al., [17]; Venkataraman & Cheng, [165]; Shen et al., [206]; Shen et al., [232]; Li et al., [265]
195	Subsidies/tax reduction	Liang et al., [226]; Liang et al., [229]
196	Successful commission and handover	Kamaruzzaman et al., [4]
197	Successful operation and maintenance	Kamaruzzaman et al., [4]
198	Supplier management	dos Santos & Jabbour, [215]; Wee & Quazi, [249] Kannan [239]
199	Supplier quality	Aktas & Ozorhon, [152]; Kannan [239]
200	Sustainability Strategy	Jagarajan et al., [16]
201	Sustainable development strategy planning and control	Xu & Chan, [242]; Xu et al., [214]; Shang et al., [227]
202	Team commitment	Maqbool & Sudong, [247]; Mavi & Standing, [231]
203	Team competency, support, and experience	Maqbool & Sudong, [247]; Shen et al., [206]; Jagarajan et al., [7]; Ahmad et al., [262]; Shen et al., [264]
204	Teamwork technical skills and background	Xu & Chan, [242]; Xu et al., [214]; Shang, et al.,[227]; Akbari et al., [228]; dos Santos & Jabbour, [215]
205	Technical	Jagarajan et al., 2015;
206	Technical and management innovation	Shen et al., [232]
207	Technological	Ishak et al., [225]
208	Technological capability of suppliers	Kannan [239]
209	Technology support	Maqbool & Sudong, [247]
210	The detailed plan for design and construction	Li et al., [216]
211	The geographical proximity of suppliers	Kannan [239]
212	The integrated and collaborative delivery process	Venkataraman & Cheng, [18]
213	Thermal comfort	Kamaruzzaman et al., [4]
214	Time, risk, cost, quality	Jagarajan et al., [16]; Low et al., [17]; Akbari et al., [228]
215	Top management support /commitment	Wee & Quazi, [249]; Li et al., [216]; dos Santos & Jabbour, [215]; Aktas & Ozorhon, [152]; Maqbool & Sudong, [247]; Venkataraman & Cheng, [165]; Mavi & Standing, [231]; Li et al., [265]
216	Use of environmentally friendly materials	Kamaruzzaman et al., [4]; Kannan [239]
217	Use of local materials and technique	Kamaruzzaman et al., [4]
218	Use of renewable and recycled material with low environmental impact	Kamaruzzaman et al., [4]
219	User behavior and demand analysis	Liang et al., [226]; Liang et al., [229]
220	Value for money	Tucker et al., [241]
221	Viable energy management program	Shang et al., [227]
222	Visual comfort	Kamaruzzaman et al., [4]
223	Waste management	Akbari et al., [228]; Kamaruzzaman et al., [4]; Mavi & Standing, [231]; Sfakianaki [266]
224	Who invests	Liang et al., [226]; Liang et al., [229]
225	Willingness to make change	Shang et al., [227]

5.2. Lack of CSFs for Green Retrofitting of Existing Healthcare Buildings

Alias et al., [219] indicated that existing project management practices of organizations in the CI do not always guarantee the project's success. Indeed, realizing a successful construction project mainly depends on how it is managed and controlled. Alias et al., [219] also noted that CSFs are very helpful in decision-making support to improve project performance. In this context, the identification of CSFs for GREHB has a crucial role in achieving the sustainability goals of existing healthcare buildings. Jagarajan et al., [238] highlight the significance of the determination of CSFs and [238] add that CSFs cannot be disregarded as they guide specialists during the green retrofitting.

According to the literature review, green retrofitting has challenging issues for healthcare facilities including high cost, lack of information, of education, knowledge and awareness and expertise, lack of governmental regulations and policies, risks and uncertainty, lack of experienced stakeholders, limited budgets, lack of green materials, lack of interest, communication and collaboration among project stakeholders, lack of inadequate certification tools and healthcare-specific challenges. (Shown in Table 8). All these factors lead to a substantial part in the failure of green retrofitting projects.

Nevertheless, in this study, the literature review illustrates that there have been several studies conducted based on green retrofitting, but there is a need for research that focuses on GREHB. In the previous literature, there is a lack of structured and inclusive investigation on CSFs for GREHB. In this section, one of the aims of this thesis is the investigation of the CSFs for green retrofitting of healthcare building projects being achieved.

5.3. A Conceptual Framework of CSFs for Green Retrofitting of Existing Healthcare Buildings

The framework was proposed as an initial conceptual framework for GREHB based on the structured literature review. The development of the conceptual framework was explained in detail in Chapter 4. The structured literature review revealed the lack of a conceptual CSFs framework for GREHB. Thus, this framework aims to contribute to the development of a comprehensive methodology based on green retrofitting with a particular focus on existing healthcare buildings.

The conceptual framework consists of three different levels for CSFs classification, respectively Level 1, Level 2, and Level 3. Level 1 consists of nine CSFs' dimensions, namely the economic dimension, environmental dimension, socio-cultural dimension, technical dimension, managerial dimension, human-dimension, technological dimension, political dimension, and the project dimension. Level 2 includes the CSFs of each main dimensions. The last level 3 includes specific factors related to Levels 1 and 2.

Economic Dimension

The economic dimension [4, 225, 266] has a critical impact in contributing to the success of the GREHB, and includes four sub dimensions in the second level respectively; the economic environment [206, 214, 242, 262, 264] cost [4, 226, 229, 262], financial incentives/ funds [7, 16, 228] and feasibility [228]. Each factor has a crucial impact on the success of the GREH. Table 16 shows the CSFs of the economic dimension for GREHB.

In the economic environment, the financial status and success of green retrofitting projects can be affected by the current interest rate [226, 229], foreign exchange rate [239], and fluctuation of the price of green materials [7]. According to Xu et al., [223], economic conditions are very dynamic and complex, which can change from time to time. So, the economic environment has a significant influence on the working and decisions of projects.

In terms of cost, investment cost such as material, labour, commissioning fee [227], initial capital cost of green buildings [7, 266], operation & maintenance cost after making improvements [152, 227], reduced life cycle cost [4] and payback period [194, 262] are the significant factors impacting the cost of green retrofitting projects. Optimizing life cycle economic performance, reducing life cycle energy costs, and providing longer economic life of the facility are a few of the factors which have a financial impact on the GREB [240].

Financial incentives and funds of green retrofitting projects can be affected by project financing- financial status [214, 242], the available financing market and financial schema [214, 242, 262], awareness of financing institutes [227], innovative financing methods [216], adequate financial resources [7, 152, 165, 262, 265], ease of receiving uniform tax and regulatory incentives [7] and subsidies/tax reduction [226, 229]. As an illustration, the availability of financial incentives and funds, including special funding support, tax preferences, and loan warrant, etc., can provide a better investment environment and the project a stronger financial status [223]. Also, Shang, et al., [227] have indicated one critical point, being that the costs after making improvements have a significant impact on successful implementation. Reducing operation and maintenance costs are the primary motivation to conduct green retrofitting projects that contribute to improving project performance [152].

Furthermore, the return on predictable ROI investment needs [7], on profitability [16], on profit distribution among stakeholders [226, 229]on the impact of the project on land value and on the local economy [4], on the financial capability of suppliers [239],on value for money [241] and on those who invest [226, 229] are essential influences to provide economic feasibility of green retrofitting projects. Also, Durmus-Pedini and Ashuri [240] highlighted that the return on investment (ROI) needs more of a historical perspective to become more predictable in the GREB.

Table 16: CSFs of economic dimension for GREHB

CSFs of GREHB				
	Level 1	Level 2	Level 3	References
	Dimension	**Sub-Dimension**	**CSFs**	
CSF EC	**Economic**			Ishak, et al., [225]; Kamaruzzaman et al., [4]; Sfakianaki [266]
CSF EC1		**Economic environment**		Shen, et al., [206]; Xu, et al., [214]; Xu & Chan, [242]; Ahmad et al., [262]; Shen et al., [264]
CSF EC1.1			Interest rate	Liang, et al., [226]; Liang, et al., [229]
CSF EC1.2			Foreign exchange rate	Kannan, [239]
CSF EC1.3			Fluctuation of the price of green materials	Jagarajan, et al., [7]
CSF EC2		**Cost**		Kamaruzzaman et al., [4]; Liang, et al., [226]; Liang, et al., [229]; Ahmad et al., [262]
CSF EC2.1			Investment cost (Material, labor, commissioning fee)	Shang, et al., [227]
CSF EC2.2			Initial capital cost of green buildings	Jagarajan, et al., [7]; Sfakianaki [266]
CSF EC2.3			Operation & Maintenance cost after making improvements	Aktas & Ozorhon, [152] ; Shang, et al., [227]
CSF EC2.4			Reduced life cycle cost	Kamaruzzaman et al., [4]
CSF EC2.5			Payback period	Wang et al., [194]; Ahmad et al., [262]
CSF EC3		**Financial incentives and funds**		Jagarajan, et al., [7]; Jagarajan, et al., [16]; Akbari, et al., [228]
CSF EC3.1			Project financing- financial status	Xu, et al., [214]; Xu & Chan, [242]
CSF EC3.2			Available financing market and financial schema	Xu, et al., [214]; Xu & Chan, [242]; Ahmad et al., [262]
CSF EC3.3			Awareness of financing institutes	Shang, et al., [227]
CSF EC3.4			Innovative financing methods	Li, et al., [216]

Table 16: CSFs of economic dimension for GREHB (continued)

CSFs of GREHB				
	Level 1	**Level 2**	**Level 3**	**References**
	Dimension	**Sub-Dimension**	**CSFs**	
CSF EC3.5			Adequate financial resources	Jagarajan, et al., [7]; Aktas, & Ozorhon, [152]; Venkataraman & Cheng, [165]; Ahmad et al., [262]; Li et al., [265]
CSF EC3.6			Ease of receiving uniform tax and regulatory incentives	Jagarajan, et al., [7]
CSF EC3.7			Subsidies/tax reduction	Liang, et al., [226]; Liang, et al., [229]
CSF EC4		**Feasibility**		Akbari, et al., [228]
CSF EC4.1			Return on predictable ROI investment needs	Jagarajan, et al., [7]
CSF EC4.2			Profitability	Jagarajan, et al., [16]
CSF EC4.3			Profit distribution among stakeholders	Liang, et al., [226]; Liang, et al., [229]
CSF EC4.4			Impact of the project on land value and local economy	Kamaruzzaman et al., [4]
CSF EC4.5			Financial capability of suppliers	Kannan, [239]
CSF EC4.6			Value for money	Tucker, et al., [241]
CSF EC4.7			Who invests	Liang, et al., [226]; Liang, et al., [229]

Environmental Dimension

The environmental dimension [16, 17 225, 247, 266] is another important issue that determines the success of healthcare buildings' green retrofitting projects for all retrofit implementation stages. The environmental dimension consists of 21 different environmental factors in Level 2: Environmental commitment and the policy of all stakeholders [239], in-use environmental performance/ the during retrofit process , reduction of energy consumption/ energy saving/efficiency [227, 228, 231, 239, 266], reduction of electricity and gas consumption [152], reduction of CO_2 emissions [4, 152, 228, 266], reduction of GHG [7, 16], reduction of water consumption/ conservation [4, 152, 231], reduced consumption of material for reuse, recycle, and recovery of material [239], accurate measurement and verification (M&V) [214, 223, 227, 242], improved IEQ [4, 243, 266], building design (architectural) [268], IAQ [4, 266], acoustic comfort, visual comfort, thermal comfort [4]advanced environmental management systems [215], green process design [215], reducing contamination level [4], waste management [4, 228, 231, 266], pollution control [4, 239, 266],and material [4]. Table 17 shows the environmental dimensions of CSFs for GREHB.

From the environmental perspective, establishing environmental policy for project stakeholders and commitment of all stakeholders is significant to improve environmental performance and promote sensitiveness in environmental protection [239].

During the life cycle of buildings, the most enormous energy consumption occurs in the operation stage. Hence, the environmental performance of existing healthcare buildings in-use/during the retrofit process is a critical determinant to provide successful retrofit implementation.

Compared to other commercial buildings, the energy usage of healthcare buildings is higher [269]. Actions to reduce energy consumption, improve energy saving and efficiency are a critical contributor to enhance environmental performance of existing buildings. Thus, retrofitting has become a major solution to decrease energy consumption of existing buildings [7].

In healthcare buildings, the calculation of the total carbon footprint must involve indirect emissions caused by the visitor, patient, and staff travel and also must include emissions caused by the procurement of goods and services. However, the calculated CO_2 emissions are expected to be higher than direct emissions alone, but it is more challenging to measure [248]. Reducing the CO_2 emissions of healthcare facilities requires immediate action to mitigate the high usage of waste and energy [249]. In this context, mitigating the carbon footprint plays a critical role, especially for the healthcare environment.

Improving the efficiency by reduction of water consumption is related to water metering, water leaking detection, water-efficient fittings, water quality standards, rainwater harvesting, and also, the irrigation system and sewerage discharge [4]. Indeed, existing healthcare systems are one of the largest water consumers in society [135]. Enhancing existing buildings' water efficiency can reduce the water demand for them and offset the need for new green buildings [250]. Healthcare buildings apply various methods to improve water efficiency as well as to reduce water utility costs. Furthermore, the occupiers of healthcare buildings can provide utility directly from water efficiency precautions [251]. Hence, the reduction of water consumption of existing healthcare buildings is a significant contributor to achieve green retrofitting goals.

Measurement and verification (M&V) provide the results and energy savings of the projects [223]. After the retrofitting process, an accurate M&V identifies the more realistic results and energy-saving data, so measurement and verification is an important component in determining the success of the retrofit project.

Particular consideration should be given to the IEQin healthcare buildings since a healthcare building that has a high IEQ will advance the effectiveness of employees and the recovery process of patients [181]. Improved IEQ not only enhances the environmental performance of existing buildings but also enhances the productivity of staff and the healing process of patients, so it is a critical point to reach success in the GREHB.

In terms of building design (architectural), the architecture of modern hospitals has crucial impacts on achieved immediate recognition and accessibility rather than old ones and provides users best practices. Another vital element in building design is colour in hospitals since colour zones provide wayfinding and signage, and they can improve the determination of hospitals' architectural environment [134]. Thus, suitable architectural design, accessibility, wayfinding, and colour strategies are those factors impacting the building design (architectural) of green retrofitting projects.

Also, the success of the green retrofitting is related to the improved IAQ which can be affected by suitable indoor ventilation (HVAC), odour, the IAQ plan, natural ventilation, and air purification. [4]. According to Alzoubi et al., [244], natural lighting, unpolluted indoor air, and proper ventilation are crucial to enhance suitably the indoor environment in healthcare buildings. In essence, the high-quality indoor environment has a significant influence on the health and well-being of occupants of the building since people mostly spend their time indoors [4].

On the other hand, improved acoustic comfort such as proving proper noise level, sound insulation, sound absorption, background noise, and improved visual comfort in terms of daylighting, the view outside, glare control, artificial lighting, and illumination level are essential factors to conduct successful green retrofitting projects in existing healthcare buildings. Also, the visual environment is a significant element that affects the morale and productivity of hospital staff and also, improves the recovery rates of patients [134].

In green retrofitting projects, green process design is one of the crucial factors which can be changed by different dimensions, including the ability to alter the process and product for reducing the impact on natural resources [239], life cycle analysis and design for disassembly (DFD) [215].

Management practices are essential to enhance successful operations in projects. Especially healthcare environment waste management, and pollution controls are essential factors in terms of the health and well-being of occupants. In terms of waste management, recycled content [231] and carbon and hazardous substance management [239] have an impact on green retrofitting projects. Also, reduction of pollution agents [239], reduction of pollutant emissions, and construction activity pollution [4] are related to pollution control. Moreover, using advanced environmental management systems influences the success of green retrofitting projects such as the existence of environmental certifications of suppliers [239], effective environmental compliance and auditing programs [165, 216] and environmental protection measures in project design [228, 239] are important elements affecting the environmental performance of projects.

Reducing contamination level is a critical element especially for the success of the green retrofitting of healthcare facilities which includes providing a suitable formaldehyde level, smoke control, and mould prevention [4], cleaning up contaminated water/land, environmental degradation [228], and water/ noise pollution minimization during execution [4, 230, 231].

Avoiding using harmful materials [239], availability of green material [7], use of environmentally friendly materials [4, 239], responsible sources of material [4], use of renewable and recycled material with low environmental impact [4], efficient use of material (over its life cycle) [4] are some of the significant factors impacting the success of the project environmentally in terms of the material category. Notably, the availability of green materials in the market is a critical risk, so it can be challenging to find materials during the construction phase [241].

Table 17: CSFs of environmental dimension for GREHB

CSFs of GREHB				
	Level 1	**Level 2**	**Level 3**	**References**
	Dimension	**CSFs**	**CSFs**	
CSF EN	**Environmental**			Jagarajan, et al., [16]; Low, et al., [17]; Ishak, et al., [225]; Maqbool & Sudong, [247]; Sfakianaki [266]
CSF EN 1		**Environmental commitment and policy of all stakeholders**		Kannan, [239]
CSF EN 2		**In-use environmental performance/ during retrofit process**		Mavi & Standing, [231]
CSF EN 3		**Reduction of energy consumption/ energy saving/efficiency**		Shang, et al., [227]; Akbari, et al., [228]; Mavi & Standing, [231]; Kannan, [239]; Sfakianaki [266]
CSF EN 4		**Reduction of electricity and gas consumption**		Aktas & Ozorhon, [152]
CSF EN 5		**Reduction of CO2 emission**		Kamaruzzaman et al., [4]; Aktas & Ozorhon, [152]; Akbari, et al., [228]; Sfakianaki [266]
CSF EN 6		**Reduction of greenhouse gas emission**		Jagarajan, et al., [7]; Jagarajan, et al., [16]
CSF EN 7		**Reduction of water consumption/ conservation**		Kamaruzzaman et al., [4]; Aktas & Ozorhon, [152]; Mavi & Standing, [231]
CSF EN 8		**Reduced consumption of material for reuse, recycle, and recovery of material**		Kannan, [239]
CSF EN 9		**Accurate measurement and verification (M&V)**		Xu & Chan, [214]; Shang, et al., [227]; Xu, et al., [242]
CSF EN 10		**Improved indoor environmental quality**		Kamaruzzaman et al., [4]; Chung, et al., [243]; Sfakianaki [266]
CSF EN 11		**Building Design (Architectural)**		Castro, et al., [268]
CSF EN 12		**Indoor air quality**		Kamaruzzaman et al., [4]; Sfakianaki [266]
CSF EN 13		**Acoustic comfort**		Kamaruzzaman et al., [4]

Table 17: CSFs of environmental dimension for GREHB (continued)

CSFs of GREHB				
	Level 1	Level 2	Level 3	References
	Dimension	**CSFs**	**CSFs**	
CSF EN 15		**Thermal comfort**		Kamaruzzaman et al., [4]
CSF EN 16		**Advanced environmental management systems**		dos Santos & Jabbour, [215]
CSF EN 16.1			Existence of environmental certifications of suppliers	Kannan, [239]
CSF EN 16.2			Effective environmental compliance and auditing program	Venkataraman & Cheng, [18]; Li, et al., [216]
CSF EN 16.3			Environmental protection measures in project design	Akbari, et al., [228]; Kannan, [239]
CSF EN 17		**Green process design**		dos Santos & Jabbour, [215]
CSF EN 17.1			Ability to alter process and product for reducing the impact on natural resources	Kannan, [239]
CSF EN 17.2			Life cycle analysis	dos Santos & Jabbour, [215]
CSF EN 17.3			Design for Disassembly (DFD)	dos Santos & Jabbour, [215]
CSF EN 18		**Reducing contamination level**		Kamaruzzaman et al., [4]
CSF EN 19		**Waste management**		Kamaruzzaman et al., [4]; Akbari, et al., [228]; Mavi & Standing, [231]; Sfakianaki [266]
CSF EN 20		**Pollution control**		Kamaruzzaman et al., [4]; Kannan, [239]; Sfakianaki [266]
CSF EN 21		**Material**		Kamaruzzaman et al., [4]
CSF EN 21.1			Avoid using harmful materials	Kannan, [239]
CSF EN 21.2			Availability of green material	Jagarajan, et al., [7]
CSF EN 21.3			Use of environmentally friendly materials	Kamaruzzaman et al., [4]; Kannan, [239]
CSF EN 21.4			Responsible source of material	Kamaruzzaman et al., [4]
CSF EN 21.5			Use of renewable and recycled material with low environmental impact	Kamaruzzaman et al., [4]
CSF EN 21.6			Efficient use of material (over its life cycle)	Kamaruzzaman et al., [4]

Socio-Cultural Dimension

Social and cultural aspects are included in this dimension. (Shown in detail in Table 18). Hence, the success of green retrofitting projects are highly affected by social [4] factors including community engagement [165], public green awareness and behaviour [235, 246], improved occupant and employer satisfaction [152, 228], improved occupants' health and wellbeing [214, 229, 266], improved employee productivity and performance [7, 229], improved health and safety [228, 239], improved social reputation [17, 152], management with social responsibilities [224], public utility [231] and comfort, maintain long-term relationships and alliances, equity labour sources and non-discrimination, penalties and punishments for unethical behaviour, flexible working arrangements, accessibility [239], and building amenities [4]. Also, cultural [4] factors affect the retrofitting project performance. Factors considered at level 2 include HHF's (Hospitals and Healthcare Facilities) sustainability behaviour [194], user behaviour and demand analysis, cultural tradition [226, 229], design compatibility with cultural values and use of local materials and technique [4].

In terms of the social aspect, sustainability practices resulted not only in improved energy and resource efficiency but also in occupants' health and wellbeing [4]. Improving health and safety is one of the vital targets in successful green retrofitting implementations [214]. Furthermore, advancing occupants' health and well-being is a crucial topic that needs to be considered during the retrofitting of healthcare building projects, especially when considering the primary aim of healthcare.

Also, green technologies and design strategies improve the health and productivity of the employee [17]. Furthermore, in view of culture, the evaluation of the cultural dimensions of the building project is significant to preserve and maintain the local and regional heritage during refurbishment [4].

Table 18: CSFs of socio-cultural dimension for GREHB

CSFs of GREHB				
	Level 1	**Level 2**	**Level 3**	**References**
	Dimension	**CSFs**	**CSFs**	
CSF SC	**Socio-Cultural**			Kamaruzzaman et al., [4]; Jagarajan, et al., [16]; Xu, P. et al., [214]; Ishak, et al., [225];
CSF SC 1		**Social**		Kamaruzzaman et al., [4]
CSF SC 1.1			Community engagement	Venkataraman & Cheng, [165]
CSF SC 1.2			Public green awareness and behavior	Chan et al., [235]; Pietzsch, et al., [246]
CSF SC 1.3			Improved occupant'/employees' satisfaction	Aktas & Ozorhon, [152]; Akbari, S. et al., [228]
CSF SC 1.4			Improved occupants' health and wellbeing	Xu, et al., [214]; Liang et al., [229]; Sfakianaki [266]
CSF SC 1.5			Improved employee productivity and performance	Jagarajan, et al., [7]; Liang et al., [229]
CSF SC 1.6			Improved health and safety	Akbari, et al., [228]; Kannan, D., [239]
CSF SC 1.7			Improved social reputation	Low et al., [17]; Aktas & Ozorhon, [152]
CSF SC 1.8			Management with social responsibilities	Abdullah et al., [224]
CSF SC 1.9			Public utility and comfort	Mavi & Standing, [231]
CSF SC 1.10			Maintain long-term relationships and alliances	Kannan, [239]
CSF SC 1.11			Equity labour sources and non-discrimination	Kannan, [239]
CSF SC 1.12			Penalties and punishments for unethical behaviour	Kannan, [239]
CSF SC 1.13			Flexible working arrangements	Kannan, [239]
CSF SC 1.14			Accessibility	Kannan, [239]
CSF SC 1.15			Building amenities	Kamaruzzaman et al., [4]
CSF SC 2		**Cultural**		Kamaruzzaman et al., [4]
CSF SC 2.1			HHF's sustainability behavior	Wang et al., [194]
CSF SC 2.2			User behavior and demand analysis	Liang, et al., [226]; Liang, et al., [229]
CSF SC 2.3			Cultural tradition	Liang, et al., [226]; Liang, et al., [229]
CSF SC 2.4			Design compatible with cultural values	Kamaruzzaman et al., [4]
CSF SC 2.5			Use of local materials and technique	Kamaruzzaman et al., [4]

Technical Dimension

CSFs belongs to the technical dimension which has an important potential to affect all green retrofitting implementation stages of existing healthcare buildings [16]. The technical dimension consists of four different factors namely: installation/equipment [7], operational [194, 246], quality of services [4], and maintainability [226, 229]. (Shown in Table 19).

Compatibility [194], and improving energy performance (HVAC, lighting, lift, etc.) [4] are the factors of the installation/equipment category at Level 3. The operational category consists of four different factors, namely reliability [4], efficiency (optimum performance and the energy-saving, building envelope, mechanical and electrical systems, and the facility's interior and finishes) [4, 128, 225], durability [4] and flexibility and adaptability [4, 239].

In terms of quality of services, reducing technical uncertainty [247] and proving technical and management innovation [232] are crucial to increase the performance of green retrofitting projects. Thus, technical competency is an essential element to green retrofitting projects that provide installation/equipment, operational issues, and quality of services, which contribute to success for healthcare-specific projects.

Table 19: CSF of technical dimensions for GREHB

CSFs of GREHB				
	Level 1	**Level 2**	**Level 3**	**References**
	Dimension	**CSFs**	**CSFs**	
CSF TECHNI	**Technical**			Jagarajan, et al., [16]
CSF TECHNI 1		**Installation/Equipment**		Jagarajan, et al., [7]
CSF TECHNI 1.1			Compatibility	Wang et al., [194]
CSF TECHNI 1.2			Energy performance (hvac, lighting, lift etc.)	Kamaruzzaman et al., [4]
CSF TECHNI 2		**Operational**		Wang et al., [194], Pietzsch et al., [246]
CSF TECHNI 2.1			Reliability	Kamaruzzaman et al., [4]
CSF TECHNI 2.2			Efficiency (optimum performance and energy saving (building envelope, mechanical and electrical systems, facilities interior and finishes)	Kamaruzzaman et al., [4]; Mohammadpour et al., [128], Ishak, et al., [225]
CSF TECHNI 2.2			Durability	Kamaruzzaman et al., [4]; Sfakianaki [266]
CSF TECHNI 2.3			Flexibility and adaptability	Kamaruzzaman et al., [4]; Kannan, [239]
CSF TECHNI 3		**Quality of services**		Kamaruzzaman et al., [4]
CSF TECHNI 3.1			Reducing technical uncertainty	Maqbool & Sudong, [247]
CSF TECHNI 3.2			Technical and management innovation	Shen, et al., [232]
CSF TECHNI 4		**Maintainability**		Liang, et al., [226]; Liang, et al., [229]

Technological Dimensions

Different from the technical dimension, the technological dimension represents the modern improvements, and the integration of technology in retrofitting projects which is seen as a significant step towards success. This dimension consists of eight factors at Level 2: material and equipment selection [16, 206, 216, and 243], innovation [4, 16, 165, and 216], green technology capabilities [239], availability of technology [7, 242], renewable energy technologies [4], the complexity and maturity of technology, information technologies, and computerization level, collaborative design and automation [226, 229].CSFs of technological dimension are shown in Table 20.

As a CSF, appropriate material and equipment selection emerges as a critical factor since it can be risky during the construction stage because of the unavailability of selected materials and equipment [7]. The risk of the unavailability of selected materials and equipment can be turned into an opportunity by selecting appropriate material and equipment to have a successful retrofitting project.

According to Slaughter [248], innovation is a significant component of the long-term competitive strategy of companies. So, using innovative technologies and approaches [165, 216, 206], innovation potential of suppliers, design capability of suppliers, and innovation in design [239] have significant impacts on building performance which is included in the innovation category.

Green technology capabilities play a critical role in reaching successful projects in green retrofitting of healthcare buildings. It is obvious that using clean technologies and materials [228], utilizing clean and renewable energy [228, 243] and use of environmentally friendly technology [239] for carbon reduction [243], have affected the performance of green retrofitting projects.

The availability of technology is another significant factor that has a substantial impact on project success. In this category, existing of technology support [247], leveraging the technology [168], and technological capability of suppliers [239] are also important to achieve project goals.

Table 20: CSFs of technological dimension for GREHB

CSFs of GREHB				
	Level 1	Level 2	Level 3	References
	Dimension	**CSFs**	**CSFs**	
CSF TECHNO	**Technological**			Ishak, et al., [225]
CSF TECHNO 1		**Material and equipment selection**		Jagarajan, et al. [16]; Shen, et al., [206]; Li, et al., [216]; Chung, et al., [243]
CSF TECHNO 2		**Innovation**		Kamaruzzaman et al., [4]; Jagarajan, et al., [16]; Venkataraman & Cheng, [165]; Li, et al., [216]; Li et al., [265]
CSF TECHNO 3		**Green technology capabilities**		Kannan, [239]
CSF TECHNO 4		**Availability of technology**		Jagarajan, et al., [7]; Xu & Chan, [242]
CSF TECHNO 4.1			Technology support	Maqbool & Sudong, [247]
CSF TECHNO 4.2			Leveraging the technology	Kim, et al., [168]
CSF TECHNO 4.3			Technological capability of suppliers	Kannan, [239]
CSF TECHNO 5		**Renewable energy technologies**		Kamaruzzaman et al., [4]
CSF TECHNO 6		**Complexity and maturity of the technology**		Liang, et al., [226]; Liang, et al., [229]
CSF TECHNO 7		**Information technologies and computerization level**		Liang, et al., [226]; Liang, et al., [229]
CSF TECHNO 8		**Collaborative design and automation**		Liang, et al., [226]; Liang, et al., [229]

Managerial/Organizational Dimension

Managerial/organizational CSFs are categorized as Level 1 main dimension together [247] which has considerable effects on the success of the retrofitting projects which consist of 17 sub dimensions, including sustainability strategy [16], leadership [7, 152, 215, 228, 236, 247], commitment of stakeholders [165, 216, 230], project and construction management [4, 16, 225, 226, 229, 242], project processes [214, 223], performance evaluation/appraisal [241], project risk and liability management [231], change management [17], quality [17, 241], HSE management [228], supplier management [215, 239, 249], information management [215, 249], lifecycle management [231], organizational structure/factors [214, 227, 231, 242], contract management [214, 223, 242], dispute management [17], and procurement and tendering [16, 241]. CSFs of the managerial/organizational dimension are shown in Table 21.

Especially, sustainability strategy management for a sustainable project is a tool which supports and accomplishes the sustainability goals of the project with SD strategies planning and control mechanisms [223]. Thus, clearly defined goals are significant to accomplish determined goals in projects and provide a better understanding of goals, objectives, scope, and vision of the projects by project participants. Hence, sustainability strategy consists of clear project goals/ objectives /scope and project vision/ priorities of stakeholders [7, 17, 168, 226, 227, 229, 230] and SD strategy planning and control [214, 227, 242].

The success of the green retrofitting projects was based on having a clear vision, providing internal leadership among stakeholders, and having a committed project leader [7]. Fiedler [256] has indicated that the effectiveness of a leader, and the behaviour and performance of the leader are the primary considerations to improve the success of organizations. Hereby, the leadership category includes the organizing skills/ capacity of the leader [206, 214, 223].

Ponniah et al., [237] state that green building projects involve more significant obstacles compared to conventional ones. So, clients need to be committed about the project and they must not leave in the middle of the project because the commitment of the clients contributes to ensuring the project's success. The commitment of stakeholders has a profound impact on successful implementations and involves client commitment [16, 152, 230, 237], willingness to make the change [227], top management support/commitment [165, 152, 215, 216, 231, 247, 249], team commitment [231, 247] and project manager commitment [7].

According to a study conducted by Venkataraman and Cheng [165], early involvement of all project participants is one of the major CSFs to conduct green building implementations. Also, Li et al., [216] indicated that the use of innovative management approaches is again one of the significant factors for critical project management which can substantially impact the environmental performance of green building projects. Successful project and construction management practices lead to better performance in green retrofitting projects in terms of time, cost, and quality. Also, monitoring, planning, and control are required for effective project management.

The project and construction management category consists of a number of factors namely, innovative management approaches [165, 216] early involvement of project participants and the right project team [165], planning, monitoring and control [17, 16, 214, 223, 242], time, risk, cost, quality [16, 17, 228], good planning, and scheduling methods [231], detailed plans for design and construction [216], reduce ambiguity and maximize stability [247], and realistic expectations and objectives [231, 247]. All these factors have profound impacts on green retrofitting projects.

Additionally, processes related to project phases have a strong influence on the environmental performance of projects. According to the literature review findings, agile project processes [231], project brief and design, successful commission and handover, successful operation and maintenance [4] need to be considered as factors contributing to the success in healthcare projects.

Li et al., [216] stated that not only considering project organizational factors but also effective feedback troubleshooting, and adequate communication should be considered in green building projects. As a result, performance evaluation/appraisal is identified as another factor which involves critical factors namely, review and improvement and feedback [216], effective feedback and troubleshooting [165, 216], effective consultation with key stakeholders [231], continuous performance measurement [231, 249], and deficiency of performance data about retrofitted existing buildings [7].

In green retrofitting projects, the management project risk and liability include successful risk planning strategies [16]. Other important factors are change management, minimal scope change [231], and interruptions in operations [226, 229] which are some of the key contributors to advance the environmental performance of projects. It is clear that, the behaviour of project participants on changes during the green retrofitting operations can impact the project performance positively or negatively. Retrofitting action is all about quality of life. Hence, quality as a CSF involves quality of design and construction [243] implementation of vigorous procedures [241], quality testing and meeting [247], met plant quality standards [231], and quality of installation.

As part of managerial processes, HSE management consists of overall health and safety measures [228] and effective health and safety protocols [230]. Providing health and safety correctly during the retrofitting stage is critical and risky, so health and safety measures and protocols play a critical role in enhancing the success of projects.

Especially for green building projects, suppliers are one of the key players, and supplier management strategies are significant. The supplier quality [152, 239], delivery reliability and on-time reliability, the geographical proximity of suppliers, product responsibility, and green purchasing capabilities [239] are CSFs which should be considered in the CSFs framework.

The information management among project participants has a strong influence on achieving goals of the projects such as information sharing [226, 229] and value engineering [152] which are critical points which should be considered in green retrofitting projects. Also, contract management is one of the critical parts and the success of projects can change according to contractual arrangements and conditions [16]. Moreover, healthcare buildings and green retrofitting projects are complex projects that can cause dispute during implementation and operations, so the proper dispute resolution management [16] can help to solve problems in projects. Another significant factor is life-cycle management since any lack of life cycle costing knowledge [227, 229] can cause financial losses during retrofitting projects.

The defining the structure of project organization and project objectives control mechanism is the major component of project organization, which directly affects project success performance [223]. Thus, appropriate organizational structure [242] and organizational maturity level [231] are identified as important components of the organizational structure dimension.

The last dimension is procurement and tendering. To enhance performance of the building, the investigation and adaptation of the correct approach [241], the integrated and collaborative delivery process [165], and the existence of a procurement standard [239] are critical elements which should be considered in green retrofitting.

Table 21: CSFs of managerial/organizational dimension for GREHB

CSFs of GREHB				
	Level 1	**Level 2**	**Level 3**	**References**
	Dimension	**CSFs**	**CSFs**	
CSF MAN	**Managerial/ Organizational**			Maqbool & Sudong, [247]
CSF MAN 1		**Sustainability Strategy**		Jagarajan, et al., [16]
CSF MAN 1.1			Clear project goals/ objectives /scope and project vision priorities of stakeholder	Jagarajan, et al., [7]; Low, et al., [17]; Kim, et al., [168]; Liang, et al., [226]; Liang, et al., [229]; Shang, et al., [227]; Banihashemi, et al., [230]; Hosseini et al., [263]; Li et al., [265]
CSF MAN 1.2			Sustainable development strategy planning and control	Xu, et al., [214]; Shang, et al., [227]; Xu & Chan, [242]
CSF MAN 2		**Leadership**		Jagarajan, et al., [7]; Aktas & Ozorhon, [152]; dos Santos & Jabbour, [215]; Akbari, et al.,[228]; Zhao, et al., [236]; Maqbool & Sudong, [247]
CSF MAN 3		**Commitment of stakeholders**		Venkataraman & Cheng, [165]; Li, et al., [216]; Banihashemi, et al, [230]; Hosseini et al., [263]
CSF MAN 3.1			Client commitment	Jagarajan, et al., [16]; Aktas & Ozorhon, [152]; Banihashemi, et al, [230]; Ponniah, et al., [237]; Hosseini et al., [263]
CSF MAN 3.2			Willingness to make change	Shang, et al., [227]
CSF MAN 3.3			Top management support /commitment	Aktas & Ozorhon, [152]; Venkataraman & Cheng, [165]; dos Santos & Jabbour, [215]; Li, et al., [216]; Mavi & Standing, [231]; Maqbool & Sudong, [247]; Wee & Quazi, [249]; Li et al., [265]
CSF MAN 3.4			Team commitment	Mavi & Standing, [231]; Maqbool & Sudong, [247]
CSF MAN 3.5			Project manager commitment	Jagarajan, et al., [7]

Table 21: CSFs of managerial/organizational dimension for GREHB (continued)

CSFs of GREHB				
	Level 1	**Level 2**	**Level 3**	**References**
	Dimension	**CSFs**	**CSFs**	
CSF MAN 4		**Project and construction management**		Kamaruzzaman et al., [4]; Jagarajan, et al., [16]; Xu & Chan, [242]; Ishak, et al., [225]; Liang, et al., [226]; Liang, et al., [229]
CSF MAN 4.1			Innovative management approaches	Li, et al., [216]; Venkataraman & Cheng, [165]
CSF MAN 4.2			Early involvement of project participants and right project team	Venkataraman & Cheng, [165]; Ahmad et al., [262]; Shen et al., [264]
CSF MAN 4.3			Planning, monitoring and control	Jagarajan, et al., [16]; Low, S.P. et al., [17]; Xu, et al., [214]; Xu, P et al.,[223]; Xu & Chan, [242]
CSF MAN 4.4			Time, risk, cost, quality	Jagarajan, et al., [16]; Low, et al., [17]; Akbari, et al., [228]
CSF MAN 4.5			Good planning and scheduling methods	Mavi & Standing, [231]
CSF MAN 4.6			The detailed plan for design and construction	Li, et al., [216]
CSF MAN 4.7			Reduce ambiguity and maximize stability	Maqbool & Sudong, [247]
CSF MAN 4.8			Realistic expectations and objectives	Mavi & Standing, [231]; Maqbool & Sudong, [247]
CSF MAN 5		**Project processes**		Xu, et al., [214]; Xu, et al., [223]
CSF MAN 5.1			Agile project processes	Mavi & Standing, [231]
CSF MAN 5.2			Project brief and design	Kamaruzzaman et al., [4]
CSF MAN 5.3			Successful commission and handover	Kamaruzzaman et al., [4]
CSF MAN 5.4			Successful operation and maintenance	Kamaruzzaman et al., [4]
CSF MAN 6		**Performance evaluation/appraisal**		Tucker, et al., [241]
CSF MAN 6.1			Review and improvement and feedback	Li, et al., [216]
CSF MAN 6.2			Effective feedback and troubleshooting	Venkataraman & Cheng, [18]; Li, et al., [216]
CSF MAN 6.3			Effective consultation with key stakeholders	Mavi & Standing, [231]
CSF MAN 6.4			Continuous performance measurement	Mavi & Standing, [231]; Wee & Quazi, [249]
CSF MAN 6.5			Deficiency of performance data about retrofitted existing buildings	Jagarajan, et al., [7]

Table 21: CSFs of managerial/organizational dimension for GREHB (continued)

CSFs of GREHB				
	Level 1	**Level 2**	**Level 3**	**References**
	Dimension	**CSFs**	**CSFs**	
CSF MAN 7		**Project risk and liability management**		Mavi & Standing, [231]
CSF MAN 8		**Change management**		Low, et al., [17]
CSF MAN 8.1			Minimal scope change	Mavi & Standing, [231]
CSF MAN 8.2			Interruptions in operations	Liang, et al., [226]; Liang, et al., [229]
CSF MAN 9		**Quality**		Low, et al., [17]; Tucker, et al., [241]
CSF MAN 9.1			Design, construction	Chung, et al., [243]
CSF MAN 9.2			Implementation of vigorous procedures	Tucker, et al., [241]
CSF MAN 9.3			Quality testing	Maqbool & Sudong, [247]
CSF MAN 9.4			Met plant quality standards	Mavi & Standing, [231]
CSF MAN 9.5			Installation	Venkataraman & Cheng, [18]; Aktas & Ozorhon, [152]
CSF MAN 10		**HSE Management**		Akbari, et al., [228]
CSF MAN 10.1			Overall health and safety measures	Akbari, et al., [228]
CSF MAN 10.2			Effective health and safety protocols	Banihashemi, et al., [230]
CSF MAN 11		**Supplier management**		dos Santos & Jabbour, [215]; Kannan, [239]; Wee & Quazi, [249]
CSF MAN 11.1			Supplier quality	Aktas & Ozorhon, [152]; Kannan, [239]
CSF MAN 11.2			Delivery reliability and on time reliability	Kannan, [239]
CSF MAN 11.3			The geographical proximity of suppliers	Kannan, [239]
CSF MAN 11.4			Product responsibility	Kannan, [239]
CSF MAN 11.5			Green purchasing capabilities	Kannan, [239]

Table 21: CSFs of managerial/organizational dimension for GREHB (continued)

CSFs of GREHB				
	Level 1	**Level 2**	**Level 3**	**References**
	Dimension	**CSFs**	**CSFs**	
CSF MAN 12		**Information management**		dos Santos & Jabbour, [215]; Wee & Quazi, [249]
CSF MAN 13		**Life-cycle management**		Mavi & Standing, [231]
CSF MAN 14		**Organizational structure/ factors**		Xu, et al., [214]; Shang, et al.,[227]; Mavi, R.K. & Standing, C., [231]; Xu & Chan, [242]
CSF MAN 15		**Contract management**		Xu, et al., [214]; Xu, et al., [223]; Xu & Chan, [242]
CSF MAN 16		**Dispute management**		Low et al., [17]
CSF MAN 17		**Procurement and tendering**		Jagarajan, et al. [16]; Tucker, et al., [241]; Sfakianaki [266]
CSF MAN 17.1			Investigation and adaptation of the correct approach	Tucker, et al., [241]
CSF MAN 17.2			The integrated and collaborative delivery process	Venkataraman & Cheng, [18]
CSF MAN 17.3			Procurement standard	Kannan, [239]

Human Dimension

From a healthcare perspective, retrofitting existing healthcare buildings requires many stakeholders from the industry which have different backgrounds. Critical participants of green retrofitting processes consist of owner/client, the government, project manager, professional bodies, occupier/user (patients, staff, employees), designer, contractor, financial institution/bank, energy service company, industry association, NGO/community, and research institution [226, 230].

Employee empowerment and motivation [215, 216, 247], professional experience and competencies, and communication/ cooperation/ collaboration/ coordination and motivation of stakeholders [7, 165, 168, 206, 214, 216, 226, 227, 229, 232, 242, 243, 247] were considered the critical factors which can contribute to successful green retrofit implementations under the dimension of the human related at level 2. (Shown in Table 22).

Employee empowerment and motivation is one of the essential components of green retrofitting projects since the empowerment of staff and employees improves their motivation and productivity which resulted in successful implementations. Giving rewards [215] to a successful implementation done by an employee and providing environmental training [215, 249] improve the employee empowerment and motivation.

According to the structured literature search, the leading professional experience and competencies factors to have successful retrofit performance are: awareness of green building technologies and environmental issues [7, 231, 234], building owners retrofit expertise [7], client competency [16, 237], stakeholders experience/competency and know-how [16, 17, 165, 206, 232], competent project managers [7, 206, 231], experience of consultants [152], experience of contractors, experience of design team [7, 152], experience sharing and education [226, 229], involvement of green building professional throughout the project lifecycle [165, 231], green building skills/training and sustainability knowledge [7, 239], skilled workers and high-quality workmanship [230, 232], existence of an energy specialist [7], team competency, support, and experience [7, 206, 247], organizing capacity and task orientation [242, 247], owners-clients awareness on SD [7, 214, 227, 242], professional/technical knowledge and expertise in GBTs [216, 234], retrofit readiness and new environmental technologies level of owners [7], teamwork technical skills and background [214, 215, 229, 228, 242], and engineering expertise [243].

Professional experience in green retrofitting projects is related to gaining knowledge from past experiences, gaining know-how, or involvement in green retrofitting projects before. Complex and high scale green building projects need professional experience to implement design and construction of green buildings successfully. A case of a lack of professional experience can impact the success and costs of the project [165]. Jagarajan et al., [7] noted that one of the significant actors in delaying the timely completion of the project was inexperienced consultants. Also, this affects the implementation of a successful retrofit project. Therefore, familiarity with green retrofit actions or energy efficiency implementations is a critical element to conduct successful projects that contribute to gain a better corporate image and market growth [152].

Venkataraman and Cheng [165] identified one of the significant failure factors as poor cooperation during the project activities. So, effective coordination among stakeholders of projects is essential to achieve project aim and objectives [223]. To illustrate, the owner of the building may engage a team of building professionals to carry out a retrofit of the building, but at the same time, there is a need for team effort among these professionals to sustainable design and technologies integration [17]. According to Cserháti and Szabó [250], communication and co-operation among stakeholders, project leadership as well as partnerships with future stakeholders were identified as the relationship-oriented success factors which have a significant role in reaching successful projects. As a result, the critical factors contributing to successful green retrofitting implementations under the communication/ cooperation/ collaboration/ coordination/ motivation of stakeholders category are: stakeholder integration [16, 206, 243], good relationships among participants, trust and partnership [206, 231, 247], partnering agreements and factors [17, 214], and clearly written lines of responsibility [17].

Table 22: CSFs of human related dimension for GREHB

CSFs of GREHB				
	Level 1	Level 2	Level 3	References
	Dimension	**CSFs**	**CSFs**	
CSF HUM	**Human**			Jagarajan, et al. [16]
CSF HUM 1		**Employee empowerment and motivation**		dos Santos & Jabbour, [215]; Li, et al., [216]; Maqbool & Sudong, [247]
CSF HUM 2		**Professional experience and competencies**		
CSF HUM 2.1			Awareness of green building technologies and environmental issues	Jagarajan, et al., [7]; Mavi & Standing, [231]; Chan, et al., [234]
CSF HUM 2.2			Building owners retrofit expertise	Jagarajan, et al., [7]
CSF HUM 2.3			Client competency	Jagarajan, et al., [16]; Ponniah, et al., [237]
CSF HUM 2.4			Stakeholders experience/competency and know-how	Jagarajan, et al., [16]; Low, et al., [17]; Venkataraman & Cheng, [165]; Shen, et al., [206]; Shen, et al., [232]; Li et al., [265]
CSF HUM 2.5			Competent project manager	Jagarajan, et al., [7]; Shen, et al., [206]; Mavi & Standing, [231]; Ahmad et al., [262]; Shen et al., [264]
CSF HUM 2.6			Experience of consultants	Aktas & Ozorhon, [152]
CSF HUM 2.7			Experience of contractors	Jagarajan, et al., [7]; Aktas & Ozorhon, [152]
CSF HUM 2.8			Experience of design team	Jagarajan, et al., [7]; Aktas & Ozorhon, [152]
CSF HUM 2.9			Experience sharing and education	Liang, et al., [226]; Liang, et al., [229]
CSF HUM 2.10			Involvement of green building professional throughout the project lifecycle	Venkataraman & Cheng, [165]; Mavi & Standing, [231]
CSF HUM 2.11			Green building skills/training and sustainability knowledge	Jagarajan, et al., [7]; Kannan, [239]
CSF HUM 2.12			Skilled workers and high-quality workmanship	Banihashemi, et al., [230]; Shen, et al., [232]; Hosseini et al., [263]

Table 22: CSFs of human related dimension for GREHB

CSFs of GREHB				
	Level 1	**Level 2**	**Level 3**	**References**
	Dimension	**CSFs**	**CSFs**	
CSF HUM 2.13			Energy specialist	Jagarajan, et al., [7]
CSF HUM 2.14			Team competency, support, and experience	Jagarajan, et al., [7]; Shen, et al., [206]; Maqbool & Sudong, [247]; Ahmad et al., [262]; Shen et al., [264]
CSF HUM 2.15			Organizing capacity and task orientation	Xu & Chan, [242]; Maqbool & Sudong, [247]
CSF HUM 2.16			Owners-clients awareness on sustainable development	Jagarajan, et al., [7]; Xu, et al., [214]; Shang, et al., [227]; Xu & Chan, [242]
CSF HUM 2.17			Professional/technical knowledge and expertise in GBTs	Li, et al., [216]; Chan, et al., [234]
CSF HUM 2.18			Retrofit readiness and new environmental technologies level of owners	Jagarajan, et al., [7]
CSF HUM 2.19			Teamwork technical skills and background	Xu, et al., [214]; dos Santos & Jabbour, [215]; Shang, et al.,[227]; Akbari, et al., [228]; Xu & Chan, [242]
CSF HUM 2.20			Engineering expertise	Chung, et al.,[243]
CSF HUM 3		**Communication/ cooperation/ collaboration/ coordination/ motivation of stakeholders**		Jagarajan, et al., [7]; Venkataraman & Cheng, [165]; Kim, et al., [168]; Shen, et al., [206]; Xu, et al., [214]; Li, et al., [216]; Liang, et al., [226]; Shang, et al., [227]; Akbari, et al., [228]; Liang, et al., [229]; Mavi & Standing, [231]; Shen, et al., [232]; Xu & Chan, [242]; Chung, et al., [243]; Maqbool & Sudong, [247]; Ahmad et al., [262]; Shen et al., [264]; Li et al., [265]; Sfakianaki [266]
CSF HUM 3.1			Stakeholder integration	Jagarajan, et al., [16]; Shen, et al., [206]; Chung, et al., [243]
CSF HUM 3.2			Good relationships among participants, trust and partnership	Shen, et al., [206]; Mavi & Standing, [231]; Maqbool & Sudong, [247]; Shen et al., [264]
CSF HUM 3.3			Partnering agreements and factors	Low, et al., [17]; Xu, et al., [214]
CSF HUM 3.4			Clear written lines of responsibility	Low, et al., [17]

Political Dimension

The government is a pioneering institution that supports and contributes to green retrofitting projects through providing funds and incentives. The sustainability and feasibility of green retrofitting projects depend on government policy and attitude. Hence, the success of GREHB depends on political factors [16, 225] which include policies [7, 214, 226, 227, 229, 233], regulations/legislation [17] and incentives [234]. Table 23 shows the CSFs of political dimension for GREHB. Policy support [7, 214, 232, 233, 242], enacting required policies in supporting sustainability principles in construction projects by governmental and professional bodies [230], the socio-political environment [206], government program and policies [226, 229], investment and involvement from the government and private companies in the green building movement [7] are some of the leading policy factors in order to have successful project implementations. Xu et al. [224] highlighted that policy incentives have a significant impact on energy efficiency enhancement in existing buildings.

The government has a greater influence on the performance and quality as the critical player in terms of providing regulation, standards and systems, building consumer awareness, and information and services [251]. Financing and task policy, market regulatory environment [227], promoting green innovation [246], the existence of green building codes and regulations [234] and clear criteria and standards [226, 229] are significant regulations/legislation factors that contribute to the success of green retrofitting projects.

Chan et al., [234] have emphasized that the absence of government incentives and the absence of codes and regulations about green building technologies become a critical barrier to the adaptation of green building technologies, so the existence of effective governmental incentives is essential. On the other hand, Darko et al., [156] have indicated that the existence of government regulations and policies and incentive schemes are one of the impactful drivers to promote green buildings. Thus, the existence of political support has a profound impact on the success of green retrofitting of existing healthcare building projects.

Table 23: CSFs of political dimension for GREHB

CSFs of GREHB				
	Level 1	Level 2	Level 3	References
	Dimension	**CSFs**	**CSFs**	
CSF POL	**Political**			Jagarajan, et al., [16]; Ishak, et al., [225]
CSF POL 1		**Policies**		Jagarajan, et al., [7]; Xu, et al., [214]; Liang, et al., [226]; Shang, et al., [227]; Liang, et al., [229]; Razman et al., [233]; Li et al., [265]
CSF POL 1.1			Policy support	Jagarajan, et al., [7]; Xu, et al., [214]; Shen, et al., [232]; Razman et al., [233]; Xu & Chan, [242]
CSF POL 1.2			Enacting required policies in supporting sustainability principles in construction projects by governmental and professional bodies	Banihashemi, et al., [230]
CSF POL 1.3			Socio-political environment	Shen, et al., [206]; Ahmad et al., [262]; Shen et al., [264]
CSF POL 1.4			Government program and policies	Liang, et al., [226]; Liang, et al., [229]
CSF POL 1.5			Investment and involvement from the government and private companies in the green building movement	Jagarajan, et al., [7]
CSF POL 2		**Regulations/legislation**		Low, et al., [17]; Li et al., [265]
CSF POL 2.1			Financing and task policy	Shang, et al., [227]
CSF POL 2.2			Market regulatory environment	Shang, et al., [227]
CSF POL 2.3			Promote green innovation	Pietzsch, et al., [246]
CSF POL 2.4			Existence of green building codes and regulations	Chan, et al., [234]
CSF POL 2.5			Clear criteria and standards	Liang, et al., [226]; Liang, et al., [229]
CSF POL 3		**Incentives**		Chan, et al., [234]

Project Dimension

Existing buildings refurbishment projects are usually different from new construction projects in terms of their complex nature and characteristics, so the determination of the CSFs with a particular focus on refurbishment is crucial to reach success in the CI [225]. Notably, each project has different characteristics and requirements, so the consideration of the project's self-related factors in early phases has significant effects on the success of projects. Additionally, Liang et al., [226] state that the building environment has direct influences on the occupants of the existing buildings.

According to the literature review, availability of resources [17, 215, 228, 231], project characteristics [232] a viable energy management program [226, 229], occupancy type [227, 229], existing facilities' conditions [226, 229], existing building evaluation [226, 229], public open space [4], existing building environment and condition [226, 229], end-user imposed restrictions [231], and owner expectation [152] were identified as project-related factors that lead to success in the green retrofitting of existing healthcare building projects.

Existing buildings' project characteristics, including project type and size [206, 231], building age, site and location limitation [214], and project complexity [231] have a strong impact on green retrofit projects. Healthcare buildings, as one of the different and complex types of projects, require particular importance in green retrofitting since their 24/7 operations play a critical role in the success of the projects [28]. Their continuous operations need to be considered during the green retrofitting process and also, the occupancy type and behaviour of occupants affect the success of the retrofit project. For example, high occupancy rates during the green retrofit process in hospitals can have a vital influence on feasibility because providing the health and safety of the hospital's patients and staff is important, and under these circumstances, providing the health and safety conditions can be challenging.

Eckelman and Sherman [28] highlighted that healthcare buildings use large amounts of energy and cause significant pollution that lead to a negative environmental effect mainly due to the age of the buildings [175]. Thus, during their green retrofitting, the consideration of building characteristics such as the age of the building is significant to retrofit performance. Table 24 presents the CSFs of project dimension for GREHB.

Table 24: CSFs of project dimension for GREHB

CSFs of GREHB				
	Level 1	Level 2	Level 3	References
	Dimension	**CSFs**	**CSFs**	
CSF PRO	**Project**			Xu, et al., [214]; Ishak, et al., [225]
CSF PRO 1		**Availability of resources**		Low, et al.,[17]; dos Santos & Jabbour, [215]; Akbari, et al., [228]; Mavi & Standing, [231]
CSF PRO 2		**Project characteristics**		Shen, et al., [232]
CSF PRO 2.1			Project type and size	Shen, et al., [206]; Mavi & Standing, [231]; Ahmad et al., [262]; Shen et al., [264]
CSF PRO 2.2			Building age	Xu, et al., [214]; Ahmad et al., [262]
CSF PRO 2.3			Site and location limitation	Xu, et al., [214]; Ahmad et al., [262]
CSF PRO 2.4			Project complexity	Mavi & Standing, [231]
CSF PRO 3		**Viable energy management program**		Shang, et al., [227]
CSF PRO 4		**Occupancy type**		Liang, et al., [226]; Liang, et al., [229]
CSF PRO 5		**Existing facilities condition**		Liang, et al., [226]; Liang, et al., [229]
CSF PRO 6		**Existing building evaluation**		Liang, et al., [226]; Liang, et al., [229]
CSF PRO 7		**Public open space**		Kamaruzzaman et al., [4]
CSF PRO 8		**Existing building environment and condition**		Liang, et al., [226]; Liang, et al., [229]
CSF PRO 9		**End user-imposed restrictions**		Mavi & Standing, [231]
CSF PRO 10		**Owner expectation**		Aktas & Ozorhon, [152]

All in all, the developed conceptual CSFs framework for GREHB was explained in detail in this part of this thesis. In addition to the explanation, to draw a clear picture, a diagram was created. To make the framework more understandable, the diagram includes only Level 1 and Level 2 at the conceptual framework for GREHB. Figure 16 demonstrates the developed diagram for the conceptual CSFs framework for GREHB.

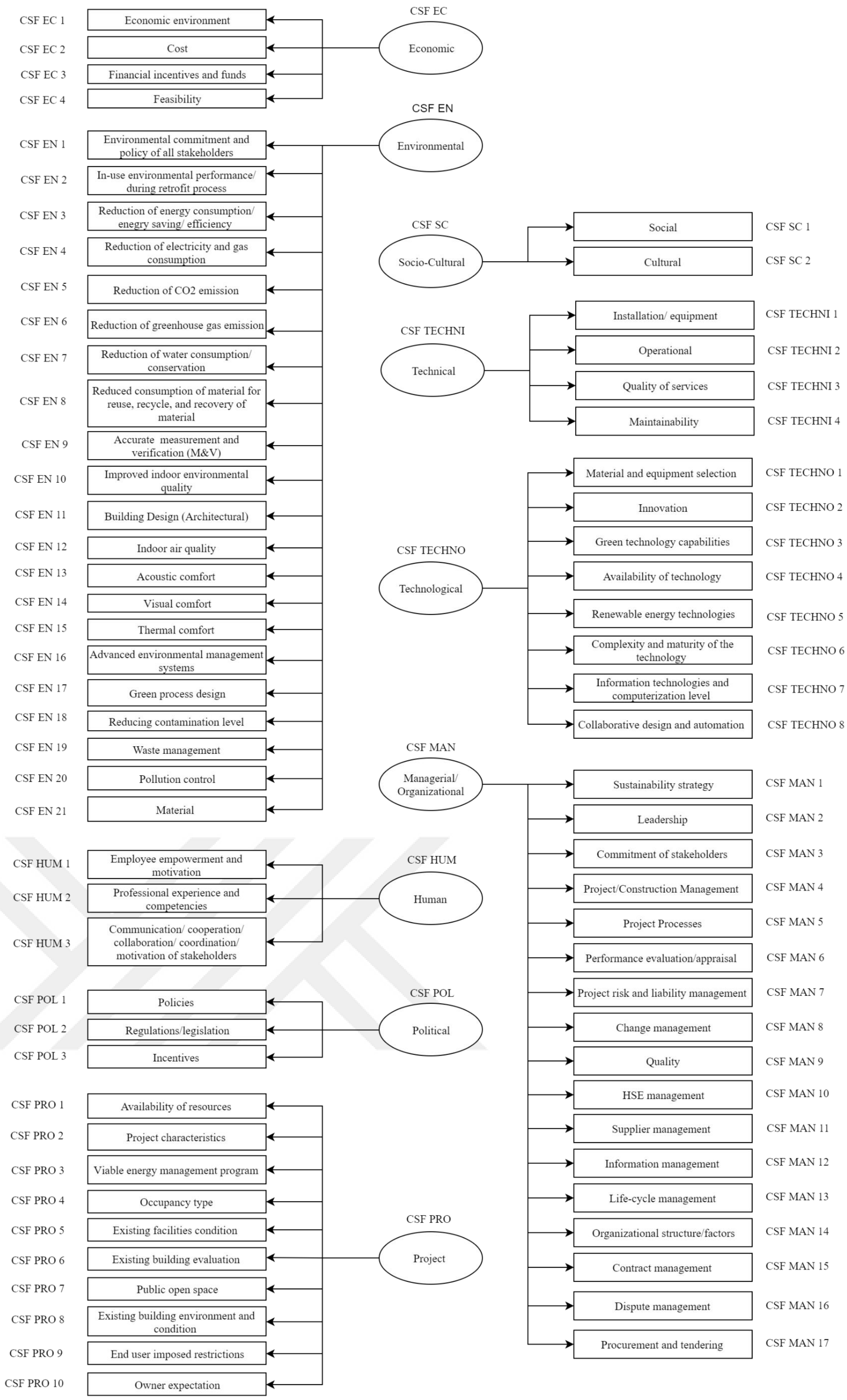


Figure 16: A priori conceptual CSFs framework

CHAPTER VI

VI. RESULTS

6.1. Statistical Procedures and Analysis

The data obtained from the results of the survey were analyzed and evaluated with the help of IBM SPSS Statistic 20 (Statistical Package for the Social Sciences) and MS Office 2018 Excel program.

Descriptive statistics, and for examining the reliability, the Cronbach's Alpha criterion were used. Descriptive statistics include measures of central tendencies such as arithmetic mean and standard deviation. These analyses were applied to understand how the data was distributed. The obtained results were transferred to tables and graphs and interpreted under the titles of a statistical procedure, analysis, and findings. All findings were tested with 95% confidence, p = 0.05 significance level (p), and bidirectional.

In order to examine the reliability levels of the questionnaire responses, the (α) model (Cronbach's Alpha Coefficient) statistical analysis procedure was applied. This method investigates whether the problem in the scale represents a homogeneous structure. The Cronbach Alpha Coefficient obtained from the statistical attitude scale is accepted as an indicator of the homogeneity of the measuring instrument. As the calculated Cronbach's Alpha Coefficient approaches 1, it can be assumed that the measuring instrument has a one-dimensional structure [257]. Kalaycı [258] stated that the reliability of the measurement as follows depends on the alpha (α) coefficient: $0.00 \leq \alpha < 0.40$ (not reliable), $0.40 \leq \alpha < 0.60$ (low reliability), $0.60 \leq \alpha < 0.80$ (quite reliable) and $0.80 \leq \alpha < 1.00$ (highly reliable).

Reliability Test

Before obtaining the data analysis to ensure that the progress of the survey was beneficial, statistical procedures were applied related to Cronbach’s Alpha Coefficient. Cronbach's Alpha was used to test the reliability of the participants' responses, and the obtained Cronbach's Alpha coefficients are given in Table 25.

Table 25: Reliability of statistical analysis

Dimension	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
Total	,998	,999	225
CSF EN- Environmental	,991	,992	26
CSF EC - Economic	,991	,992	33
CSF SC- Socio- Cultural	,989	,990	22
CSF TECHNI- Technical	,984	,986	12
CSF TECHNO- Technological	,981	,983	11
CSF MAN- Managerial/Organizational	,996	,996	58
CSF HUM- Human	,990	,991	27
CSF POL- Political	,986	,989	13
CSF PRO- Project	,983	,985	14
CSF ALL	,971	,972	9

Yasar [257] noted that as the calculated Cronbach's alpha coefficient approaches to 1, it can be considered that the measuring instrument has a reliable structure. The result showed that the measured Cronbach’s alpha value is 0.998; it means that the data obtained from the survey was found as having a high reliability. Also, in terms of all dimensions of the survey, the Cronbach’s Alpha values have high reliability.

6.2. Descriptive Statistics

The Response Rate

The response rate of the survey was 24.2 % (46/190). E-mail surveys are widely used to collect data in the CI. This generally results in a 20-25% respond rate that is acceptable for construction management research, despite poor response rates [259]. The completion of the questionnaire took three months. Although very high response rates could not be reached, there is not any missing data in the questionnaire forms. So, missing data analysis was not done for the questionnaire.

Calculation of margin of error

The necessity of a large sample size for inferential statistical analysis is generally accepted. In general, in reference to the number of samples, if the threshold value is greater than 30 (n> 30), it is considered a practical rule to evaluate the sample as large [260]; [261]. Thus, 46 questionnaires obtained from the study were evaluated as a sufficient number to perform inferential statistical analyses. The margin of error for 46 questionnaires was calculated with the help of the formula:

m: margin of error

p: estimated variance

n: sample size

z *: standard variable table value (α = 0.05, for z * = 1,96)

$$m = z^* \sqrt{\frac{\hat{p}(1-\hat{p})}{n}} \quad (1)$$

When calculating the margin of error, it is estimated that the maximum variance occurs as the worst-case scenario when p = 0.5 [261]. In this context, with the given formula, the error margin in the obtained sample was calculated as 14.45% with a 95% confidence limit. This result indicates that the results obtained from the survey are within ± 14.45% range with a 95% probability.

Respondents Information

In this section, the results obtained through descriptive statistics related to the respondents were given. The experience in years of respondents was questioned as it increases the meaningfulness and reliability of the evaluations related to the CSFs of green retrofitting for existing healthcare buildings. The results regarding the experience in years of the respondents are summarized in Table 26.

Table 26: Experience year of the respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 1 year	2	4,3	4,3	4,3
	1-5 years,	4	8,7	8,7	13,0
	6-10 years,	16	34,8	34,8	100,0
	11-15 years,	12	26,1	26,1	39,1
	16-20 years,	12	26,1	26,1	65,2
	Total	46	100,0	100,0	

2 (4.3%) of the respondents who answered the questionnaire have less than one year of experience; 4 (8.7%) of them 1-5 years; 16 (34.8 %) of them 6-10 years; 12 (26.1%) of them 11-15 years; and 12 (26.1%) of them 16-20 years of experience.

The evaluation of the obtained data shows that 52.1% of the respondents have had experience in green buildings and sustainability for 11 years and more. The average of experience in years of the respondents was found to be 11 years. Therefore, in terms of the validity and reliability of the answers obtained in the context of the survey, the results of the study regarding the year of experience are supportive. (Shown in Table 27).

Table 27: The average of experience years of respondents

Experience year

N	Valid	46
	Missing	0
Mean		11,09
Median		12,00
Mode		12[a]
Std. Deviation		5,163
Range		19
Minimum		1
Maximum		20

The distribution of survey respondents in terms of their expertise; 26 (56.5%) of them were academicians; 16 (34.8%) of them were green building experts; 4 (8.7%) of them were found to be architects. (Shown in Table 28). According to the results, it was concluded that 26 (43.4%) of the total respondents were practitioners (green building experts and architects). In light of this result, it was found that among the respondents, 56% of them (26 people) are from the academia, and 43% of them (20 people) are practitioners. Therefore, academics and practitioners had a close participation rate in the survey. The average of the experience of the academicians, architects and green building experts are 12 years, 8 years and 10 years respectively.

Table 28: The distribution of respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Academic	26	56,5	56,5	56,5
	Architect	4	8,7	8,7	65,2
	Green Building Expert	16	34,8	34,8	100,0
	Total	46	100,0	100,0	

6.3. Analysis of Critical Success Factors

The investigation of CSFs for GREHB is the main objective of this thesis. This part presents the primary results of the conducted survey. Participants were asked to evaluate the importance of 216 CSFs compiled from the literature among 9 dimensions, for GREHB by using a 5-point Likert scale. In the Likert scale, 1=not important, 2=slightly important, 3=important, 4=very important, and 5=extremely important.

Descriptive statistics for the data obtained were calculated as mean, standard deviation, minimum values, and maximum values, and the confidence interval for each indicator. Accordingly, mean values of CSFs were calculated and ranked, and the factors remaining above the 3 = Important value on the scoring scale were chosen as the factors that play a role in the GREHB.

81 (37.5%) of the total CSFs received mean values were about or greater than 4.0, and 113 (52.3%) of the total CSFs received mean values were about or greater than 3.0, and also, 22 (10.1%) of the total CSFs received mean values were less than 3.0.

Based on Level 1 in the proposed Conceptual Framework for GREHB, the survey results showed the proposed nine dimensions with a mean value for each dimension ranging from 3,22 to 4,74. (Shown in Table 29). Among the main dimensions which were questioned separately in this survey, “CSF EN- Environmental” gained the highest ranking of 4,74. This result indicated that "CSF EN- Environmental" is identified as the most critical dimension in GREHB. The mean value of the proposed dimensions are above 3 points, so all of them are found valid and necessary for the GREHB.

Table 29: Mean values of main dimensions at level 1 of proposed framework

	CSF- Level 1	**Mean**	**Std. Deviation**	**N**
1	CSF EN- Environmental Dimension	4,74	,535	46
2	CSF HUM- Human Dimension	4,48	,722	46
3	CSF EC – Economic Dimension	4,13	,687	46
4	CSF MAN- Managerial/Organizational	4,09	,890	46
5	CSF PRO- Project Dimension	3,96	,868	46
6	CSF POL- Political Dimension	3,78	,841	46
7	CSF TECHNI- Technical Dimension	3,70	,813	46
8	CSF TECHNO- Technological Dimension	3,65	,822	46
9	CSF SC- Socio- Cultural Dimension	3,22	1,031	46

Further, in terms of main dimensions at level 1, the evaluation, according to the profession, is demonstrated in Table 30. All respondents evaluated the "CSF EN- Environmental" dimension as the most critical dimension for GREHB, and they also evaluated the "CSF SC- Socio-Cultural" dimension as the least important. Respondents whose profession is academic ranked "CSF EN- Environmental", "CSF HUM- Human", "CSF EC – Economic", "CSF MAN- Managerial/Organizational", and "CSF PRO- Project" dimensions above 4 points. Respondents whose profession is architect ranked only "CSF EN- Environmental", "CSF HUM- Human", and "CSF MAN- Managerial/ Organizational" dimensions above 4 points. Also, respondents whose profession is green building expert ranked "CSF EN- Environmental", "CSF HUM- Human", "CSF EC – Economic", and "CSF MAN- Managerial/Organizational" dimensions above 4 points. This data demonstrated that respondents from different professions have similar perspectives for the GREHB.

Table 30: Mean values of main dimensions at level 1 of proposed framework according to profession

	Profession	Academic	Architect	Green Building Expert
	Experience Year Average	12	8	10
Main Dimensions	CSF EC - Economic	4,15	3,50	4,25
	CSF EN- Environmental	4,76	4,50	4,75
	CSF SC- Socio- Cultural	3,26	2,50	3,31
	CSF TECHNI- Technical	3,76	3,50	3,63
	CSF TECHNO- Technological	3,69	3,50	3,63
	CSF MAN- Managerial/Organizational	4,11	4,00	4,06
	CSF HUM- Human	4,53	4,25	4,44
	CSF POL- Political	3,80	3,50	3,75
	CSF PRO- Project	4,00	3,75	3,94

Based on Level 2 in the proposed Conceptual Framework for GREHB, the survey results show that 72 CSFs with a mean value for each factor ranging from 2,83 to 4,70 were identified. (Shown in Table 30). CSFs with an average of 3 and above are shown in gray in Table 31.

Among the CSFs in level 2, “Reduction of energy consumption/energy saving/efficiency,” “CSF EN 4- Reduction of electricity and gas consumption,” “CSF EN 18- Reducing contamination level (Formaldehyde level, smoke control, mold prevention, cleaning up contaminated water/land, environmental degradation, water/ noise pollutions minimization during execution)” are found as the most important CSFs in GREHB with highest mean values of 4,70.

Table 31: Mean values of CSFs at level 2 of proposed framework

CSFs- Level 2			Mean	Std. Deviation	N
1	**CSF EN 3**	Reduction of energy consumption/energy saving/efficiency	4,70	,465	46
2	**CSF EN 4**	Reduction of electricity and gas consumption	4,70	,465	46
3	**CSF EN 18**	Reducing contamination level (Formaldehyde level, smoke control, mould prevention, cleaning up contaminated water/land, environmental degradation, water/ noise pollutions minimization during execution)	4,70	,756	46
4	**CSF EN 7**	Reduction of water consumption/ conservation (Water metering, water leaking detection, water efficient fittings, water quality standard, rainwater harvesting, irrigation system and sewerage discharge etc.)	4,65	,566	46
5	**CSF EN 5**	Reduction of CO2 emission	4,61	,714	46
6	**CSF EN 19**	Waste management (Recycled content, carbon and hazardous substance management)	4,61	,714	46
7	**CSF EN 6**	Reduction of greenhouse gas emission	4,57	,720	46
8	**CSF EN 20**	Pollution control (Reduction of pollution agents, reduction of pollutant emissions, construction activity pollution)	4,57	,834	46
9	**CSF HUM 2**	Professional experience and competencies	4,52	,722	46
10	**CSF PRO 4**	Occupancy type (Hospital Operational status (24/7))	4,52	,722	46
11	**CSF EN 15**	Thermal comfort (Thermal design/modelling and zoning/control)	4,43	,655	46
12	**CSF EN 10**	Improved indoor environmental quality	4,39	,774	46
13	**CSF EN 12**	Indoor air quality (Ventilation (HVAC), odour, indoor air quality plan, natural ventilation, air purification)	4,39	,774	46
14	**CSF EN 17**	Green process design	4,39	,714	46
15	**CSF TECHNO 3**	Green technology capabilities (Carbon reduction, clean technologies, and materials, utilizing clean and renewable energy, use of environmentally friendly technology)	4,39	,649	46
16	**CSF MAN 1**	Sustainability strategy	4,39	,977	46
17	**CSF MAN 2**	Leadership (Organizing skills/ capacity of team leader)	4,35	,924	46
18	**CSF EN 1**	Environmental commitment and policy of all stakeholders (Protect and enhance ecological value)	4,26	,855	46
19	**CSF MAN 3**	Commitment of stakeholders	4,26	,801	46
20	**CSF MAN 6**	Performance evaluation/appraisal	4,26	,743	46
21	**CSF EN 9**	Accurate measurement and verification (M&V)	4,22	,786	46
22	**CSF MAN 9**	Quality	4,22	,786	46
23	**CSF EN 14**	Visual comfort (Daylighting, view out, glare control, artificial lighting, illumination level)	4,17	,973	46
24	**CSF TECHNO 5**	Renewable energy technologies	4,17	,643	46
25	**CSF MAN 13**	Life-cycle management	4,17	,877	46
26	**CSF TECHNI 3**	Quality of services	4,13	,619	46
27	**CSF EN 8**	Reduced consumption of material for reuse, recycle, and recovery of material	4,09	,939	46

Table 31: Mean values of CSFs at level 2 of proposed framework

CSF- Level 2			Mean	Std. Deviation	N
28	CSF PRO 3	Viable energy management program	4,09	,661	46
29	CSF POL 2	Regulations/legislation	4,04	,918	46
30	CSF PRO 6	Existing building evaluation	4,04	,868	46
31	CSF EC 4	Feasibility	4,00	,667	46
32	CSF EN 11	Building Design (Architectural) (Ergonomics, connection with outdoor, spatial arrangements, amount of space)	4,00	,989	46
33	CSF EC 2	Cost	3,96	,469	46
34	CSF EN 13	Acoustic comfort (Noise level, sound insulation, sound absorption, background noise)	3,96	1,053	46
35	CSF PRO 5	Existing facilities condition (Taking advantage of the building's existing properties)	3,91	1,071	46
36	CSF MAN 4	Project/Construction Management	3,87	,859	46
37	CSF PRO 8	Existing building environment and condition	3,87	,909	46
38	CSF PRO 9	End user-imposed restrictions	3,83	,877	46
39	CSF PRO 10	Owner expectation	3,83	,877	46
40	CSF EN 21	Material	3,78	,664	46
41	CSF POL 1	Policies	3,78	,841	46
42	CSF HUM 3	Communication/ cooperation/ collaboration/ coordination/ motivation of stakeholders	3,70	,866	46
43	CSF PRO 2	Project characteristics	3,70	,866	46
44	CSF PRO 1	Availability of resources (Adequate resource availability (finance, labor, plant, materials) and human, scarce resources to value retrofit)	3,65	,822	46
45	CSF MAN 10	HSE Management	3,61	,829	46
46	CSF EC 1	Economic environment	3,57	,834	46
47	CSF EN 2	In-use environmental performance/ during retrofit process	3,57	1,109	46
48	CSF EN 16	Advanced environmental management systems	3,57	1,025	46
49	CSF TECHNO 1	Material and equipment selection (Advanced machinery and equipment and materials)	3,57	,834	46
50	CSF TECHNO 2	Innovation (Innovative technologies and approaches, the innovation potential of suppliers, R&D and design capability of suppliers, innovation in design)	3,57	,779	46
51	CSF TECHNO 8	Collaborative design and automation	3,57	,981	46
52	CSF MAN 5	Project processes	3,57	,720	46
53	CSF POL 3	Incentives (Non-financial and financial)	3,57	1,109	46
54	CSF EC 3-	Financial incentives and funds	3,52	1,110	46
55	CSF TECHNI 4	Maintainability	3,52	,937	46
56	CSF TECHNI 2	Operational	3,48	,836	46
57	CSF TECHNO 4	Availability of technology	3,48	,722	46

Table 31: Mean values of CSFs at level 2 of proposed framework

CSF- Level 2			Mean	Std. Deviation	N
58	**CSF MAN 14**	Organizational structure/factors (Appropriate organizational structure and organizational maturity level)	3,48	,781	46
59	**CSF TECHNO 6**	Complexity and maturity of the technology	3,30	,756	46
60	**CSF TECHNI 1**	Installation/Equipment	3,26	,855	46
61	**CSF MAN 7**	Project risk and liability management (Risk planning)	3,17	,877	46
62	**CSF MAN 11**	Supplier management	3,17	,877	46
63	**CSF HUM 1**	Employee empowerment and motivation (Rewards and environmental training)	3,17	1,060	46
64	**CSF TECHNO 7**	Information technologies and computerization level	3,13	1,087	46
65	**CSF MAN 15**	Contract Management (Contractual arrangement and condition)	3,13	,859	46
66	**CSF SC 1**	Social	3,09	,985	46
67	**CSF MAN 8**	Change management	3,09	,985	46
68	**CSF MAN 16**	Dispute Management (Proper dispute resolution management)	3,09	,985	46
69	**CSF SC 2**	Cultural	3,04	1,010	46
70	**CSF MAN 12**	Information management	3,04	1,010	46
71	**CSF MAN 17**	Procurement and tendering	3,04	,965	46
72	**CSF PRO 7**	Public open space	2,83	1,060	46

Based on Level 3 in the proposed CSFs' Conceptual Framework for GREHB, the survey results show that 144 CSFs were identified with a mean value for each factor ranging from 2.48 to 4.78. (Shown in Table 32). CSFs with an average of 3 and above are shown in gray in Table 32. According to the data, the most important CSF for GREHB with a maximum ranking score 4.78 was found to be "CSF HUM 2.6- Experience of consultants" at Level 3 and "CSF EC 4.7- Who invests" was found to be the lowest important factor with the minimum ranking score 2.48.

Table 32: Mean values of CSFs at level 3 of proposed framework

CSFs- Level 3			Mean	Std. Deviation	N
1	**CSF HUM 2.6**	Experience of consultants	4,78	,513	46
2	**CSF HUM 2.1**	Awareness of green building technologies and environmental issues	4,74	,535	46
3	**CSF SC 1.4**	Improved occupants' health and wellbeing	4,70	,553	46
4	**CSF HUM 2.10**	Involvement of green building professional throughout the project lifecycle	4,70	,628	46
5	**CSF MAN 5.4**	Successful operation and maintenance	4,65	,640	46
6	**CSF MAN 5.3**	Successful commission and handover	4,61	,714	46
7	**CSF EC 2.3**	Operation & maintenance cost after making improvements	4,52	,781	46
8	**CSF HUM 2.17**	Professional/technical knowledge and expertise in GBTs	4,52	,658	46
9	**CSF EC 2.4**	Reduced life cycle cost	4,48	,836	46
10	**CSF HUM 2.7**	Experience of contractors	4,48	,781	46
11	**CSF HUM 2.11**	Green building skills/training and sustainability knowledge	4,48	,658	46
12	**CSF HUM 2.13**	Energy specialist	4,48	,722	46
13	**CSF POL 2.5**	Clear criteria and standards	4,48	,586	46
14	**CSF MAN 4.2**	Early involvement of project participants and the right project team	4,43	,720	46
15	**CSF HUM 2.8**	Experience of and design team	4,43	,779	46
16	**CSF SC 1.6**	Improved health and safety	4,39	,930	46
17	**CSF POL 2.4**	Existence of green building codes and regulations	4,39	,714	46
18	**CSF MAN 1.1**	Clear project goals/ objectives /scope/vision, and priorities of stakeholder	4,35	,971	46
19	**CSF MAN 3.3**	Top management support/commitment	4,35	,706	46
20	**CSF MAN 5.2**	Project brief and design	4,35	,706	46
21	**CSF MAN 6.3**	Effective consultation with key stakeholders	4,35	,766	46
22	**CSF HUM 2.5**	Competent project manager	4,35	,706	46
23	**CSF EC 2.5**	Payback period	4,30	,866	46
24	**CSF EN 21.3**	Use of environmentally friendly materials	4,30	,695	46
25	**CSF SC 1.14**	Accessibility	4,30	,813	46
26	**CSF MAN 3.5**	Project manager commitment	4,30	,695	46
27	**CSF SC 1.5**	Improved employee productivity and performance	4,26	,743	46
28	**CSF TECHNI 1.2-**	Energy performance (HVAC, lighting, lift etc.)	4,26	,743	46
29	**CSF POL 2.3**	Promote green innovation	4,26	,681	46
30	**CSF EN 17.1**	Ability to alter process and product for reducing the impact on natural resources	4,22	,841	46

Table 32: Mean values of CSFs at level 3 of proposed framework

CSFs- Level 3			Mean	Std. Deviation	N
31	**CSF MAN 6.1**	Review and improvement and feedback	4,22	,786	46
32	**CSF MAN 6.2**	Effective feedback and troubleshooting	4,22	,786	46
33	**CSF HUM 2.12**	Skilled workers and high-quality workmanship	4,22	,841	46
34	**CSF EC 2.2**	Initial capital cost of green buildings	4,17	,769	46
35	**CSF SC 2.2**	User behavior and demand analysis	4,17	,825	46
36	**CSF TECHNI 2.2**	Efficiency (optimum performance and energy saving, building envelope, mechanical and electrical systems, facilities interior and finishes)	4,17	,643	46
37	**CSF EN 17.2**	Life cycle analysis	4,13	,687	46
38	**CSF SC 1.3**	Improved occupant'/employees' satisfaction	4,09	,784	46
39	**CSF EN 21.5**	Use of renewable and recycled material with low environmental impact	4,04	,759	46
40	**CSF MAN 1.2**	Sustainable development strategy planning and control	4,04	,815	46
41	**CSF MAN 3.4**	Team commitment	4,04	,698	46
42	**CSF MAN 6.4**	Continuous performance measurement	4,04	,759	46
43	**CSF HUM 2.2**	Building owners retrofit expertise	4,04	,868	46
44	**CSF HUM 2.14**	Team competency, support, and experience	4,04	,698	46
45	**CSF HUM 2.18**	Retrofit readiness and new environmental technologies level of owners	4,04	,759	46
46	**CSF HUM 2.20**	Engineering expertise	4,04	,698	46
47	**CSF EC 2.1**	Investment cost (material, labor, commissioning fee)	4,00	,843	46
48	**CSF SC 2.1**	HHF's sustainability behavior	4,00	,843	46
49	**CSF HUM 2.4**	Stakeholders experience/competency and know-how	4,00	,894	46
50	**CSF MAN 9.1**	Design, construction	3,96	,815	46
51	**CSF PRO 2.1**	Project type and size	3,96	,868	46
52	**CSF EN 21.1**	Avoid using harmful materials	3,91	,725	46
53	**CSF EN 21.2**	Availability of green material	3,91	,784	46
54	**CSF EN 21.4**	Responsible source of material	3,91	,784	46
55	**CSF MAN 3.1**	Client commitment	3,91	,890	46
56	**CSF MAN 9.3**	Quality testing	3,91	,784	46
57	**CSF MAN 9.4**	Met plant quality standards	3,91	,725	46
58	**CSF PRO 2.4**	Project complexity	3,91	,725	46
59	**CSF MAN 4.6**	The detailed plan for design and construction	3,87	,859	46
60	**CSF MAN 3.2**	Willingness to make change	3,83	,877	46

Table 32: Mean values of CSFs at level 3 of proposed framework

CSFs- Level 3			Mean	Std. Deviation	N
61	**CSF MAN 4.3**	Planning, monitoring and control	3,83	,926	46
62	**CSF MAN 4.5**	Good planning and scheduling methods	3,83	,825	46
63	**CSF HUM 2.19**	Teamwork technical skills and background	3,83	,769	46
64	**CSF HUM 3.1**	Stakeholder integration (Well integrated team)	3,83	,825	46
65	**CSF EN 21.6**	Efficient use of material (over its life cycle)	3,78	,892	46
66	**CSF EC 3.5**	Adequate financial resources	3,74	,801	46
67	**CSF MAN 11.4**	Product responsibility	3,74	,612	46
68	**CSF MAN 4.4**	Time, risk, cost, quality	3,70	,756	46
69	**CSF MAN 6.5**	Deficiency of performance data about retrofitted existing buildings	3,70	,866	46
70	**CSF POL 1.5**	Investment and involvement from the government and private companies in the green building movement	3,70	1,093	46
71	**CSF EN 16.3**	Environmental protection measures in project design	3,65	,706	46
72	**CSF MAN 4.8**	Realistic expectations and objectives	3,65	,875	46
73	**CSF MAN 11.5**	Green purchasing capabilities	3,65	,822	46
74	**CSF HUM 2.3**	Client competency	3,65	,766	46
75	**CSF HUM 3.2**	Good relationships among participants, trust and partnership	3,65	,924	46
76	**CSF POL 1.1**	Policy support	3,65	,766	46
77	**CSF EC 3.1**	Project financing/financial status	3,61	,977	46
78	**CSF SC 1.15**	Building amenities	3,61	,881	46
79	**CSF MAN 4.1**	Innovative management approaches	3,61	,774	46
80	**CSF EC 4.1**	Return on predictable ROI investment needs	3,57	,886	46
81	**CSF MAN 10.2**	Effective health and safety protocols	3,57	,834	46
82	**CSF MAN 11.1**	Supplier quality	3,57	,720	46
83	**CSF MAN 17.2**	The integrated and collaborative delivery process	3,57	,981	46
84	**CSF EN 16.2**	Effective environmental compliance and auditing program	3,52	,983	46
85	**CSF TECHNI 2.2**	Durability	3,52	,722	46
86	**CSF HUM 2.16**	Owners-clients awareness on sustainable development	3,52	1,070	46
87	**CSF POL 1.4**	Government program and policies	3,52	1,110	46
88	**CSF PRO 2.2**	Building age	3,52	1,188	46
89	**CSF EC 4.6**	Value for money	3,48	,888	46
90	**CSF MAN 10.1**	Overall health and safety measures	3,48	,888	46

Table 32: Mean values of CSFs at level 3 of proposed framework

CSFs- Level 3			Mean	Std. Deviation	N
91	**CSF MAN 17.1**	Investigation and adaptation of the correct approach	3,48	,937	46
92	**CSF HUM 2.9**	Experience sharing and education	3,48	1,150	46
93	**CSF TECHNI 3.2**	Technical and management innovation	3,43	,981	46
94	**CSF MAN 4.7**	Reduce ambiguity and maximize stability	3,43	,779	46
95	**CSF MAN 5.1**	Agile project processes	3,43	,720	46
96	**CSF HUM 3.4**	Clear written lines of responsibility	3,43	1,068	46
97	**CSF POL 2.1**	Financing and task policy	3,43	1,068	46
98	**CSF EC 4.2**	Profitability	3,39	,829	46
99	**CSF SC 1.2**	Public green awareness and behavior	3,39	1,145	46
100	**CSF SC 1.8**	Management with social responsibilities	3,39	,881	46
101	**CSF TECHNI 2.1**	Reliability	3,39	,829	46
102	**CSF POL 2.2**	Market regulatory environment	3,39	1,022	46
103	**CSF SC 2.5**	Use of local materials and technique	3,35	,875	46
104	**CSF HUM 2.15**	Organizing capacity and task orientation	3,35	,971	46
105	**CSF PRO 2.3**	Site and location limitation	3,35	,924	46
106	**CSF SC 1.7**	Improved social reputation	3,30	,963	46
107	**CSF TECHNI 2.3**	Flexibility and adaptability	3,30	,963	46
108	**CSF POL 1.2**	Enacting required policies in supporting sustainability principles in construction projects by governmental and professional bodies	3,30	1,008	46
109	**CSF TECHNI 1.1**	Compatibility	3,26	1,042	46
110	**CSF TECHNO 4.1**	Technology support	3,22	,786	46
111	**CSF MAN 9.2**	Implementation of vigorous procedures	3,17	,926	46
112	**CSF MAN 11.2**	Delivery reliability and on time reliability	3,17	,926	46
113	**CSF SC 1.1**	Community engagement	3,13	1,166	46
114	**CSF SC 2.4**	Design compatible with cultural values	3,13	,957	46
115	**CSF TECHNI 3.1**	Reducing technical uncertainty	3,13	,859	46
116	**CSF HUM 3.3**	Partnering agreements and factors (Partners previously work together with previous collaboration experience)	3,13	,957	46
117	**CSF POL 1.3**	Socio-political environment	3,13	1,310	46
118	**CSF EC 3.2**	Available financing market and financial schema	3,09	1,112	46
119	**CSF SC 1.9**	Public utility and comfort	3,04	1,095	46
120	**CSF SC 2.3**	Cultural tradition	3,04	1,053	46

Table 32: Mean values of CSFs at level 3 of proposed framework

CSFs- Level 3			Mean	Std. Deviation	N
121	**CSF TECHNO 4.2**	Leveraging the technology	3,04	,815	46
122	**CSF EC 3.4**	Innovative financing methods	3,00	1,155	46
123	**CSF MAN 17.3**	Procurement standard	3,00	,989	46
124	**CSF EC 1.3**	Fluctuation of the price of green materials	2,96	,918	46
125	**CSF TECHNO 4.3**	Technological capability of suppliers	2,96	1,010	46
126	**CSF EC 4.4**	Impact of the project on land value and local economy	2,87	1,343	46
127	**CSF EC 3.3**	Awareness of financing institutes	2,83	1,253	46
128	**CSF EC 4.5**	Financial capability of suppliers	2,83	1,217	46
129	**CSF EC 3.7**	Subsidies/tax reduction	2,78	1,228	46
130	**CSF EN 16.1**	Existence of environmental certifications of suppliers	2,78	,941	46
131	**CSF EN 17.3**	Design for disassembly (DFD)	2,78	,987	46
132	**CSF SC 1.12**	Penalties and punishments for unethical behavior	2,78	1,191	46
133	**CSF MAN 8.2**	Interruptions in operations	2,78	1,073	46
134	**CSF MAN 9.5**	Installation time	2,78	1,114	46
135	**CSF SC 1.11**	Equity labour sources and non-discrimination	2,74	1,237	46
136	**CSF MAN 8.1**	Minimal scope change	2,74	,953	46
137	**CSF MAN 11.3**	The geographical proximity of suppliers	2,74	,999	46
138	**CSF EC 3.6**	Ease of receiving uniform tax and regulatory incentives	2,70	1,133	46
139	**CSF EC 1.1**	Interest rate	2,65	1,286	46
140	**CSF EC 1.2**	Foreign exchange rate	2,61	1,358	46
141	**CSF EC 4.3**	Profit distribution among stakeholders	2,61	,881	46
142	**CSF SC 1.10**	Maintaining long-term relationships and alliances	2,61	1,022	46
143	**CSF SC 1.13**	Flexible working arrangements	2,57	1,109	46
144	**CSF EC 4.7**	Who invests	2,48	,983	46

Also, in terms of main dimensions at Level 3 in the proposed framework, the mean value for each CSFs was analyzed. Only the first 5 CSFs with an average of 3 and above are included in the analysis. (Shown in Appendix D).

According to the data, the most important CSF for environmental dimension with a maximum ranking score 4.30 was found to be “CSF EN 21.3- Use of environmentally friendly materials” at Level 3. Based on human dimension the most significant CSF with a maximum ranking score 4.78 was found to be “CSF HUM 2.6- Experience of consultants.” In terms of economic dimension, the most critical CSF is found as “CSF EC 2.3- Operation & maintenance cost after making improvements” with a mean value of 4.52. For managerial/organizational dimension, “CSF MAN 5.4- Successful operation and maintenance” is found as the most significant CSF with the mean value of 4.65. The most critical CSF for project dimension is identified as “CSF PRO 2.1- Project type and size” with a maximum ranking score 3.96. “CSF POL 2.5- Clear criteria and standards” is identified as the most important CSF for political dimension at Level 3 with a mean score of 4,48. For the technical dimension, “CSF TECHNI 1.2- Energy performance (HVAC, lighting, lift etc.)” is found as the most critical CSF with the maximum ranking score 4.26. The most significant CSF for the technological dimension is defined as “CSF TECHNO 4.1-Technology support” with a mean value of 3.22. For the last dimension, which is socio-cultural, the most critical CSF with the maximum ranking score 4.70 identified as to be “CSF SC 1.4- Improved occupants' health and wellbeing.”

6.4. Comments and Suggestions of the Respondents

In the last part of the questionnaire, participants were asked to identify the CSFs that they found necessary in GREHB in addition to given CSFs in the survey.

The remarks of the respondents illustrated that:

- use of environmentally friendly materials,
- awareness of green building technologies and environmental issues,
- innovative management approaches,
- project schedule,
- feasibility analysis,
- project, human, and environmental-related CSFs should also be considered.

Also, they emphasized that green retrofit actions have to support patient health and wellbeing.

6.5. Final Conceptual CSFs Framework for Green Retrofitting of Existing Healthcare Buildings

Based on the results of the survey conducted in this thesis, the determined factors that gained 3 "Important" points and more in the Likert scale in green retrofitting have been accepted as CSFs. In this context, the factors below 3 points were removed from the conceptual framework. The finalized version of the conceptual framework is shown in Figure 17. For the finalized version of the conceptual framework, all levels at the proposed framework are shown in detail in Appendix E.

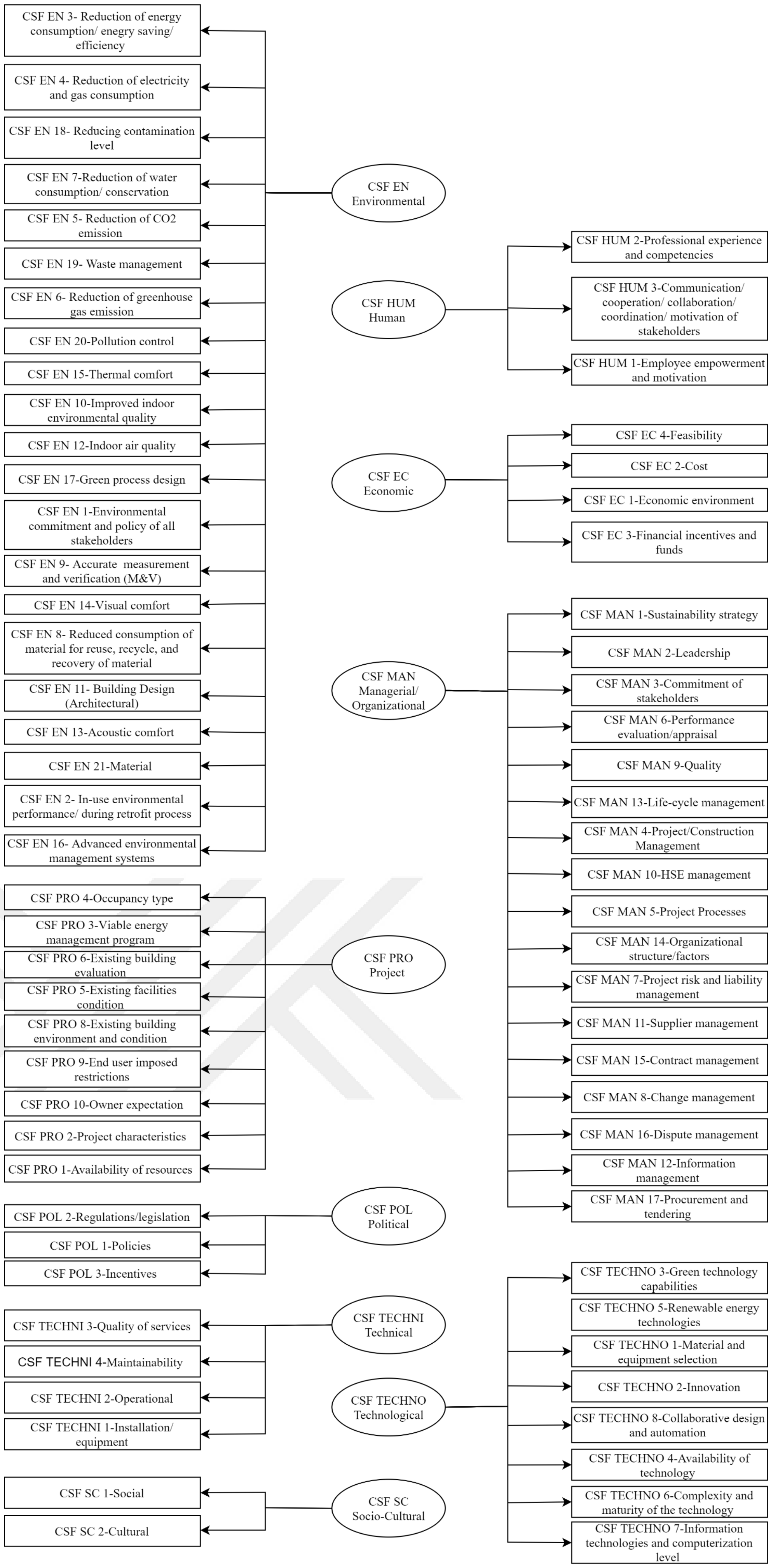


Figure 17: Final conceptual CSFs framework for GREHB

6.6. Validation of the Framework

Validation Survey Statistical Procedures and Analysis

The results of the validation survey were analyzed and evaluated with the help of IBM SPSS Statistic 20 and MS Office 2018 Excel program. Descriptive and inferential statistics such as arithmetic mean, mode, median, standard deviation, and coefficient of variation were used to evaluate the data obtained from the questionnaire.

In addition to descriptive statistics, a series of statistical analysis methods such as Cronbach Alphas criteria were used. All results of the validation study were tested with 95% confidence, $p = 0.05$ significance level (p), and bidirectional.

The Cronbach Alpha Coefficient is used to assess the reliability levels of the questionnaire responses in this study. This statistical procedure investigates whether the problem on the scale represents a homogeneous structure. The closer the calculated Cronbach's Alpha Coefficient is to 1, the more reliable it can be assumed and to have a one-dimensional structure [257].

Respondents Information of Validation Survey

The validation survey was conducted with eight professionals; 4 professionals are academics and the other 4 practitioners are green building experts. The survey which includes the final framework in Figure 17 was sent to the respondents. Table 33 shows the respondents information of the validation survey.

Table 33: Respondents information of validation survey

Respondents	Experience	Profession
R1	18	Academic
R2	17	Academic
R3	13	Academic
R4	12	Academic
R5	8	Green Building Expert
R6	9	Green Building Expert
R7	6	Green Building Expert
R8	4	Green Building Expert

Validation Results from Questionnaire Survey

The evaluation of the developed CSFs framework for GREHB, whether they are valid, usable, relevant, and comprehensive, or not illustrates that the mean values of these criteria were ranked higher than "3=Important". The survey results show that the mean values of the identified four validation criteria are ranging from 4,00 to 4,13. Thus, it is seen that professionals and practitioners evaluated the CSFs framework for GREHB as valid, usable, relevant, and comprehensive. Table 34 represents the descriptive statistics of the validation survey.

Table 34: The descriptive statistics of validation survey

	N	Minimum	Maximum	Sum	Mean	Std. Deviation	Variance
Valid	8	3	5	32	4,00	,756	,571
Usable	8	3	5	33	4,13	,641	,411
Relevant	8	3	5	32	4,00	,535	,286
Comprehensive	8	3	5	33	4,13	,991	,982
Valid N (listwise)	8						

The results of the reliability statistics performed by applying Cronbach's Alpha test for validation criteria of CSFs framework for GREHB are shown in Table 35. The reliability of the scale is interpreted as follows depending on the alpha (α) coefficient; $.00 \leq \alpha < 0.40$ (not reliable), $0.40 \leq \alpha < 0.60$ (low reliability), $0.60 \leq \alpha < 0.80$ (quite reliable) and $0.80 \leq \alpha < 1.00$ (highly reliable) [258]. The overall reliability value for all validation criteria was found as Cronbach’s Alpha coefficient (0.773). The scale consisting of validation criteria was $0.60 \leq 0.7073 < 0.80$ and it was “quite reliable."

Table 35: Reliability statistics of validation survey

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
,773	,774	4

As a result, in this section, the evaluations received from academics and green building experts are positive for the developed CSFs framework for GREHB. Evaluations of validation survey results are reliable, and the criteria for validity were above the average. These outcomes provided substantial evidence of the validity and reliability of the developed framework.

VII. DISCUSSION

In this study, the review of the literature revealed that there is a lack of comprehensive research about the CSFs for GREHB specifically. Therefore, similar studies related with the determination of CSFs of green retrofitting of existing and new buildings were discussed with a special reference to the findings of this thesis.

As stated previously, in terms of the main dimensions at level 1 the most important CSFs for GREHB were scattered among *Environmental, Human Related, Economic, Managerial, Project Related, Political, Technical, Technological, and Socio-Cultural Dimensions.* (Shown in Table 28).

Low et al., [17] classified CSFs as *pre-project-related factors, project management-related factors, client-related factors, project team-related factors, and external factors* in the context of greening existing buildings in Singapore. The respondents of the study of Low et al., [17] have ranked CSFs among the aforementioned factor categories.

The most important 10 CSFs for greening existing buildings according to Low et al., [17]; *"building owners' involvement, legislation, cost management, responsiveness of building owner, effective project planning and* *control (plans and schedule), clear project scope and priorities of stakeholders, minimize disturbance to existing occupants, quality management, competence of project manager, and space management"* are focused in the context of this thesis' findings.

The most significant 10 CSFs at level 2 were found as "r*eduction of energy consumption/energy saving/efficiency, reduction of electricity and gas consumption, reducing contamination level, reduction of water consumption/ conservation, reduction of* CO_2 *emission, waste management, reduction of GHG, pollution control, professional experience and competencies, and occupancy type (hospital operational status (24/7))"* in this thesis. The ranking of CSFs at level 2 are given in Table 30.

The comparison of the results of the Low et al., [17]'s study and this thesis demonstrates that while CSFs related to the environmental dimension come to the forefront in this thesis findings, in the Low et al., [17]'s study, CSFs associated with the client related CSFs came to the fore.

In terms of main dimensions and main greening considerations, these studies draw similar conclusions. For example, the study conducted by Low et al., [17] has similar results in terms of main dimensions at level 1 Managerial/ Organizational, Human Related, and Projects Related factors in this thesis. However, the comparison of the CSFs at level 2 shows that both Low et al., [17] 's study and this thesis differ from each other. In terms of CSFs at level 2, it is significant that only competency and occupancy related factors have similar conclusions. Therefore, the differences of the most significant ten CSFs at level 2 can be derived from the diversity of the respondents' profile, location of the conducted studies, cultural differences and also, from the main considerations of the studies.

Shen et al., [206] conducted another CSFs study related to green buildings to determine critical patterns and the overall picture of the green building sector in Thailand. The most critical main CSFs dimensions in the study of Shen et al., [206] were found to be the *"competence of project participants, integration of project team, technical and management innovation, external environment, project characteristics."* According to the results of Shen et al., [206]'s study and this thesis, similarities in terms of the main CSFs dimensions have been found.

The results of the study of Shen et al., [206] underline that the most important 10 CSFs are as follows: *competence of green building (GB) consultant, competence of designer, competence of project team, competence of contractor, economic environment, competence of project manager, project team motivation, support from senior decision makers, communication among participants, and socio-political environment.* In fact, the comparison of Shen et al., [206]'s study and this thesis shows that in terms of the CSFs at level 2 in this thesis, the results of these two studies do not have similar results. While CSFs related to the environmental dimension gain importance in this thesis, in Shen et al., [206]'s study, CSFs associated with the competence of project participants dimension gained importance. However, it can be said that based on the critical factor of professional experience and competencies in this thesis, the most significant CSFs of the study of Shen et al., [206] mainly share similar perspectives.

Different from the CSFs studies related to retrofitting, Zainol et al., [19] conducted a study associated with operations and maintenance problems in green buildings. The results of the study show that *technical issues* are the most crucial factor that leads to green building O&M problems in Malaysia. Respectively, *managerial, social and cultural, political and legal, environmental and biological factors* follow the *technical issues* in terms of the status of criticality. Although in Zainol et al., [19]'s study and this thesis, the most important critical factor dimension varies, all identified dimensions are similar in both studies. Consideration of *environmental, managerial, political, technical, and socio-cultural* perspectives have been seen as common significant factors in achieving successful projects in Zainol et al., [19]'s study and this thesis. Also, this thesis includes all the main dimensions defined in Zainol et al., [19]'s study.

The results of the Zainol et al., [19]'s study showed that the most important 10 CSFs include *design problems, cultural practices, third party vandalism, political & government restrictions and standards, contractual defects, environmental effects, biological effects, construction related defects, building characteristic* and *maintenance related defects.*

In terms of the most critical CSFs, the respondents of both Zainol et al., [19]'s study and this thesis have different conclusions. While, Zainol et al., [19] found that "*design problem, cultural practices, third party vandalism, political & government restrictions and standards, contractual defects, environmental effects, biological effects, construction related defects*" are the most important factors, *"reduction of energy consumption/energy saving/efficiency, reduction of electricity and gas consumption, reducing contamination level"* were determined the most important CSFs at level 2 by respondents of this thesis. The most important factor in this thesis is mainly related to the environmental dimension. Also, in the study conducted by Zainol et al., [19], the respondents of the study argue that the environmental effects factor is one of the most significant factors. From the view of an environmental perspective, it can be said that both of these studies have environmental concerns in order to conduct successful projects. Consequently, it can be stated that differences exist between the survey results of both critical factor studies which are related to the context and primary consideration of these studies. While the study of Zainol et al., [19] is mainly based on critical factors for operation and maintenance of green buildings, this thesis is based on the identification of CSFs for GREHB.

To conclude, it can be noted that differences between survey results of studies related to the identification of the most critical CSFs can arise from the location of the conducted studies, different cultures, and main considerations of the studies by means of retrofitting of an existing building or constructing a new building. Table 36 represents the comparison of these three studies' results.

Table 36: The comparison of the results of existing studies and this thesis

References	Low et al., 2014 [17]	Shen et al., 2017 [206]	Zainol et al., 2014 [19]	Ergin, 2019
Context	CSFs for retrofitting new and existing buildings	CSFs for green buildings	CSFs for operations and maintenance of green buildings	CSFs for GREHB
Location	Singapore	Thailand	Malaysia	Turkey
Respondents	Directors/vice presidents, senior managers, architects, engineers, project managers, other related positions from 31 respondents	Professional consultants and designers (architects and engineers) from 38 respondents	Academics, professionals from 30 respondents	Academics, architects and green building experts from 46 respondents
Identified main CSFs dimensions	1- Pre-project-related factors 2- Project management-related factors 3- Client-related factors 4- Project team-related factors 5- External factors	1- Competence of project participants 2- Integration of project team 3- Technical and management innovation 4- External environment 5- Project characteristics	1- Technical Defects 2- Managerial Problems 3- Social & Cultural Problems 4- Political & Legal Factors 5- Environmental & Biological Effects	1- Environmental 2- Economic 3- Socio-Cultural 4- Technical 5- Technological 6- Managerial/Organizational 7- Human Related 8- Political 9-Project Related
The most important CSFs	1- Building owners' involvement 2-Legislation 3-Cost management 4-Responsiveness of building owner 5-Effective project planning and control (plans and schedule) 6-Clear project scope and priorities of stakeholders 7-Minimize disturbance to existing occupants 8-Quality management 9-Competence of project manager 10-Space management	1- Competence of GB consultant 2- Competence of designer 3- Competence of project team 4- Competence of contractor 5- Economic environment 6- Competence of project manager 7- Project team motivation 8- Support from senior decision makers 9- Communication among participants 10- Socio-political environment	1- Design problems 2- Cultural practices 3- Third party vandalism 4- Political & government restrictions & standards 5- Contractual defects 6- Environmental effects 7- Biological effects 8- Construction related defects 9- Building characteristic 10- Maintenance related defects	1- Reduction of energy consumption/energy saving/efficiency 2- Reduction of electricity and gas consumption 3- Reducing contamination level 4- Reduction of water consumption/ conservation 5- Reduction of CO_2 emission 6- Waste management 7- Reduction of GHG 8- Pollution control 9-Professional experience and competencies 10- Occupancy type (Hospital Operational status (24/7))

In terms of the CSFs at level 3, which include more focused evaluations, the most important 10 CSFs are respectively: *Experience of consultants, Awareness of green building technologies and environmental issues, Improved occupants' health and wellbeing, Involvement of green building professional throughout the project lifecycle, Successful operation and maintenance, Successful commission and handover, Operation & maintenance cost after making improvements, Professional/technical knowledge and expertise in GBTs (Green Building Technologies), Reduced life cycle cost, Experience of contractors.*

According to the most important 10 CSFs in level 3, identified factors are related to the *human, socio-cultural, managerial/ organizational, and economic dimensions.* Especially, *human related* factors at level 3 including *experience of consultants, awareness of green building technologies and environmental issues, the involvement of a green building professional throughout the project lifecycle, professional/technical knowledge and expertise in GBTs*, *experience of contractors* constitute half of the most important factors identified at Level 3. Although the *human* dimension ranked as the second most important main dimension at level 1, CSFs of the *human* dimension ranked as the most critical factor at level 3.

Furthermore, another critical point is *that improved occupants' health and wellbeing,* which is related to the *socio-cultural* factor, is ranked as the third important subfactor at Level 3, but contrary to Level 3, the *socio-cultural* factor is ranked as the least important factor at Level 1. Contrary to this result, the factor of *improving the well-being of employees* is ranked as the least critical driver in the study of Low et al., [17]. The results of Low et al., [17]'s study and this thesis do not have parallel findings in terms of health and wellbeing. It can be stated that differences between the survey results of both studies related to the identification of the most critical CSFs subfactors can arise from location of the conducted studies, different cultures, and main considerations of the studies. The primary consideration of the conducted study by Low et al., [17] is new and existing buildings, but this thesis mainly considers existing healthcare buildings. Particularly from a health perspective, the main motivation for the existence of health care buildings is to increase the health and welfare of patients and staff [152]. Similarly, improving health and safety is one of the vital actors in successful green retrofitting implementations [214]. Thus, it can be emphasized that the ranking of improved occupants' health and wellbeing is a supportive result of the GREHB.

Moreover, based on main dimension CSFs at level 3 in the proposed framework the most significant 5 CSFs were ranked in Appendix D. If the mean values of CSFs are under 3 points, they were not included in the tables.

Environmental dimension includes critical CSFs which are the *use of environmentally friendly materials, ability to alter process and product for reducing the impact on natural resources, life cycle analysis, use of renewable and recycled material with low environmental impact, avoid using harmful material.*

Experience of consultants, awareness of green building technologies and environmental issues, involvement of green building professional throughout the project lifecycle, professional/technical knowledge and expertise in GBTs, and *experience of contractors* are the most significant human dimension CSFs at level 3. Compared to the results of Low et al., [17]'s study, although the first 5 CSFs are differing in terms of professional experience and competencies perspective Low et al., [17]'s study and these findings have similar concerns.

In terms of economic dimension, *operation & maintenance cost after making improvements, reduced life cycle cost, payback period, initial capital cost of green buildings, investment cost (material, labor, commissioning fee)* are found as the most important CSFs at level 3.

Managerial/organizational dimension includes significant 5 CSFs which are *successful operation and maintenance, successful commission and handover, early involvement of project participants and the right project team, clear project goals/ objectives /scope/vision, and priorities of stakeholder, top management support/commitment.* Compared to the results of Low et al., [17]'s study, *clear project goals/ objectives /scope/vision, and priorities of stakeholder* and *top management support* are also significant CSFs for Low et al., [17]'s study.

Project dimension CSFs' at level 3 consists of only 4 CSFs with a mean value higher the 3 points. They are *project type and size, project complexity, building age, site and location limitation.* Similarly, the conducted study by Shen et al., [206] demonstrated that *type of the project* and *project size* which are related to project characteristics found as one of the significant CSFs. These two CSFs are not included the table 36 because the table contains only the first 10 CSFs for each level. In terms of project dimension CSFs, the comparison of Shen et al., [206]'s study and these findings show that these two studies have common perspectives.

In terms of political dimension*, clear criteria and standards, existence of green building codes and regulations, promote green innovation, investment and involvement from the government and private companies in the green building movement, policy support* are the most significant CSFs at level 3.

The most important technical dimension CSFs at level 3 respectively are *energy performance (HVAC, lighting, lift etc.), efficiency (optimum performance and energy saving, building envelope, mechanical and electrical systems, facilities interior and finishes), technical and management innovation, durability, technical and management innovation, reliability*. Also, Shen et al., [206] emphasized the technical *and managerial innovation as an important CSF.*

Technological dimension has only 2 CSFs at level 3 since only these two CSFs ranked as 3 points and above. The most significant CSFs are technology *support and leveraging the technology.*

The last dimension is socio-cultural which includes *improved occupants' health and wellbeing, improved health and safety, accessibility, improved employee productivity and performance, user behavior and demand analysis as the most important CSFs.*

To make overall remarks, the results of the study demonstrated that as the levels of CSFs change, the most critical elements at each level differ according to the main considerations. In terms of the main dimensions at level 1, *environmental* dimension was ranked by the respondents of this thesis as the most critical factor that leads to successful green retrofitting in healthcare buildings. It can be said that the respondents of this thesis mainly have an environmental perspective, and they can have a professional background about environmental and ecological issues. Thus, this shows that the professional background of the respondents of this thesis can have a significant impact on the identification of the most significant CSFs for this study.

The comparison of existing studies and this thesis shows that although the main dimensions are similar at level 1, the CSFs differ when compared at level 2. Thus, this comparison demonstrates that the results of existing studies are differentiating in CSF categories. The main reasons that might lead to these differences are the primary considerations and objectives (context), the location differences, cultural differences, and professional backgrounds of the respondents of the studies. Although this thesis has similar conclusions with existing studies, it has diversifying aspects in terms of green retrofitting and healthcare and has supportive results such as Occupancy *Type (Hospital Operational status (24/7))* and *Improved Occupants' Health and Wellbeing* which are the main concerns of healthcare buildings. Healthcare buildings provide care 24 hours and 7 days to patients while providing services to visitors, staff and employees. Therefore, healthcare buildings should be considered as different from other types of buildings [14]. So, while providing care and services, improvement of health and wellbeing is critical to successful retrofitting implementation for existing healthcare buildings. As a result, this study provided critical outcomes for the GREHB.

CHAPTER VIII

VIII. CONCLUSION

The research demonstrated in this thesis investigates the CSFs for GREHB. Green retrofitting is one critical solution to mitigate the impacts of existing healthcare buildings on the environment. Identification of CSFs for a successful green retrofitting implementation eliminates the difficulties caused by the lack of CSFs for greening existing healthcare buildings. This thesis is an essential stage that can lead architects, green building experts, and academic studies towards successful GREHB.

According to the review of the literature, there is a lack of comprehensive study about the identification of CSFs for green retrofitting with a particular focus on healthcare buildings. Thus, this thesis starts with the examination of exiting healthcare buildings, their contribution towards sustainability, and green retrofitting studies. The thesis continues with the survey and statistical analysis of the conducted survey to identify the CSFs. The results of this survey demonstrated that *"CSF EN- Environmental"* is found the most important main dimension to GREHB. *CSF EN- Environmental* factor is followed by *CSF HUM- Human Related, CSF EC-Economic, CSF MAN-Managerial/Organizational, CSF-PRO-Project-related, CSF POL- Political, CSF TECHNI-Technical, CSF TECHNO-*

Technological, and CSF SC- Socio-Cultural respectively. Furthermore, in terms of the determined subfactors, *"CSF EN 3- Reduction of energy consumption/energy saving/efficiency," "CSF EN 4- Reduction of electricity and gas consumption," "CSF EN 18- Reducing contamination level (Formaldehyde level, smoke control, mold prevention, cleaning up contaminated water/land, environmental degradation, water/ noise pollutions minimization during execution)"* are found as the most important critical subfactors in GREHB. As a result of the conducted survey, a conceptual CSFs framework for GREHB has been finalized. Furthermore, through the validation of the survey, the reliability and validity of this framework were proved.

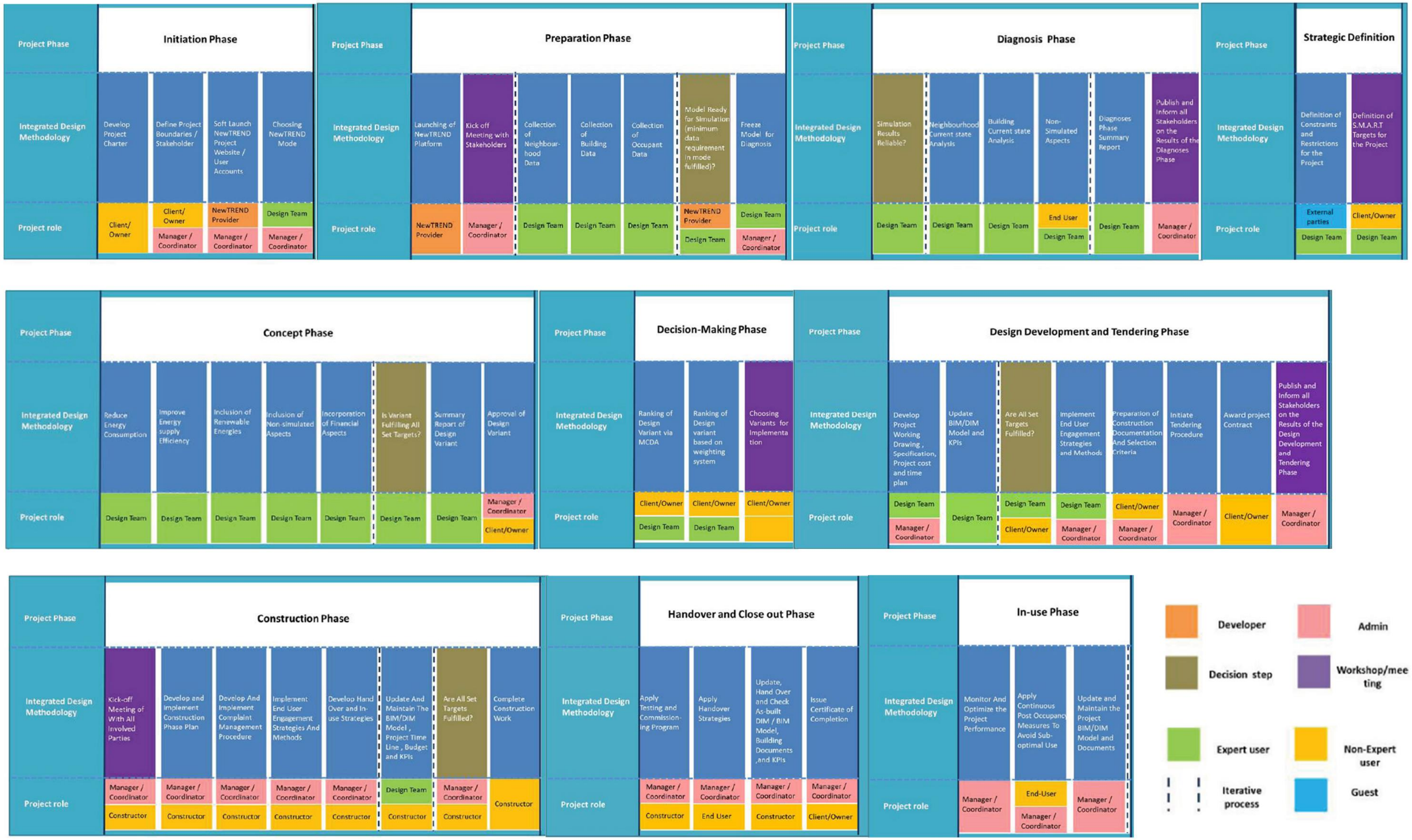
Notably, from a healthcare perspective, the results of this thesis are found supportive. Enhancing healthcare buildings' environmental performance by reduction of energy consumption, electricity and gas consumption, and contamination level is significant not only for building level but also vital for occupants of healthcare buildings. The improvement of building performance also contributes to improving the health and wellbeing of occupants; it is a valid result from a healthcare perspective. Another significant result from a healthcare perspective is the occupancy type because the 24/7 usage of healthcare buildings is critical during the retrofitting process and in order to realize a successful project.

Healthcare is both a complex and sensitive industry, so healthcare providers, academics, green buildings experts, and also architects need to be aware of the significance of the GREHB. The identification of the CSFs for green retrofitting for existing healthcare buildings and the development of a comprehensive CSFs framework is a critical approach to achieve successful green retrofitting projects. The developed conceptual CSFs framework for GREHB addresses all critical factors required to implement successful green retrofitting. This set of CSFs can be used as potential inputs, which can be considered as a possible checklist for practitioners and stakeholders when conducting a green retrofitting of a healthcare project in the preparation phase. In this way, the sustainability performance of healthcare buildings can be improved.

All in all, this thesis will be constructive for implementations of green retrofitting projects based on healthcare buildings and for future research on the subject.

APPENDIX A

Appendix A: Integrated retrofit design methodology for NewTrend



APPENDIX B

Appendix B: The questionnaire

Critical Success Factors for Green Retrofitting of Existing Healthcare Buildings

To provide environmental protection, sustainability has become a major concern for all sectors around the world. The healthcare sector is one of these important sectors. With the awareness of sustainability in the health sector, “green hospital” practices come to the forefront to improve the sustainability of healthcare buildings and to reduce the environmental impact of the buildings.

The aim of this study is to investigate the Critical Success Factors (CSFs) for green retrofitting of existing healthcare buildings. The research is carried out within the scope of a master thesis prepared in Özyeğin University Graduate Program in Architecture. All information, opinions and suggestions shared by the participants will be meticulously maintained. The information obtained will help to understand the important factors that will be successful in green retrofitting of existing healthcare buildings and to develop a conceptual framework within the scope of the thesis

It is crucial to submit the questionnaire by **10 July 2019** at the latest. The questionnaire s included the factors obtained from the literature review. For each factor, there are boxes for indicating the importance. Select the order of importance that suits you best for the answer to each question. Thank you very much for your time and cooperation.

Thank you very much for your time and cooperation.

For any questions and comments, please contact us with the following e-mail and telephone information.

Kind Regards,

Aslıhan ERGİN

Özyeğin University

Dr. Işılay TEKÇE

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Appendix B: The questionnaire (Continued)

* 1. Job

* 2. Experience year

* 3. CSF EC

	Not Important	Slightly Important	Important	Very Important	Extremely Important
CSF EC 1- Economic environment	○	○	○	○	○
CSF EC 1.1- Interest rate	○	○	○	○	○
CSF EC 1.2- Foreign exchange rate	○	○	○	○	○
CSF EC 1.3- Fluctuation of the price of green materials	○	○	○	○	○
CSF EC 2- Cost	○	○	○	○	○
CSF EC 2.1- Investment cost (material, labor, commissioning fee)	○	○	○	○	○
CSF EC 2.2- Initial capital cost of green buildings	○	○	○	○	○
CSF EC 2.3- Operation & maintanance cost after making improvements	○	○	○	○	○

Appendix B: The questionnaire (Continued)

	Not Important	Slightly Important	Important	Very Important	Extremely Important
CSF EC 2.4- Reduced life cycle cost	○	○	○	○	○
CSF EC 2.5- Payback period	○	○	○	○	○
CSF EC 3- Financial incentives and funds	○	○	○	○	○
CSF EC 3.1- Project financing/financial status	○	○	○	○	○
CSF EC 3.2- Available financing market and financial schema	○	○	○	○	○
CSF EC 3.3- Awarenesses of financing institutes	○	○	○	○	○
CSF EC 3.4- Innovative financing methods	○	○	○	○	○
CSF EC 3.5- Adequate financial resources	○	○	○	○	○
CSF EC 3.6- Ease of receiving uniform tax and regulatory incentives	○	○	○	○	○
CSF EC 3.7- Subsidies/tax reduction	○	○	○	○	○
CSF EC 4- Feasibility	○	○	○	○	○

Appendix B: The questionnaire (Continued)

	Not Important	Slightly Important	Important	Very Important	Extremely Important
CSF EC 4.1- Return on predictable ROI investment needs	◯	◯	◯	◯	◯
CSF EC 4.2- Profitability	◯	◯	◯	◯	◯
CSF EC 4.3- Profit distribution among stakeholders	◯	◯	◯	◯	◯
CSF EC 4.4- Impact of the project on land value and local economy	◯	◯	◯	◯	◯
CSF EC 4.5- Financial capability of suppliers	◯	◯	◯	◯	◯
CSF EC 4.6- Value for money	◯	◯	◯	◯	◯
CSF EC 4.7- Who invests	◯	◯	◯	◯	◯

* 4. CSF EN

	Not Improtant	Slightly Important	Important	Very Important	Extremely Important
CSF EN 1- Environmental commitment and policy of all stakeholders (Protect and enhance ecological value)	◯	◯	◯	◯	◯
CSF EN 2- In-use environmental performance/ during retrofit process	◯	◯	◯	◯	◯

Appendix B: The questionnaire (Continued)

	Not Improtant	Slightly Important	Important	Very Important	Extremely Important
CSF EN 3- Reduction of energy consumption/enegry saving/efficiency	○	○	○	○	○
CSF EN 4- Reduction of electricity and gas consumption	○	○	○	○	○
CSF EN 5- Reduction of CO2 emission	○	○	○	○	○
CSF EN 6- Reduction of greenhouse gas emission	○	○	○	○	○
CSF EN 7- Reduction of water consumption/ conservation (Water metering, water leaking detection, water efficient fittings, water quality standard, rainwater harvesting, irrigation system and sewerage discharge etc.)	○	○	○	○	○
CSF EN 8- Reduced consumption of material for reuse, recycle, and recovery of material	○	○	○	○	○
CSF EN 9- Accurate measurement and verification (M&V)	○	○	○	○	○
CSF EN 10- Improved indoor environmental quality	○	○	○	○	○

Appendix B: The questionnaire (Continued)

	Not Improtant	Slightly Important	Important	Very Important	Extremely Important
CSF EN 11- Building Design (Architectural) (Ergonomics, connection with outdoor, spatial arrengements, amount of space)	○	○	○	○	○
CSF EN 12- Indoor air quality (Ventilation (HVAC) , odour, indoor air quality plan, natural ventilation, air purification)	○	○	○	○	○
CSF EN 13- Acoustic comfort (Noise level, sound insulation, sound absorption, background noise)	○	○	○	○	○
CSF EN 14- Visual comfort (Daylighting, view out, glare control, artificial lighting, illumination level)	○	○	○	○	○
CSF EN 15- Thermal comfort (Thermal design/modelling and zoning/control)	○	○	○	○	○
CSF EN 16- Advanced environmental management systems	○	○	○	○	○
CSF EN 16.1- Existence of environmental certifications of suppliers	○	○	○	○	○

Appendix B: The questionnaire (Continued)

	Not Improtant	Slightly Important	Important	Very Important	Extremely Important
CSF EN 16.2- Effective environmental compliance and auditing program	◯	◯	◯	◯	◯
CSF EN 16.3- Environmental protection measures in project design	◯	◯	◯	◯	◯
CSF EN 17- Green process design	◯	◯	◯	◯	◯
CSF EN 17.1- Ability to alter process and product for reducing the impact on natural resources	◯	◯	◯	◯	◯
CSF EN 17.2- Life cycle analysis	◯	◯	◯	◯	◯
CSF EN 17.3- Design for disassembly (DFD)	◯	◯	◯	◯	◯
CSF EN 18- Reducing contamination level (Formaldehyde level, smoke control, mould prevention, cleaning up contaminated water/land, environmental degradation, water/ noise pollutions minimisation during execution)	◯	◯	◯	◯	◯
CSF EN 19- Waste management (Recycled content, carbon and hazardous substance management)	◯	◯	◯	◯	◯

Appendix B: The questionnaire (Continued)

	Not Improtant	Slightly Important	Important	Very Important	Extremely Important
CSF EN 20- Pollution control (Reduction of pollution agents, reduction of polluant emissions, construction activity pollution)	◯	◯	◯	◯	◯
CSF EN 21- Material	◯	◯	◯	◯	◯
CSF EN 21.1- Avoid using harmful materials	◯	◯	◯	◯	◯
CSF EN 21.2- Availability of green material	◯	◯	◯	◯	◯
CSF EN 21.3- Use of environmentally friendly materials	◯	◯	◯	◯	◯
CSF EN 21.4- Responsible source of material	◯	◯	◯	◯	◯
CSF EN 21.5- Use of renewable and recycled material with low environmental impact	◯	◯	◯	◯	◯
CSF EN 21.6- Efficient use of material (over its life cycle)	◯	◯	◯	◯	◯

* 5. CSF SC

	Not Improtant	Slightly Important	Important	Very Important	Extremely Important
CSF SC 1- Social	◯	◯	◯	◯	◯
CSF SC 1.1- Community engagement	◯	◯	◯	◯	◯
CSF SC 1.2- Public green awareness and behavior	◯	◯	◯	◯	◯

Appendix B: The questionnaire (Continued)

	Not Improtant	Slightly Important	Important	Very Important	Extremely Important
CSF SC 1.3- Improved occupant'/employees' satisfaction	○	○	○	○	○
CSF SC 1.4- Improved occupants' health and wellbeing	○	○	○	○	○
CSF SC 1.5- Improved employee productivity and performance	○	○	○	○	○
CSF SC 1.6- Improved health and safety	○	○	○	○	○
CSF SC 1.7- Improved social reputation	○	○	○	○	○
CSF SC 1.8- Management with social responsibilities	○	○	○	○	○
CSF SC 1.9- Public utility and comfort	○	○	○	○	○
CSF SC 1.10- Maintaining long-term relationships and alliances	○	○	○	○	○
CSF SC 1.11- Equity labour sources and non-discrimination	○	○	○	○	○
CSF SC 1.12- Penalties and punishments for unethical behavior	○	○	○	○	○
CSF SC 1.13- Flexible working arrangements	○	○	○	○	○
CSF SC 1.14- Accessibility	○	○	○	○	○

Appendix B: The questionnaire (Continued)

	Not Improtant	Slightly Important	Important	Very Important	Extremely Important
CSF SC 1.15- Building amenities	◯	◯	◯	◯	◯
CSF SC 2- Cultural	◯	◯	◯	◯	◯
CSF SC 2.1- HHF's sustainability behavior	◯	◯	◯	◯	◯
CSF SC 2.2- User behavior and demand analysis	◯	◯	◯	◯	◯
CSF SC 2.3- Cultural tradition	◯	◯	◯	◯	◯
CSF SC 2.4- Design compatible with cultural values	◯	◯	◯	◯	◯
CSF SC 2.5- Use of local materials and technique	◯	◯	◯	◯	◯

Appendix B: The questionnaire (Continued)

* 7. CSF TECHNO

	Not Improtant	Slightly Important	Important	Very Important	Extremely Important
CSF TECHNO 1- Material and equipment selection (Advanced machinery and equipment and materials)	○	○	○	○	○
CSF TECHNO 2- Innovation (Innovative technologies and approaches, the innovation potential of suppliers, R&D and design capability of suppliers, innovation in design)	○	○	○	○	○
CSF TECHNO 3- Green technology capabilities (Carbon reduction, clean technologies, and materials, utilizing clean and renewable energy, use of environmentally friendly technology)	○	○	○	○	○
CSF TECHNO 4- Availability of technology	○	○	○	○	○
CSF TECHNO 4.1- Technology support	○	○	○	○	○
CSF TECHNO 4.2- Leveraging the technology	○	○	○	○	○

Appendix B: The questionnaire (Continued)

	Not Improtant	Slightly Important	Important	Very Important	Extremely Important
CSF TECHNO 4.3- Technological capability of suppliers	○	○	○	○	○
CSF TECHNO 5- Renewable energy technologies	○	○	○	○	○
CSF TECHNO 6- Complexity and maturity of the technology	○	○	○	○	○
CSF TECHNO 7- Information technologies and computerization level	○	○	○	○	○
CSF TECHNO 8- Collaborative design and automation	○	○	○	○	○

* 8. CSF MAN

	Not Improtant	Slightly Important	Important	Very Important	Extremely Important
CSF MAN 1- Sustainability strategy	○	○	○	○	○
CSF MAN 1.1- Clear project goals/ objectives /scope/vision, and priorities of stakeholder	○	○	○	○	○
CSF MAN 1.2- Sustainable development strategy planning and control	○	○	○	○	○
CSF MAN 2- Leadership (Organizing skills/ capacity of team leader)	○	○	○	○	○

Appendix B: The questionnaire (Continued)

	Not Improtant	Slightly Important	Important	Very Important	Extremely Important
CSF MAN 3- Commitment of stakeholders	◯	◯	◯	◯	◯
CSF MAN 3.1- Client commitment	◯	◯	◯	◯	◯
CSF MAN 3.2- Willingness to make change	◯	◯	◯	◯	◯
CSF MAN 3.3- Top management support/commitment	◯	◯	◯	◯	◯
CSF MAN 3.4- Team commitment	◯	◯	◯	◯	◯
CSF MAN 3.5- Project manager commitment	◯	◯	◯	◯	◯
CSF MAN 4- Project/Construction Management	◯	◯	◯	◯	◯
CSF MAN 4.1- Innovative management approaches	◯	◯	◯	◯	◯
CSF MAN 4.2- Early involvement of project participants and the right project team	◯	◯	◯	◯	◯
CSF MAN 4.3- Planning, monitoring and control	◯	◯	◯	◯	◯
CSF MAN 4.4- Time, risk, cost, quality	◯	◯	◯	◯	◯
CSF MAN 4.5- Good planning and scheduling methods	◯	◯	◯	◯	◯
CSF MAN 4.6- The detailed plan for design and construction	◯	◯	◯	◯	◯
CSF MAN 4.7- Reduce ambiguity and maximize stability	◯	◯	◯	◯	◯

Appendix B: The questionnaire (Continued)

	Not Improtant	Slightly Important	Important	Very Important	Extremely Important
CSF MAN 4.8- Realistic expectations and objectives	○	○	○	○	○
CSF MAN 5- Project processes	○	○	○	○	○
CSF MAN 5.1- Agile project processes	○	○	○	○	○
CSF MAN 5.2- Project brief and design	○	○	○	○	○
CSF MAN 5.3- Successful commission and handover	○	○	○	○	○
CSF MAN 5.4- Successful operation and maintenance	○	○	○	○	○
CSF MAN 6- Performance evaluation/appraisal	○	○	○	○	○
CSF MAN 6.1- Review and improvement and feedback	○	○	○	○	○
CSF MAN 6.2- Effective feedback and troubleshooting	○	○	○	○	○
CSF MAN 6.3- Effective consultation with key stakeholders	○	○	○	○	○
CSF MAN 6.4- Continuous performance measurement	○	○	○	○	○
CSF MAN 6.5- Deficiency of performance data about retrofitted existing buildings	○	○	○	○	○
CSF MAN 7- Project risk and liability management (Risk planning)	○	○	○	○	○

Appendix B: The questionnaire (Continued)

	Not Improtant	Slightly Important	Important	Very Important	Extremely Important
CSF MAN 8- Change management	◯	◯	◯	◯	◯
CSF MAN 8.1- Minimal scope change	◯	◯	◯	◯	◯
CSF MAN 8.2- Interruptions in operations	◯	◯	◯	◯	◯
CSF MAN 9- Quality	◯	◯	◯	◯	◯
CSF MAN 9.1- Design, construction	◯	◯	◯	◯	◯
CSF MAN 9.2- Implementation of vigorous procedures	◯	◯	◯	◯	◯
CSF MAN 9.3- Quality testing	◯	◯	◯	◯	◯
CSF MAN 9.4- Met plant quality standards	◯	◯	◯	◯	◯
CSF MAN 9.5- Installation time	◯	◯	◯	◯	◯
CSF MAN 10- HSE Management	◯	◯	◯	◯	◯
CSF MAN 10.1- Overall health and safety measures	◯	◯	◯	◯	◯
CSF MAN 10.2- Effective health and safety protocols	◯	◯	◯	◯	◯
CSF MAN 11-Supplier management	◯	◯	◯	◯	◯
CSF MAN 11.1- Supplier quality	◯	◯	◯	◯	◯
CSF MAN 11.2- Delivery reliability and on time reliability	◯	◯	◯	◯	◯

Appendix B: The questionnaire (Continued)

	Not Improtant	Slightly Important	Important	Very Important	Extremely Important
CSF MAN 11.3- The geographical proximity of suppliers	◯	◯	◯	◯	◯
CSF MAN 11.4- Product responsibility	◯	◯	◯	◯	◯
CSF MAN 11.5- Green purchasing capabilities	◯	◯	◯	◯	◯
CSF MAN 12- Information management	◯	◯	◯	◯	◯
CSF MAN 13- Life-cycle management	◯	◯	◯	◯	◯
CSF MAN 14- Organizational structure/factors (Appropriate organizational structure and organizational maturity level)	◯	◯	◯	◯	◯
CSF MAN 15- Contract Management (Contractual arrangement and condition)	◯	◯	◯	◯	◯
CSF MAN 16- Dispute Management (Proper dispute resolution management)	◯	◯	◯	◯	◯
CSF MAN 17- Procurement and tendering	◯	◯	◯	◯	◯
CSF MAN 17.1- Investigation and adaptation of the correct approach	◯	◯	◯	◯	◯
CSF MAN 17.2- The integrated and collaborative delivery process	◯	◯	◯	◯	◯

Appendix B: The questionnaire (Continued)

	Not Improtant	Slightly Important	Important	Very Important	Extremely Important
CSF MAN 17.3- Procurement standard	○	○	○	○	○

* 9. CSF HUM

	Not Improtant	Slightly Important	Important	Very Important	Extremely Important
CSF HUM 1- Employee empowerment and motivation (Rewards and environmental training)	○	○	○	○	○
CSF HUM 2- Professional experience and competencies	○	○	○	○	○
CSF HUM 2.1- Awarenesses of green building technologies and environmental issues	○	○	○	○	○
CSF HUM 2.2- Building owners retrofit expertize	○	○	○	○	○
CSF HUM 2.3- Client competency	○	○	○	○	○
CSF HUM 2.4- Stakeholders experience/competency and know-how	○	○	○	○	○
CSF HUM 2.5- Competent project manager	○	○	○	○	○
CSF HUM 2.6- Experience of consultants	○	○	○	○	○
CSF HUM 2.7- Experience of contractors	○	○	○	○	○
CSF HUM 2.8- Experience of and design team	○	○	○	○	○
CSF HUM 2.9- Experience sharing and education	○	○	○	○	○
CSF HUM 2.10- Involvement of green building professional throughout the project lifecycle	○	○	○	○	○

Appendix B: The questionnaire (Continued)

	Not Improtant	Slightly Important	Important	Very Important	Extremely Important
CSF HUM 2.11- Green building skills/training and sustainability knowledge	◯	◯	◯	◯	◯
CSF HUM 2.12- Skilled workers and high-quality workmanship	◯	◯	◯	◯	◯
CSF HUM 2.13- Energy specialist	◯	◯	◯	◯	◯
CSF HUM 2.14- Team competency, support, and experience	◯	◯	◯	◯	◯
CSF HUM 2.15- Organizing capacity and task orientation	◯	◯	◯	◯	◯
CSF HUM 2.16- Owners-clients awareness on sustainable development	◯	◯	◯	◯	◯
CSF HUM 2.17- Professional/technical knowledge and expertise in GBTs	◯	◯	◯	◯	◯
CSF HUM 2.18- Retrofit readiness and new environmental technologies level of owners	◯	◯	◯	◯	◯
CSF HUM 2.19- Teamwork technical skills and background	◯	◯	◯	◯	◯
CSF HUM 2.20- Engineering expertise	◯	◯	◯	◯	◯
CSF HUM 3- Communication/ cooperation/ collaboration/ coordination/ motivation of stakeholders	◯	◯	◯	◯	◯
CSF HUM 3.1- Stakeholder integration (Well integrated team)	◯	◯	◯	◯	◯
CSF HUM 3.2- Good relationships among participants, trust and partnership	◯	◯	◯	◯	◯

Appendix B: The questionnaire (Continued)

	Not Improtant	Slightly Important	Important	Very Important	Extremely Important
CSF HUM 3.3- Partnering agreements and factors (Partners previously work together with previous collaboration experience)	◯	◯	◯	◯	◯
CSF HUM 3.4- Clear written lines of responsibility	◯	◯	◯	◯	◯

Appendix B: The questionnaire (Continued)

* 10. CSF POL

	Not Improtant	Slightly Important	Important	Very Important	Extremely Important
CSF POL 1- Policies	◯	◯	◯	◯	◯
CSF POL 1.1- Policy support	◯	◯	◯	◯	◯
CSF POL 1.2- Enacting required policies in supporting sustainability principles in construction projects by governmental and professional bodies	◯	◯	◯	◯	◯
CSF POL 1.3- Socio-political environment	◯	◯	◯	◯	◯
CSF POL 1.4- Government program and policies	◯	◯	◯	◯	◯
CSF POL 1.5- Investment and involvement from the government and private companies in the green building movement	◯	◯	◯	◯	◯
CSF POL 2- Regulations/legislation	◯	◯	◯	◯	◯
CSF POL 2.1- Financing and task policy	◯	◯	◯	◯	◯
CSF POL 2.2- Market regulatory environment	◯	◯	◯	◯	◯
CSF POL 2.3- Promote green innovation	◯	◯	◯	◯	◯
CSF POL 2.4- Existence of green building codes and regulations	◯	◯	◯	◯	◯
CSF POL 2.5- Clear criteria and standards	◯	◯	◯	◯	◯
CSF POL 3- Incentives (Non financial and financial)	◯	◯	◯	◯	◯

Appendix B: The questionnaire (Continued)

* 11. CSF PRO

	Not Improtant	Slightly Important	Important	Very Important	Extremely Important
CSF PRO 1- Availability of resources (Adequate resource availability (finance, labor, plant, materials) and human, scarce resources to value retrofit)	○	○	○	○	○
CSF PRO 2- Project characteristics	○	○	○	○	○
CSF PRO 2.1- Project type and size	○	○	○	○	○
CSF PRO 2.2- Building age	○	○	○	○	○
CSF PRO 2.3- Site and location limitation	○	○	○	○	○
CSF PRO 2.4- Project complexity	○	○	○	○	○
CSF PRO 3- Viable energy management program	○	○	○	○	○
CSF PRO 4- Occupancy type (Hospital Operational status (24/7))	○	○	○	○	○

Appendix B: The questionnaire (Continued)

	Not Improtant	Slightly Important	Important	Very Important	Extremely Important
CSF PRO 5- Existing facilities condition (Taking advantage of the building's existing properties)	◯	◯	◯	◯	◯
CSF PRO 6- Existing building evaluation	◯	◯	◯	◯	◯
CSF PRO 7- Public open space	◯	◯	◯	◯	◯
CSF PRO 8- Existing building environment and condition	◯	◯	◯	◯	◯
CSF PRO 9- End user imposed restrictions	◯	◯	◯	◯	◯
CSF PRO 10- Owner expectation	◯	◯	◯	◯	◯

12. CSF ALL

	Not Important	Slightly Important	Important	Very Important	Extremely Important
CSF EC - Economic	◯	◯	◯	◯	◯
CSF EN- Environmental	◯	◯	◯	◯	◯
CSF SC- Socio- Cultural	◯	◯	◯	◯	◯
CSF TECHNI- Technical	◯	◯	◯	◯	◯
CSF TECHNO- Technological	◯	◯	◯	◯	◯
CSF MAN- Managerial/Organizational	◯	◯	◯	◯	◯
CSF HUM Human Related	◯	◯	◯	◯	◯
CSF POL- Political	◯	◯	◯	◯	◯
CSF PRO- Project Related	◯	◯	◯	◯	◯

Appendix B.1: The questionnaire (Continued)

13. Please, write the factors that you find important, except for the success factors described above in the green retrofitting of existing healthcare.

APPENDIX C

Appendix C: The permission of ethical committee

ÖZYEĞİN ÜNİVERSİTESİ

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İNSAN ARAŞTIRMALARI ETİK KURULU
TOPLANTI TUTANAĞI

TOPLANTI SAYISI	:	**2019/7**
TOPLANTI TARİHİ	:	24.06.2019
TOPLANTI YERİ	:	Özyeğin Üniversitesi
KATILANLAR	:	Prof. Dr. G. Canan Ergin Dr. Sibel Oktar Thomas Dr. Ceren Hayran Şanlı

ARAŞTIRMA ETİK KURULU
PROJE BAŞVURU FORMU (FORM A)

Projenin Adı	Mevcut hastane yapılarının yeşil hastaneye dönüştürülmesinde kritik başarı faktörlerinin incelenmesi
Proje Yürütücüsü	Aslıhan Ergin ve Dr. Işılay TEKÇE- Tez Danışmanı
Proje Yürütücüsünün İletişim Bilgileri	E-mail: aslihan.ergin@ozu.edu.tr Tel: 05367183888
Projeye Katılan Diğer Araştırmacılar	-
Projenin Süresi (Başlangıç ve Bitiş Tarihi)	26.06.2019- 10.07.2019
Araştırmanın Amacı ve Özeti	Çevresel endişelerin artması ile, sürdürülebilirlik kavramı günümüzde birçok endüstri tarafından önemli bir konu haline gelmiştir. Sürdürülebilirliğin ana hedeflerinden biri iç hava kalitesini iyileştirerek kullanıcıların sağlık ve refahını arttırmaktır. Kullanıcıların sağlığı ve refahı göz önüne alındığında sağlık sektörünün sürdürülebilirlikte önemli bir rolü olduğu gözükmektedir. Bu bağlamda sağlık yapılarında sürdürülebilirliği sağlamak ve yapıların çevreye etkilerini azaltmak adına "yeşil hastane" uygulamaları ön plana çıkmaktadır. Fakat yeni yeşil hastanelerin yapılması mevcut hastanelerin çevreye olan zararlı etkilerini azaltmamaktadır. Bu durum hastanelerin temel hedefi olan sağlık ve refahı sağlama durumu ile ters düşmektedir. Bu yüzden, bu araştırma, mevcut sağlık binalarının operasyonlarının sürdürülebilir bir şekilde yürütülmesini sağlayacak mevcut sağlık binalarının yeşil güçlendirme için Kritik Başarı Faktörlerini (CSF) araştırmayı ve bu bağlamda bir çerçeve geliştirmeyi amaçlamaktadır.
Etik ve Veri Yönetim Planı	Bu çalışma için akademisyenler ve yeşil bina uygulaması yapan firmalardan oluşan 30 katılımcıya anket ile mevcut bir hastane

CHS. [signature] [signature]

Appendix C: The permission of ethical committee (Continued)

ÖZYEĞİN ÜNİVERSİTESİ

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	binasını yeşil bir hastane dönüştürmek için gerekli kritik başarı faktörleri Likert ölçeğinde önem ağırlığı sorularak yapılacaktır. a) Katılımcıların gizliliği esas alınacaktır, anket sorularında katılımcılara kişisel (ad, soyad vb.) bilgiler sorulmayacaktır. Katılımcılara sadece mesleği ve kaç yıldır çalıştığı sorulacaktır. Diğer sorular literatür taramasından elde edilen kritik başarı faktörlerinin önem ağırlığının sorulduğu sorulardır. Katılımcılara anket soruları gönderilecektir. b) Araştırmada elde edilen bilgiler Aslıhan Ergin tarafından kayıt altına tutulacak ve katılımcıların cevapları önem ağırlığı analizi yapılarak genel bir sonuç elde edilecektir.
Katılımcı Özellikleri	Bu çalışma temel olarak yeşil hastane binaları üzerinde durduğu için yeşil binalar ve yeşil hastaneler ve mevcut binaların yeşil binaya dönüştürülmesi konularında çalışmalar yapmış tecrübe sahibi profesyonellere e-posta ile gönderilecektir. Anket çalışması, akademisyenler ve yeşil bina uygulaması yapan firmalardan oluşan 30 katılımcıya gönderilecektir.
Araştırma Bütçesi ve Kaynakları	Bütçe gerektirecek bir araştırma değildir. Araştırmada herhangi bir kaynaktan destek alınmayacaktır.

Özyeğin Üniversitesi *Mimarlık ve Tasarım Fakültesi* öğretim üyesi *Dr. Işılay Tekçe* ve tez öğrencisi *Aslıhan Ergin* 'in yürütücülüğünü üstleneceği "*Mevcut hastane yapılarının yeşil hastaneye dönüştürülmesinde kritik başarı faktörlerinin incelenmesi.*" başlıklı proje değerlendirilmiştir.

Proje etik açısından uygun bulunmuştur.	☒
Projenin etik açısından geliştirilmesi gerekmektedir.	☐
Proje etik açısından uygun bulunmamıştır.	☐

İmzalar:

Prof. Dr. G. Canan Ergin Etik Kurulu Başkanı	Dr. Sibel Oktar Thomas Etik Kurulu Üyesi	Dr. Ceren Hayran Şanlı Etik Kurulu Üyesi

APPENDIX D

Appendix D1: Mean values of the environmental dimension CSFs at level 3 of the proposed framework

	CSFs - Level 3		Mean	Std. Deviation	N
1	**CSF EN 21.3**	Use of environmentally friendly materials	4,30	,695	46
2	**CSF EN 17.1**	Ability to alter process and product for reducing the impact on natural resources	4,22	,841	46
3	**CSF EN 17.2**	Life cycle analysis	4,13	,687	46
4	**CSF EN 21.5**	Use of renewable and recycled material with low environmental impact	4,04	,759	46
5	**CSF EN 21.1**	Avoid using harmful materials	3,91	,725	46

Appendix D2: Mean values of the human dimension CSFs at level 3 of the proposed framework

	CSFs - Level 3		Mean	Std. Deviation	N
1	**CSF HUM 2.6**	Experience of consultants	4,78	,513	46
2	**CSF HUM 2.1**	Awareness of green building technologies and environmental issues	4,74	,535	46
3	**CSF HUM 2.10**	Involvement of green building professional throughout the project lifecycle	4,70	,628	46
4	**CSF HUM 2.17**	Professional/technical knowledge and expertise in GBTs	4,52	,658	46
5	**CSF HUM 2.7**	Experience of contractors	4,48	,781	46

Appendix D3: Mean values of the economic dimension CSFs at level 3 of the proposed framework

	CSFs - Level 3		Mean	Std. Deviation	N
1	**CSF EC 2.3**	Operation & maintenance cost after making improvements	4,52	,781	46
2	**CSF EC 2.4**	Reduced life cycle cost	4,48	,836	46
3	**CSF EC 2.5**	Payback period	4,30	,866	46
4	**CSF EC 2.2**	Initial capital cost of green buildings	4,17	,769	46
5	**CSF EC 2.1**	Investment cost (material, labor, commissioning fee)	4,00	,843	46

Appendix D4: Mean values of the managerial/organizational dimension CSFs at level 3 of the proposed framework

CSFs - Level 3			Mean	Std. Deviation	N
1	**CSF MAN 5.4**	Successful operation and maintenance	4,65	,640	46
2	**CSF MAN 5.3**	Successful commission and handover	4,61	,714	46
3	**CSF MAN 4.2**	Early involvement of project participants and the right project team	4,43	,720	46
4	**CSF MAN 1.1**	Clear project goals/ objectives /scope/vision, and priorities of stakeholder	4,35	,971	46
5	**CSF MAN 3.3**	Top management support/commitment	4,35	,706	46

Appendix D5: Mean values of the project dimension CSFs at level 3 of the proposed framework

CSFs - Level 3			Mean	Std. Deviation	N
1	**CSF PRO 2.1**	Project type and size	3,96	,868	46
2	**CSF PRO 2.4**	Project complexity	3,91	,725	46
3	**CSF PRO 2.2**	Building age	3,52	1,188	46
4	**CSF PRO 2.3**	Site and location limitation	3,35	,924	46

Appendix D6: Mean values of the political dimension CSFs at level 3 of the proposed framework

CSFs - Level 3			Mean	Std. Deviation	N
1	**CSF POL 2.5**	Clear criteria and standards	4,48	,586	46
2	**CSF POL 2.4**	Existence of green building codes and regulations	4,39	,714	46
3	**CSF POL 2.3**	Promote green innovation	4,26	,681	46
4	**CSF POL 1.5**	Investment and involvement from the government and private companies in the green building movement	3,70	1,093	46
5	**CSF POL 1.1**	Policy support	3,65	,766	46

Appendix D7: Mean values of the technical dimension CSFs at level 3 of the proposed framework

CSFs - Level 3			Mean	Std. Deviation	N
1	**CSF TECHNI 1.2**	Energy performance (HVAC, lighting, lift etc.)	4,26	,743	46
2	**CSF TECHNI 2.2**	Efficiency (optimum performance and energy saving, building envelope, mechanical and electrical systems, facilities interior and finishes)	4,17	,643	46
3	**CSF TECHNI 2.2**	Durability	3,52	,722	46
4	**CSF TECHNI 3.2**	Technical and management innovation	3,43	,981	46
5	**CSF TECHNI 2.1**	Reliability	3,39	,829	46

Appendix D8: Mean values of the technological dimension CSFs at level 3 of the proposed framework

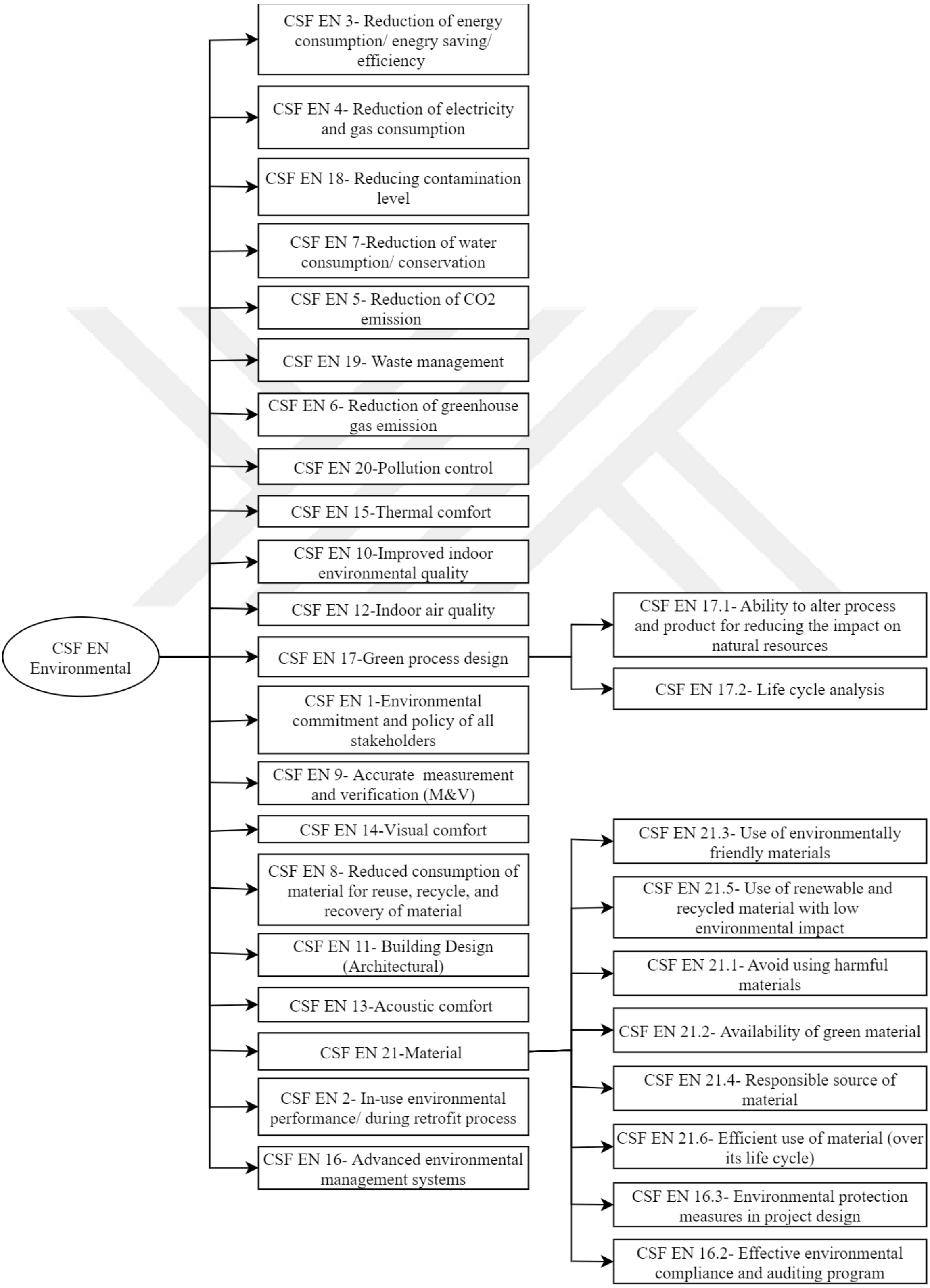
CSFs - Level 3			Mean	Std. Deviation	N
1	**CSF TECHNO 4.1**	Technology support	3,22	,786	46
2	**CSF TECHNO 4.2**	Leveraging the technology	3,04	,815	46

Appendix D9: Mean values of the socio-cultural dimension CSFs at level 3 of the proposed framework

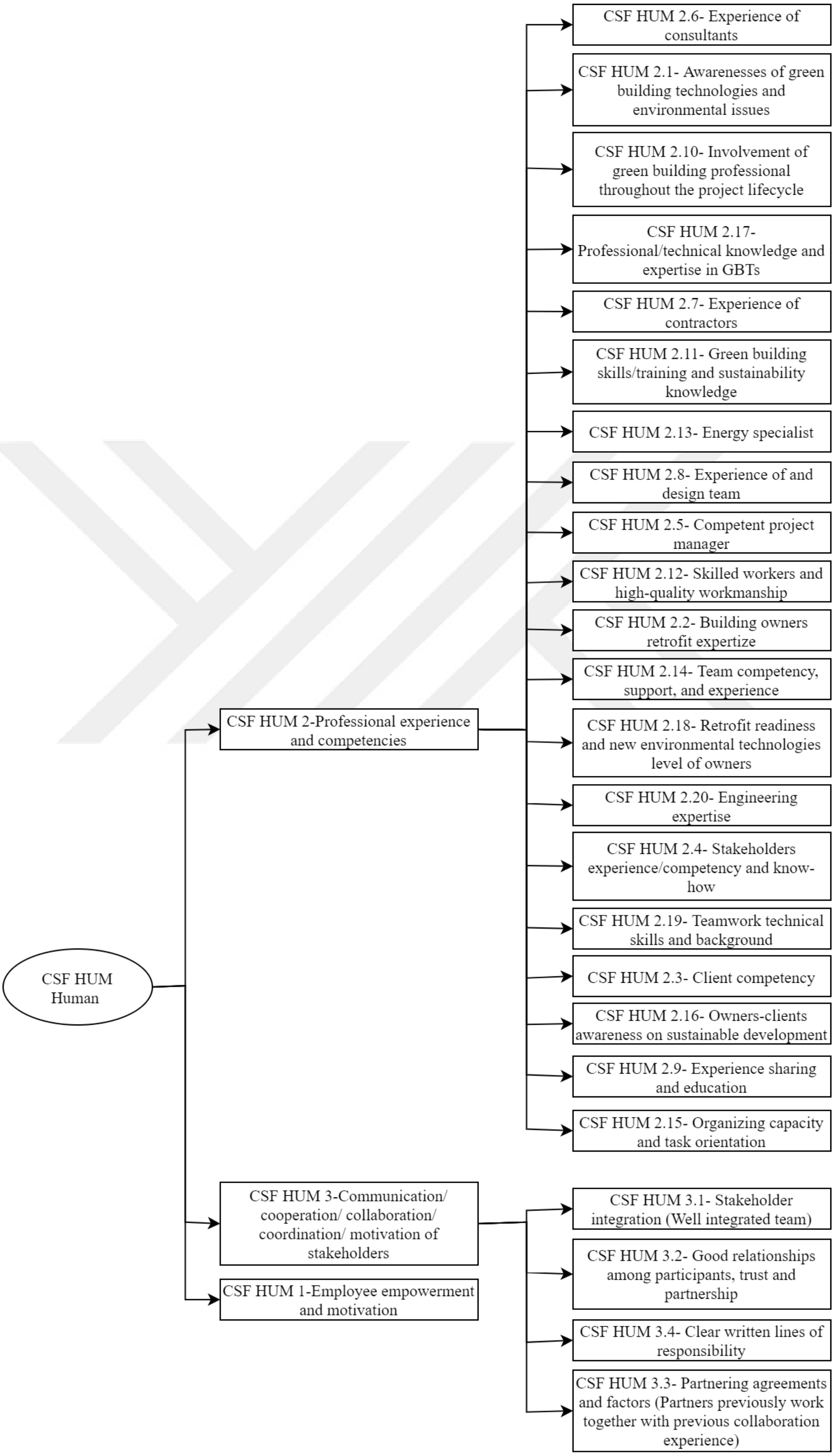
CSFs - Level 3			Mean	Std. Deviation	N
1	**CSF SC 1.4**	Improved occupants' health and wellbeing	4,70	,553	46
2	**CSF SC 1.6**	Improved health and safety	4,39	,930	46
3	**CSF SC 1.14**	Accessibility	4,30	,813	46
4	**CSF SC 1.5**	Improved employee productivity and performance	4,26	,743	46
5	**CSF SC 2.2**	User behavior and demand analysis	4,17	,825	46

APPENDIX E

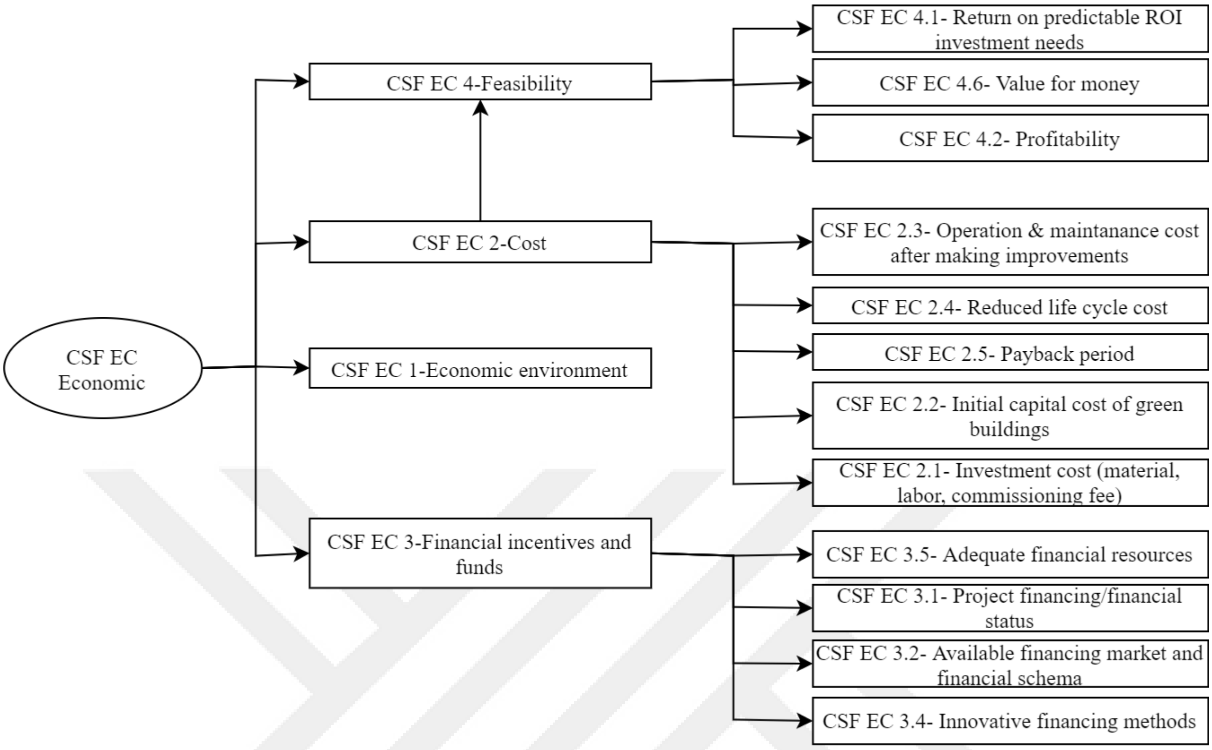
Appendix E1: Environmental dimension's CSFs in the framework



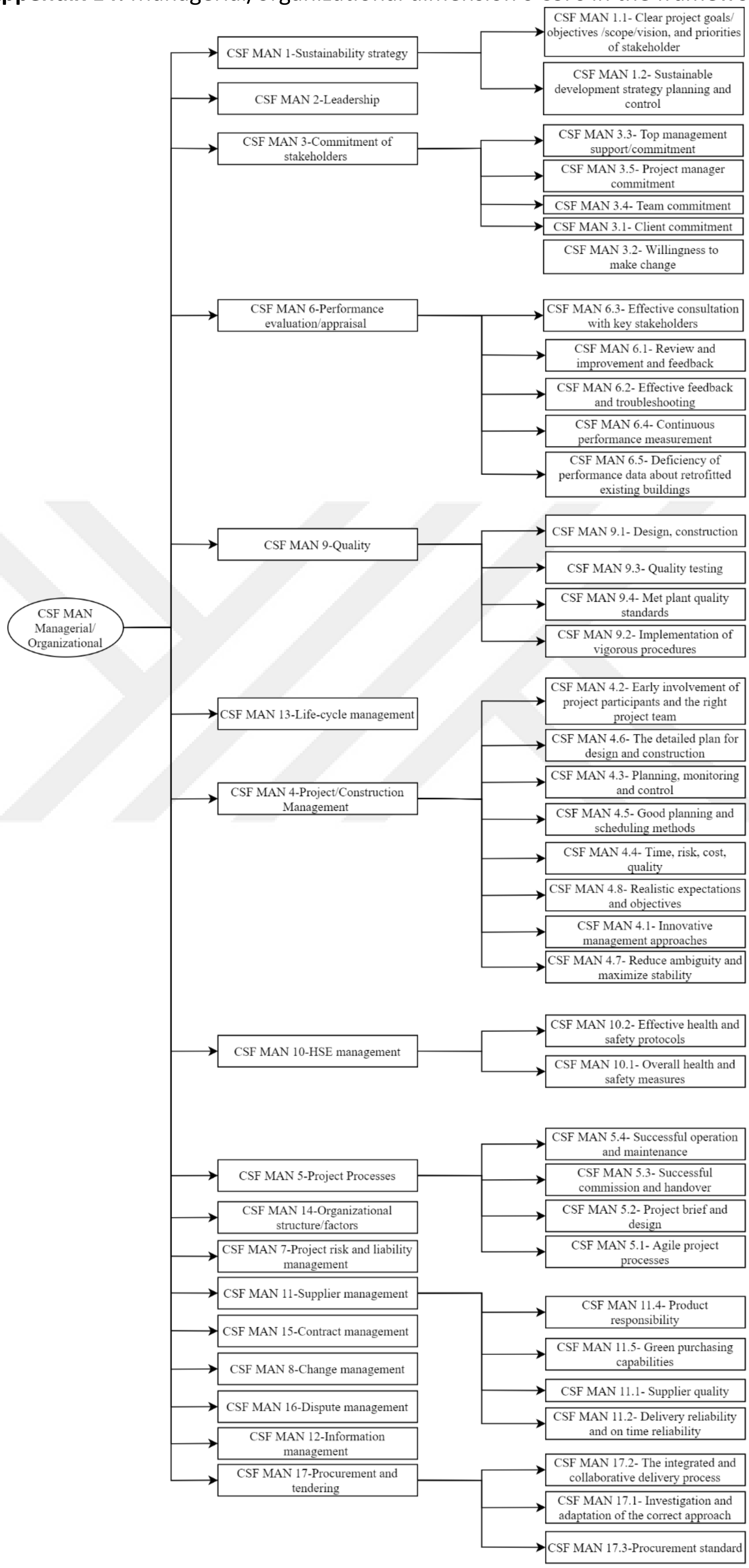
Appendix E2: Human dimension's CSFs in the framework



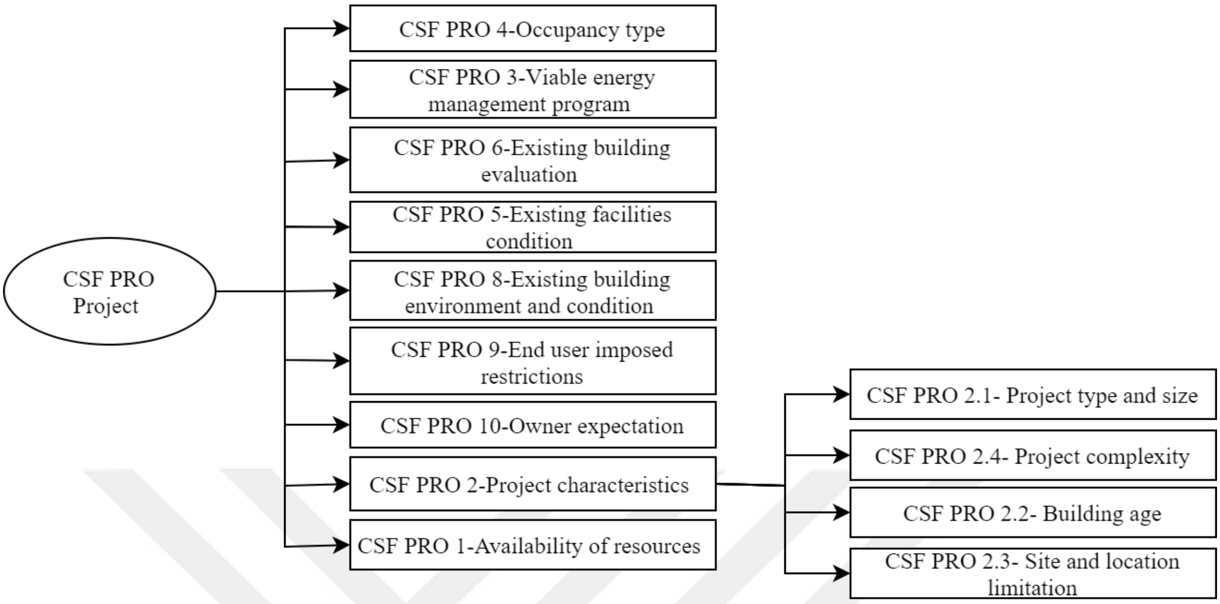
Appendix E3: Economic dimension's CSFs in the framework



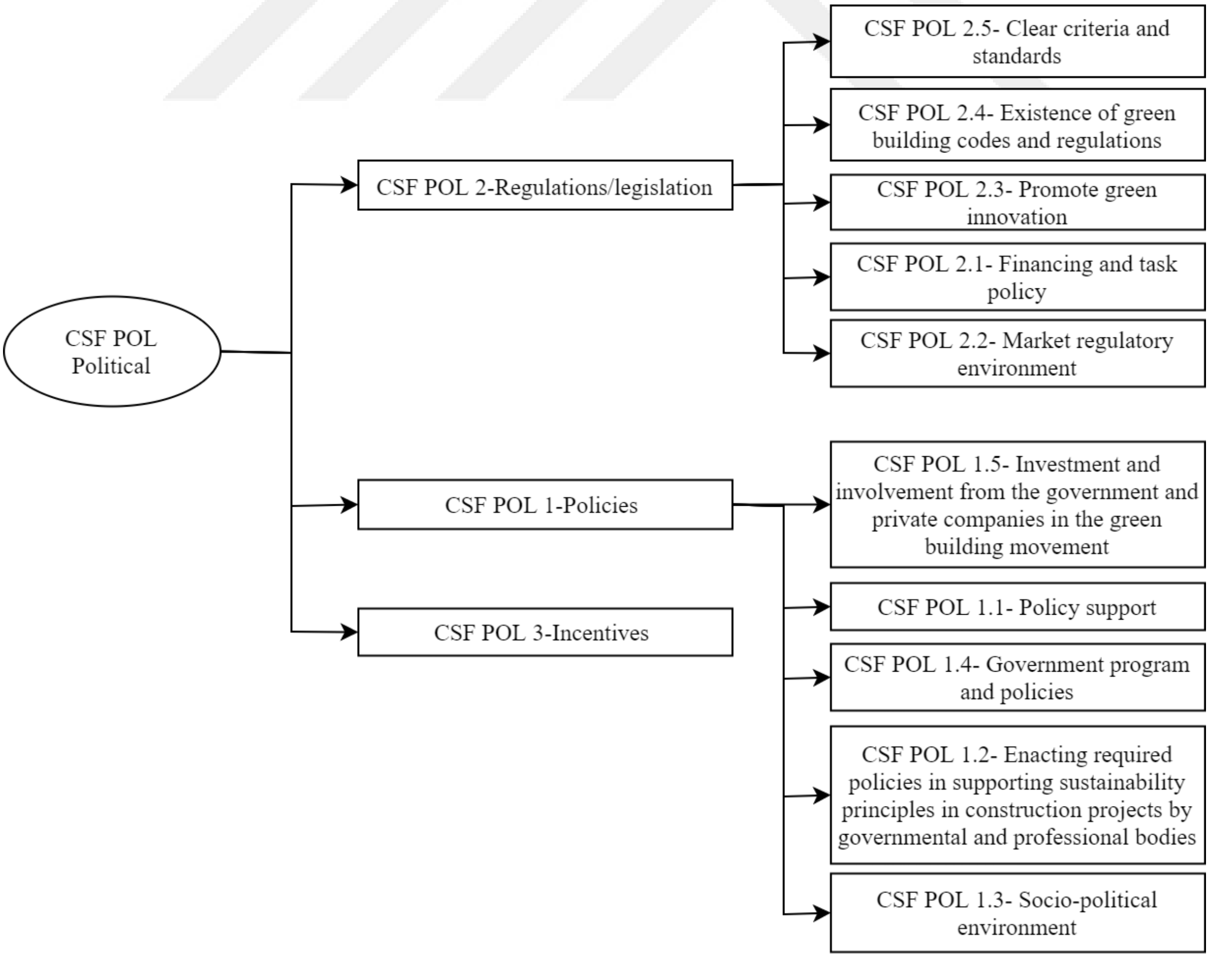
Appendix E4: Managerial/organizational dimension's CSFs in the framework



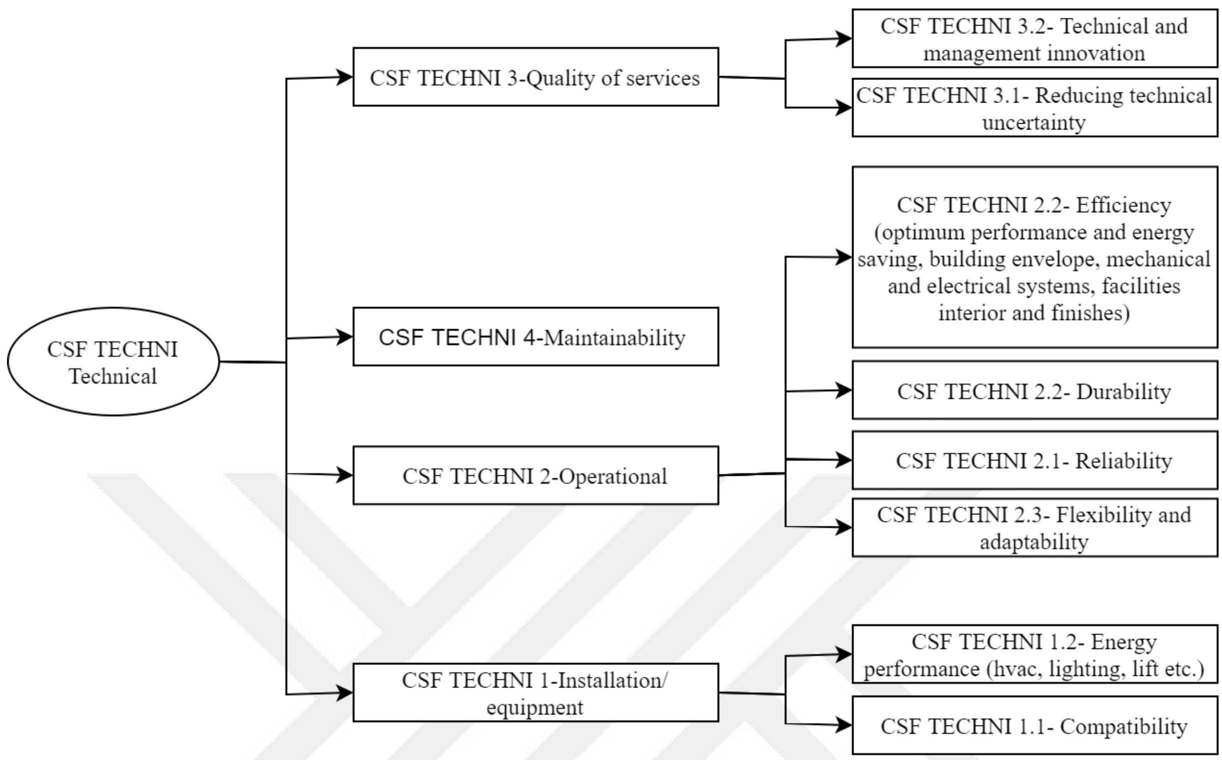
Appendix E5: Project dimension's CSFs in the framework



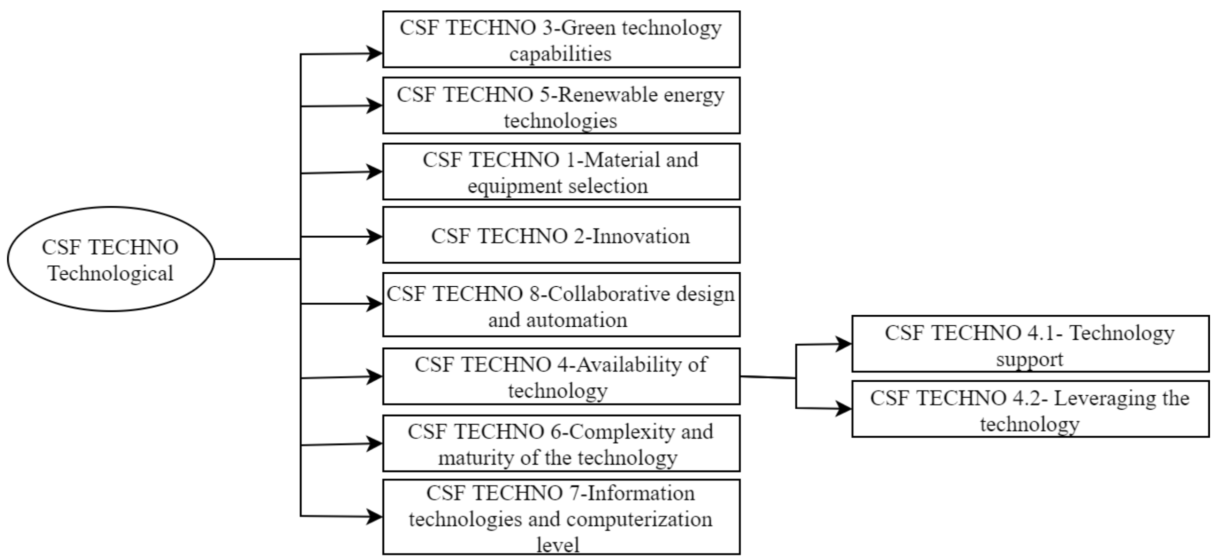
Appendix E6: Political dimension's CSFs in the framework



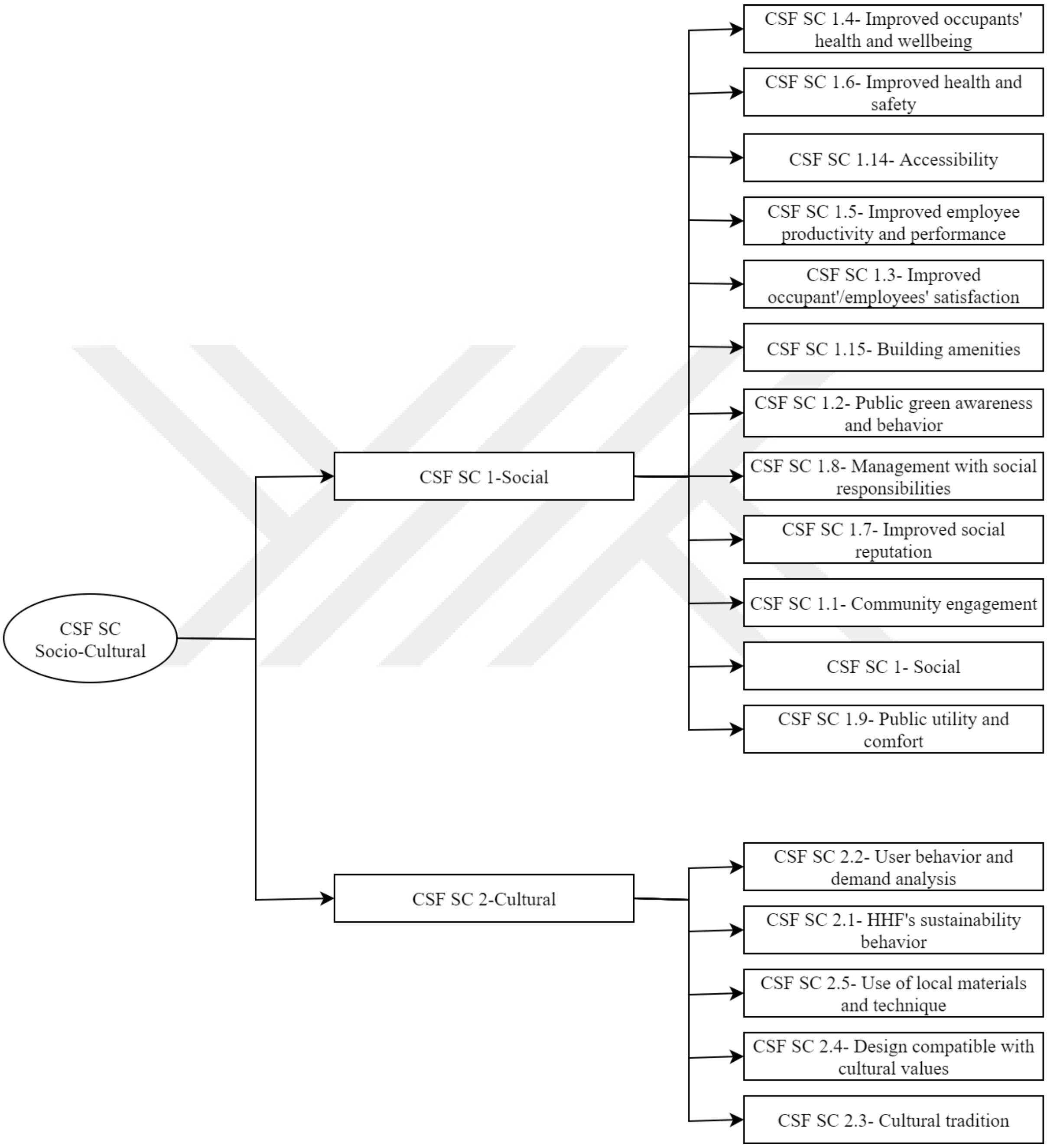
Appendix E7: Technical dimension's CSFs in the framework



Appendix E8: Technological dimension's CSFs in the framework



Appendix E9: Socio-cultural dimension's CSFs in the framework



APPENDIX F

Validation of the CSFs Framework for Green Retrofitting of Existing Healthcare Buildings

To provide environmental protection, sustainability has become a major concern for all sectors around the world. The healthcare sector is one of these important sectors. With the awareness of sustainability in the health sector, “green hospital” practices come to the forefront to improve the sustainability of healthcare buildings and to reduce the environmental impact of the buildings. In this context, a CSFs framework for green retrofitting for existing healthcare buildings were developed.

The aim of this survey is to evaluate the critical success factors (CSFs) framework for green retrofitting of existing healthcare buildings. The research is carried out within the scope of a master thesis prepared in Özyeğin University Graduate Program in Architecture. All information, opinions and suggestions shared by the participants will be meticulously maintained. The information obtained will help to validation of conceptual framework within the scope of the thesis.

The questionnaire is included the evaluation criteria obtained from the literature review. For each question, there are boxes for indicating the degree of developed framework. Select the order of degree that suits you best for the answer to each question. Thank you very much for your time and cooperation.

Thank you very much for your time and cooperation. For any questions and comments, please contact us with the following e-mail and telephone information.

Kind Regards,

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Question 1:

Profession:……………………………………………………

Question 2:

Experience year:…………………………………………

Question 3:

Please evaluate the degree of developed CSFs framework for green retrofitting of existing buildings. To evaluate the developed framework are given in Figure 1.

	1	2	3	4	5
Valid					
Usable					
Relevant					
Comprehensive					

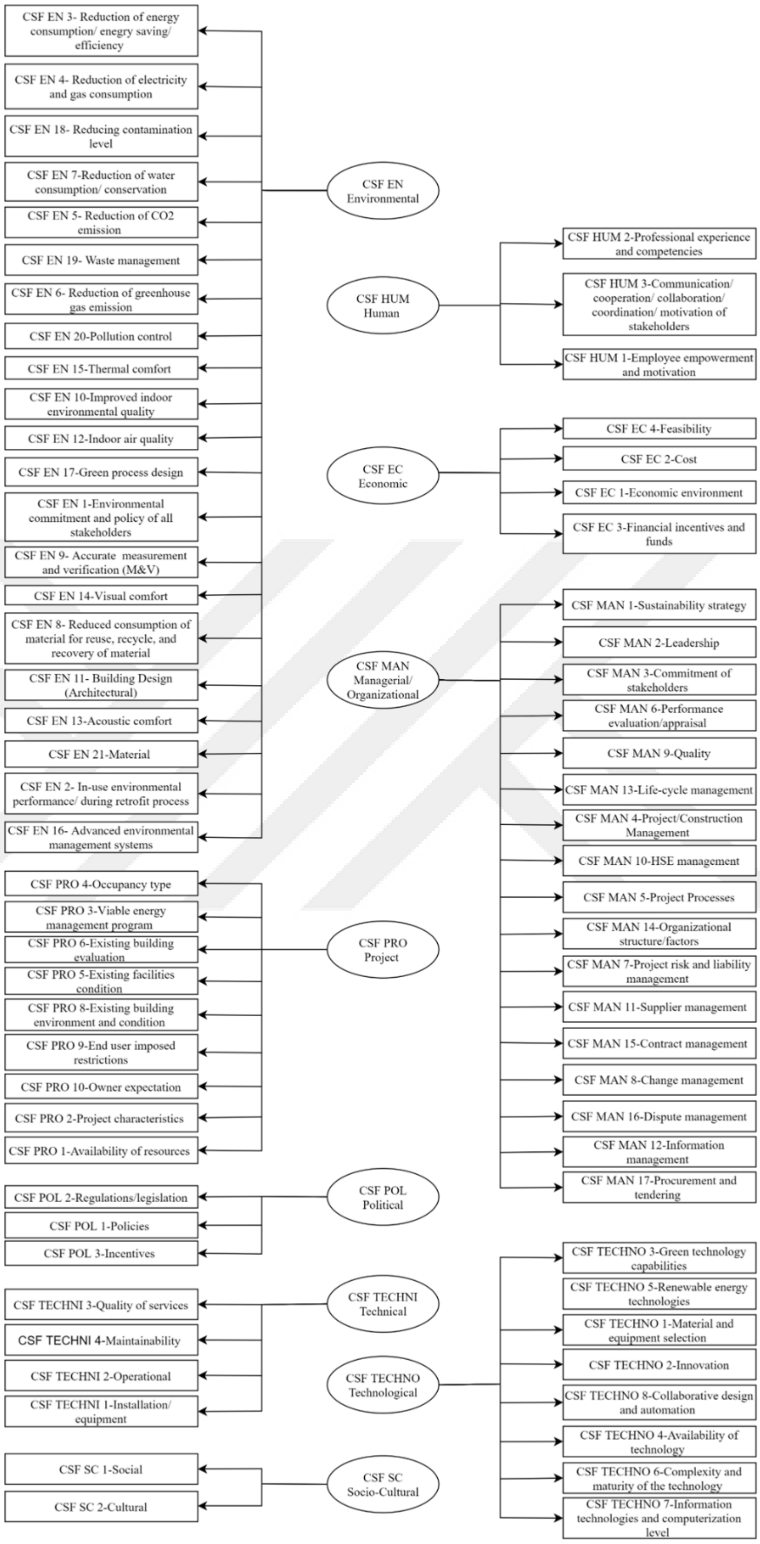

Figure 1: Developed Framework for GREHB with second level CSFs

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