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Building Sustainability Assessment Methods for Healthcare – proposal of the list of indicators and system of weights suitable for the Brazilian context

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Building Sustainability Assessment Methods for Healthcare – proposal of the list of indicators and system of weights suitable for the Brazilian context

Master's Dissertation
International Master in Sustainable Built Environment

Work supervised by
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DIREITOS DE AUTOR E CONDIÇÕES DE UTILIZAÇÃO DO TRABALHO POR TERCEIROS

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STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration.

I further declare that I have fully acknowledged the Code of Ethical Conduct of the University of Minho.

MÉTODOS DE AVALIAÇÃO DE SUSTENTABILIDADE PARA EDIFÍCIOS HOSPITALARES – PROPOSTA DE LISTA DE INDICADORES E SISTEMA DE PESOS ADAPTÁVEIS PARA O CONTEXTO BRASILEIRO

RESUMO

Os indícios das mudanças climáticas aumentaram as necessidades de ações, a fim de evitar consequências para as gerações futuras, levando em consideração as atividades de impacte substancial no ambiente. O reconhecimento da sustentabilidade e o desempenho energético da construção levaram a um envolvimento global das implicações associadas, o que resultou no desdobramento de vários meios de se prever a eficácia e a classificação das construções. As edificações voltadas para a assistência médica, dinâmicas e funcionais, focadas no processo de cura e no conforto de seus usuários, têm um papel significativo na sociedade e necessidade emergente de ter um grande desempenho a fim de atender às exigências de seu planeamento estratégico (redução de custos, conformidade regulatória, responsabilidade social e melhoria de desempenho), integrando assim a sustentabilidade com a operação. Esta pesquisa aborda as principais questões relacionadas à sustentabilidade voltada a construção no setor de saúde brasileiro, analisando a adequação dos métodos mais comuns de avaliação internacional aplicados ao contexto social, económico e ambiental. Apresenta também a situação atual do ambiente hospitalar e seu impacte (energia, água e resíduos) no Brasil. Para alem destes pontos, são analisados os principais métodos de avaliação de sustentabilidade desenvolvidos para este tipo de edificação, comparando a lista de indicadores e identificando as possibilidades e potencialidades para a sua adaptação ao contexto brasileiro. O estudo encontra-se focado na adaptação do método português para a avaliação da sustentabilidade de edifícios de saúde (HBSAtool-PT) ao contexto brasileiro. Para tanto, foi realizada uma pesquisa para avaliar a opinião de especialistas na construção sobre a importância dos indicadores, conduzidos e definidos posteriormente pelo método AHP. Como resultado, propõe-se uma estrutura para avaliar a sustentabilidade em edifícios de saúde no Brasil, composta por quarenta e oito indicadores, distribuídos em vinte e três categorias.

Palavras-chave: Edifícios hospitalares, Construção Sustentável, Métodos de Avaliação para edificações sustentáveis, Certificação sustentável, Sistema de classificação.

BUILDING SUSTAINABILITY ASSESSMENT METHODS FOR HEALTHCARE – PROPOSAL OF THE LIST OF INDICATORS AND SYSTEM OF WEIGHTS SUITABLE FOR THE BRAZILIAN CONTEXT

ABSTRACT

The indication of climate change has increased the necessity for actions to avoid severe consequences for future generations, taking into consideration the activities that have a substantial impact in the natural environment. The recognition of the benefits of the sustainability and energy efficiency led to an involvement in a global scale to the implications associated with it, which has resulted in the development of several methods to estimate and rate the building performance. Healthcare buildings, functional and dynamic structures, are focused on the healing process and comfort of its users, have a significant role in the society and an emerging need of having a greater performance in order to meet the requires from its strategic planning (cost reductions, regulatory compliance, social responsibility and performance improvement) by integrating sustainability into facility's operations. This research addresses critical issues regarding the sustainability of the Brazilian healthcare sector, by analysing the suitability of the most common international healthcare building sustainability assessment methods to the social, economic and environmental contexts. It presents the current situation of the healthcare environment and its impact (energy, water and waste) in Brazil. Additionally, it analyses the main sustainability assessment methods developed for this type of building by comparing the list of indicators and identifying the possibilities and potentialities for adapting to the Brazilian context. Focused on the adaptation of the Portuguese (HBSAtool-PT) list of indicators and weighting system to assess the sustainability of healthcare buildings to the Brazilian healthcare buildings. For this purpose, a survey to assess the opinion of building construction experts regarding the importance of sustainability indicators was conducted. A weighting system for the proposed indicators was developed using the AHP method. As a result, this research proposes a framework to assess the sustainability of healthcare buildings in Brazil composed by forty-eight indicators, distributed among twenty-three categories.

Keywords: Healthcare Building, Sustainable Construction, Building Sustainability Assessment Method, Sustainable Certification, Rating systems

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GLOSSARY OF ACRONYMS

ABNT – Brazilian Association of Technical Standards

AHP – Analytic Hierarchy Process

ANVISA – National Sanitary Surveillance Agency

BD + C – Building Design and Construction

BRE – Building Research Establishment

BREEAM – Building Research Establishment Assessment Method

BSA – Building Sustainability Assessment

CASBEE – Comprehensive Assessment System for Building Environment Efficiency

GBCA – Green Building Council of Australia

HBSA – Healthcare Building Sustainability Assessment

HBSAtool-PT – Healthcare Building Sustainability Assessment tool – Portugal

HQE – Haute Qualité Environnementale

LCA – Life Cycle Assessment

LEED – Leadership in Energy and Environmental Design

NBR – Brazilian Technical Standards

NHS – National Health Service

PGRSS – Health Services Waste Management Plan

RDC – Resolution of Collegiate Board

RII – Relative Importance Index

SBTool – Sustainable Building Tool

SED – Sustainable Effective Design

USGBC – United States Green Building Council

WBCSD – World Business Council for Sustainable Development

WHO – World Health Organisation

1 INTRODUCTION

The building industry, one of the largest sectors in people (services) and materials involved, has a great impact on the economy and society, and because of its statement consumes large amounts of natural resources and its adverse environmental impacts are widely concerned. As reported by World Business Council for Sustainable Development (WBCSD, 2007), the building sector accounts for about 40% of total energy use, 30% of greenhouse gas (GHG) emission, 17% of fresh water consumption, 25% of harvested wood, and produces between 45% to 65% of disposed waste in landfills. As a consequence, the control of environmental impacts of the building sector has become a major issue and projections of future global population and economic growth and predict a steady increase in global energy demand. Energy use in the built environment is responsible for more than 40% of global its utilisation and is considered as a key contributor to the climate change, as the promotion of energy efficiency buildings by using mitigation measures is therefore a key element in ensuring a more sustainable future (World Business Council for Sustainable Development, 2007).

Figure 1: Awareness and involvement of building professional (World Business Council for Sustainable Development, 2007)

The awareness of environmental building issues is relatively high in all markets but the numbers drop sharply on questions about involvement in green building activity. A research made by WBCSD to measure the perceptions about building sustainability, for instance Figure 1 shows the percentage of leaders, policy-makers and business people that finance, design, build and occupy buildings who are aware, have considered it and have been involved. In Brazil 33% of those who are aware have considered sustainable building, and 30% of those who have considered it have been involved, which means only 9% of respondents have direct experience (WBCSD, 2007). Only a third of those who said they were aware of green buildings had considered involvement, and only a smaller group had actually been involved.

An assessment method is a tool for evaluating the building performance and consolidate sustainable development into the construction process, considering existent or new buildings, with a rank attributed after a detailed report. It serves as a management tool or guideline to address concerns during design, construction, and operation phases, and provides data of interest for stakeholders (e.g. governments across the world encourage project entrepreneurs to use rating systems by offering tax incentives). While the rating systems share the general aim of assessing sustainability, each system adjusts itself to the economic and cultural environment in a specific territory, originally designed to work in (Darko *et al.* 2016).

These sustainable building assessment rating systems are largely market-driven since they rely on recognition of the value of sustainable buildings, being voluntary rather than mandatory. A number of methods have been developed to assist its demand in particular, including: The Building Research Establishment Assessment Method (BREEAM), Sustainable Building Tool (SBTool), Leadership in Energy and Environmental Design (LEED), Comprehensive Assessment System for Building Environment Efficiency (CASBEE) and Green Building Council of Australia Green Star have subsequently emerged. The assessment is undertaken by accredited professionals that are commissioned by the institution that manages each tool.

Healthcare buildings are very complex due to different types of users combined with the circulation flow, the dynamism by the necessity of changing, the integration of technologies and systems and its social contribution in the community. The incorporation of sustainable development concepts in the company's strategy is considered a factor for the success of the hospital environmental sustainability project, in accordance with sustainable initiatives, measurements of risks and impacts (goals, metrics, monitoring and evaluation), managements programs (water, energy efficiency), less aggressive materials, transparency actions, educational programs, communication and responsible teams.

In Brazil, the healthcare sector is starting to look at sustainability as an opportunity, and efforts are being made to define the indicators in different scales and methodologies. One of the limitations to develop a method to support the practical implementation of the sustainability goals in the Brazilian healthcare sector is the lack of comprehensive information about its performance. Besides, the Brazilian territory is very vast, and therefore, there are diverse economic, environmental and social goals, being difficult to develop an effective method to be applied all over the country. The analysis and interpretation of the current situation in Brazil is a crucial step stone in the development of a sustainability assessment framework that fits the market need and stakeholders' expectations.

So, the aim that this research is: to appraise the progression and evolution of the most recognised Sustainability Assessment Methods for Healthcare; to assess the potential of different building sustainability assessment tools to support decision making, considering their appropriateness to the context for which they were developed and the potential for internationally recognised certification; and the possibility of adapting these tools to the Brazilian context, supplemented by a discussion of the salient facts, along with a conclusion from the important issues.

1.1 Sustainability of Healthcare Buildings

Healthcare services are water and energy intensive users, mainly due to their continuous operation, requiring light, heat, intensive ventilation, sterilisation and preparation of food. They are responsible for generating a great amount of waste and producing polluting emissions. Built environment accounts for 40% of all CO_2 emissions and hospitals alone count for 4% of the built environment (Kras, 2011). Therefore, it is necessary that hospitals feel the urgency to undertake actions to reduce their CO_2 emissions. Given that, these toxic emissions are prone to cause respiratory diseases and other illnesses within the citizens. Hospitals are actually undermining the health of the communities that they are trying to serve (Kras, 2011).

Since hospitals provide patient care for people within a community, they can be characterised inherent to social responsibility, by taking care of patients as the core business. In sharp contrast to this, hospitals are among the biggest polluters and contributors to climate change in the world (World Health Organisation and Healthcare Without Harm, 2009).

In England, the National Health Service (NHS) is the largest employer and biggest spender, since its buildings contribute to environmental damage through the consumption of natural resources, but at the same time, the NHS contributes to social and economic regeneration and reduces its own ecological footprint – lower carbon emissions, effective waste management and reduced water consumption. As combating climate change is so important, the UK Sustainable Development Commission's target for a carbon neutral public sector is crucial, meaning that healthcare buildings should aim to make no contribution to climate change. Through effective design of buildings and land management to support local biodiversity, the NHS can improve the physical and mental wellbeing of patients, staff, visitors and the local community (Griffiths, 2006).

In the United States of America (USA), hospitals are the second most energy-intensive buildings, using double amount of energy per square foot than regular office buildings. Moreover, medical waste incinerators are ranked among the top four sources for dioxin and anthropogenic mercury emissions, substances that can easily spread through air, land and water. It is estimated that the hospital industry's conventional energy use causes about $ 600 million per year in increased healthcare costs due to increases in asthma, other respiratory illnesses and emergency department visits (WHO, 2009).

In late 1980s and during the 1990s, the World Health Organisation (WHO) concept of health, became significant for identifying the concept of a 'healthy building' in terms of building performances (i.e., indoor air quality, thermal comfort, lighting quality and acoustics). A healthy building is free of hazardous material (e.g. lead and asbestos) and capable of fostering health and comfort of the occupants during its entire life cycle, supporting social needs and enhancing productivity (Sahamir & Zakaria, 2014).

The healthcare sector is constantly changing, considered flexible and adaptable to deal with it. In the last few years, sustainability has started to attract increased attention of many hospitals and the trend to design and build hospitals using sustainable technology, renewable resources and systems to reduce energy consumption and carbon emissions is making possible to achieve higher building performance, supporting a healing environment. A growing number of hospitals are becoming more interested in a sustainable approach and it is critically important that all stakeholders (i.e.: government, industry and etc.) develop new strategies that improve the quality of environment, social and economic dimensions.

1.2 Background

The health sector in Brazil has gone through many changes in the last years, becoming more evident its concern regarding the sustainability, mainly because of the involvement of society with the growing concerns about the environment and the quality of the interior spaces, reflected not only in patients but also in employees. Consequently, the constant technological changes and the need to incorporate them into hospitals lead to a plurality of design issues that have to be taken into consideration, such as the building flexibility and adaptability.

The need to apply modern concepts in hospital management has an influence to suit techniques and tools, successfully used by other sectors, that joins and support the principles of sustainability, contributing to the economy, social satisfaction and environmental care. The design professional can collaborate to provide another experience to the healthcare environment, known as cold, sober and intimidating to a humanised, ludic, reliable and secure space, increasing the healing ambience of the patient and reducing the length of hospitalisation. Also, to the employee, by designing rest areas, it enables better quality care and the result would be higher yield, safety and better performance. To this set of concerns, which an architect has, it is still necessary to conciliate all the technical requirements with the sustainable questions involved (environmental, social and economic improvements).

The study object is, thus, healthcare buildings, covering all the complexity of design, operation and maintenance and the aspiration is to study and analyse the sustainable assessment methods and its potential to be adapted to the Brazilian context. This was done through the implementation of a questionnaire to test their viability and the necessity to adaptation.

1.3 Changes in the Brazilian Healthcare Landscape

To characterise and present the distribution of hospitals in Brazil, in addition to the trajectory over time, using data provided by the Brazilian Federation of Hospitals and the National Health Confederation (2019) in an annual report, the number of hospitals, with number of beds, are important indicators for determining the health resources available to the population and, consequently, the capacity of care of a region.

Between 2010 and 2019, the total number of hospitals suffered a small decrease in the whole national territory, as shows in Figure 2 and Figure 3, this variation represents a reduction of 205 hospitals in 2019 when compared to 2010, but that variation is not constant.

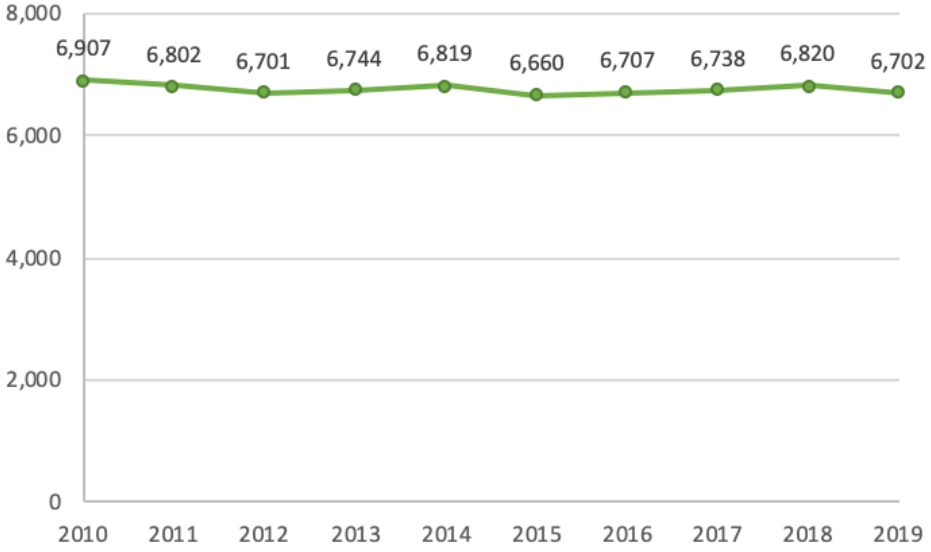

Figure 2: Historical Series of Hospitals in Brazil – between 2010-2019 (adapted from: Brazilian Federation of Hospitals, 2019)

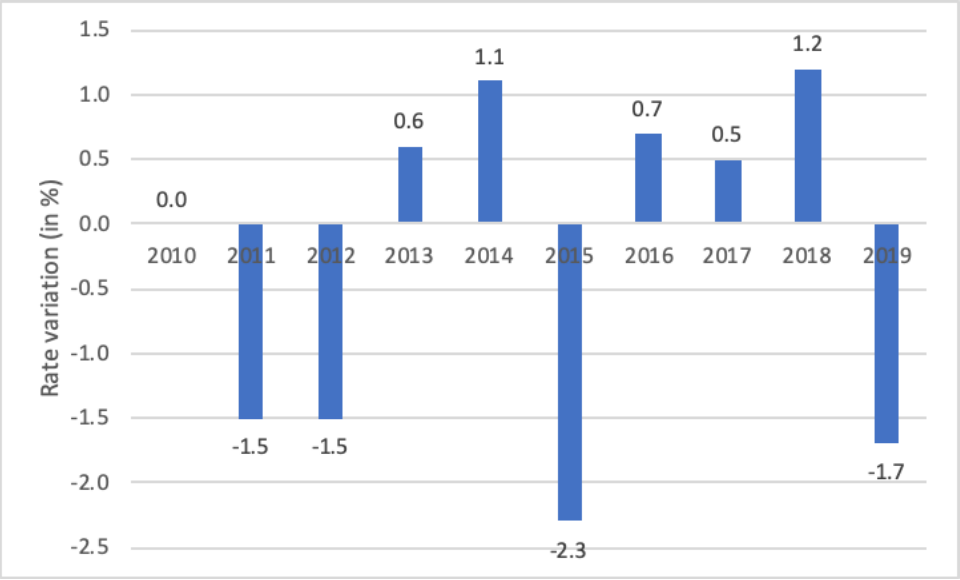

Figure 3: Annual Variation Rate of the Historical Series of Hospitals in Brazil – between 2010-2019 (adapted from: Brazilian Federation of Hospitals, 2019)

The number of hospitals by legal nature (private or public) can be noted that the fall throughout the period occurred among private hospitals, since there was no decrease in the number of public hospitals in any of the analysed years. The variation in the number of private hospitals fluctuated over the years.

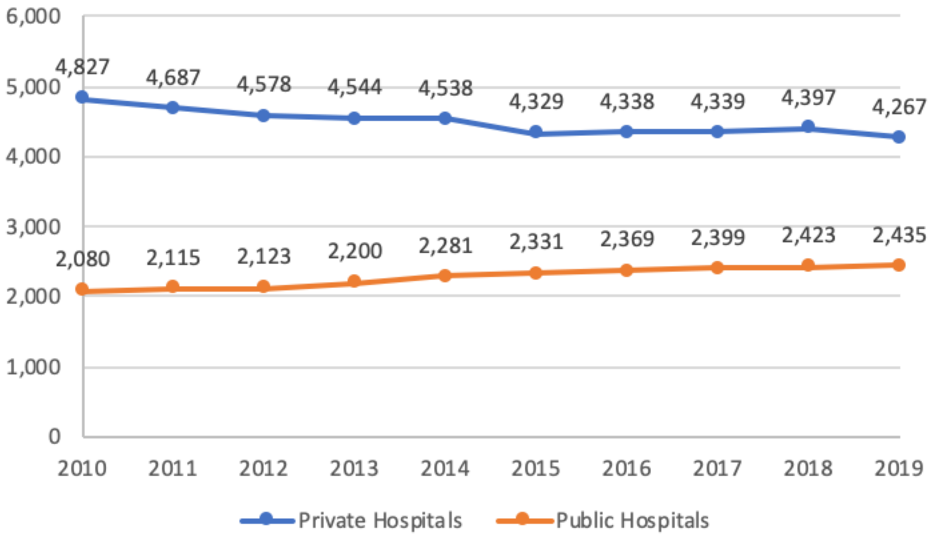

Figure 4: Historical Series of Hospitals in Brazil, by Legal Nature of the Hospital – between 2010-2019 (adapted from: Brazilian Federation of Hospitals, 2019)

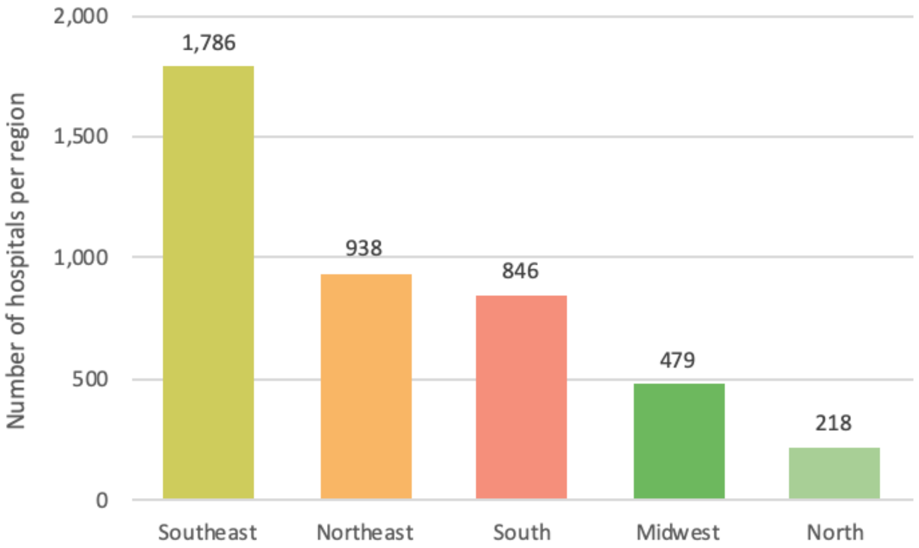

Figure 5: Distribution of Private Hospitals by Region – 2019 (adapted from: Brazilian Federation of Hospitals, 2019)

In 2019, there were 4,267 private hospitals in Brazil, the majority located in the Southeast region (41.4%), especially in São Paulo, presented by Figure 4 and Figure 5. Of the total private hospitals, most are for profit (56.9%), but this proportion varies considerably between regions, being the highest in the North (66.3%) and lowest in the South (22.7%). Figure 6 shows the panorama related to the number of private beds, as in 2019, Brazil had 260,695 beds in private hospitals, again the majority in the Southeast region (46.4%). The distribution of hospitals by state is not proportional to the distribution of beds per state, showing that hospitals in the North and Northeast are mostly small (Brazilian Federation of Hospitals, 2019).

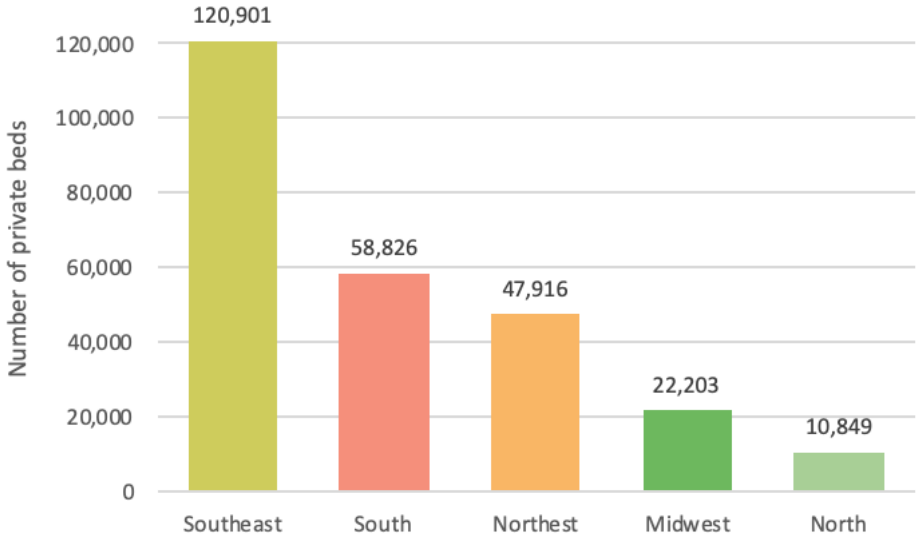

Figure 6: Distribution of Private Beds by Region – 2019 (adapted from: Brazilian Federation of Hospitals, 2019)

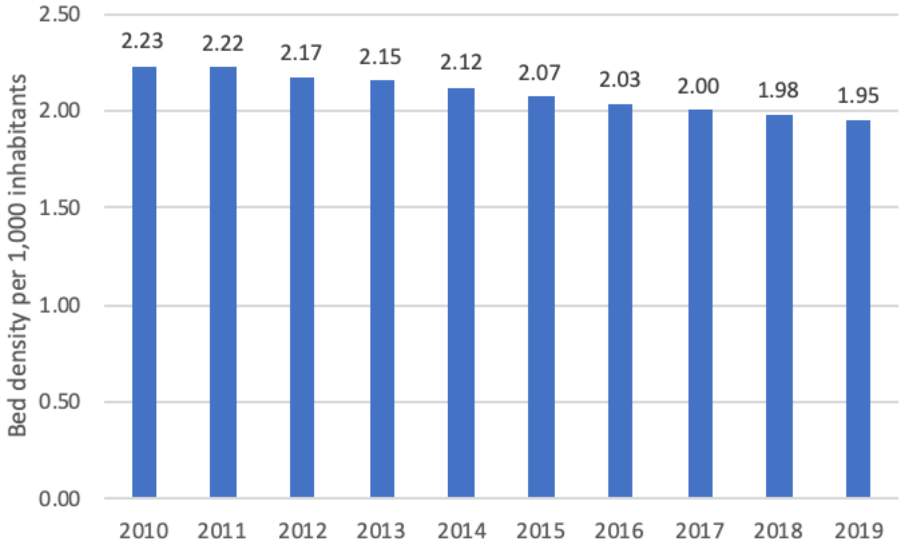

Figure 7: Historical Series of Bed Density in Brazil – between 2010-2019 (adapted from: Brazilian Federation of Hospitals, 2019)

Taking into account the resident population estimated each year and the number of beds in the national territory, regardless of the legal nature or type of hospital, it is possible to analyse the evolution of the ratio of the number of beds per 1,000 inhabitants. Figure 7 presents the trajectory of bed density, which is decreasing throughout the analysed period, being in 2010 estimated at 2.23 beds/1,000 inhabitants, while in 2019 the estimate was 1.95. The World Health Organisation estimates an average of 3.2 beds per 1,000 inhabitants (WHO, 2017).

1.4 Objective

Underestimated decisions at the early design stage are often difficult and expensive to remediate during the operation stage. Besides, for large-scale projects, such as hospital buildings, the environmental impact and cost can be massive if not well accomplished. The purpose of the study is to identify and analyse the sustainability assessment methods for healthcare buildings, also studing their suitability and necessity of adaptation to be used in the Brazilian context. This analysis is focused on the assessing the potential of adaptation of the Portuguese method for healthcare buildings (HSBAtool-PT).

The HBSAtool-PT, LEED v4 for Building Design and Construction and BREEAM International New Constructions 2016, were be the BSA methods used to select parameters and categories, to interpret the potentialities and possibilities of adaptation by studying comparatively the list of indicators, analysing the weighting defined by each method and to establish a comparison between the classification levels.

The carried out analysis, which is intended as feasible to the Brazilian environment as possible, was based on a methodology for evaluating the sustainability of construction with the assistance of need to shift the index (reducing or increasing) within the modifications fundamental to make the weight system authentic. First, a list of indicators was defined based on the well-known assessment methods to fit the Brazilian context, and submitted to sustainable healthcare experts to gather their opinim. Afterwards, the priorities (system of weights) of the proposed list of indicators, were delineated upon a survey evolving the main stakeholders into the design, management and maintenance of healthcare buildings.

The investigation's intention of a sustainable list of indicators for hospital buildings is to present the pros and cons and design a support tool capable of achieving a good classification in an internationally recognised certification system, leading the definition of sustainable project practices into the sense of its future realisation.

1.5 Structure of the document

The present work is organised into seven chapters. The first chapter presents an introduction to the proposed theme, addressing the contribution of the construction sector to the environment and society. Thus, the justification was developed, and the objectives of the work established. The structure of the document is also presented in the first chapter.

The second chapter presents the state-of-art, highlighting the generic concepts of the international assessment methods, the comparative matrix between existing rating systems and finally, the Brazilian context.

In the third chapter, the methodological procedure used in this research is presented in order to meet the proposed objectives. It begins with a description of the survey for identifying the universe of buildings to be studied, as well as the Analytical Hierarchy Process (AHP) method.

The following chapter presents the development that took place in order to achieve the proposed adaptation for the healthcare BSA method that suits the Brazilian context.

The fifth chapter presents the research results. In section 5.1, the outcome of the research carried out in Brazil is shown and in section 5.2, the results are ranked according to the importance of each dimension.

Finally, the research discussions and conclusions developed based on the results, and the bibliographic review are presented. The limitations of the research and recommendations for future work are also listed in these last chapters.

2 STATE OF THE ART

2.1 Historical approach

Since the 1970s, the performance evaluation and environmental assessment of buildings have generated intense research (Cole, 1998) in parallel with the development of the concept of sustainable building and motivated by the growing focus on the main agents involved. However, until the 1990s, the construction sector began to recognise the significant impact of its activities on the environment, the economy, public health and well-being in cities (Haapio & Viitaniemi, 2008). In fact, construction is currently one of the main reasons for accelerating climate change (de Klijn-Chevalerias & Javed, 2017).

According to Haapio and Viitaniemi (2008), to address this problem in the last decades, numerous assessment methods allows grading and certification of the building's sustainability and its surroundings in all phases of its life cycle. These methods have been developed based on a series of indicators to measure different aspects, divided by a set of criteria that provide quantitative and qualitative economic, social and environmental performances.

The existing methods, in order to promote a more accurate assessment, should cover the list of the standardised sustainability criteria (Castro, Mateus e Bragança, 2017a).

2.2 Global Agenda for Green and Healthy Hospitals

The Global Agenda for Green and Healthy Hospitals is intended to support initiatives around the world to promote greater sustainability and environmental health in the health sector and thereby strengthen health systems globally. A green and healthy hospital promotes public health by reducing its environmental impacts and eliminating its contribution to the burden of disease, also recognises the relationship between health and the environment, demonstrating through its governance, strategy and operations. It connects local needs with its environmental actions and practices primary prevention by engaging in community efforts to promote environmental health, health equity and a green economy.

Goals of the agenda (Health Care Without Harm, 2006):

a. Leadership - Prioritise environmental health as a strategic imperative.
b. Chemical Substances - Replace hazardous substances with safer alternatives.

c. Waste - Reduce, treat and dispose of health care waste safely.
d. Energy - Implement energy efficiency and clean renewable energy generation.
e. Water - Reduce water consumption.
f. Transportation - Improve transportation for patients and staff.
g. Food - Buy and offer healthy and cultivated food in a sustainable way.
h. Pharmaceuticals - Manage and target pharmaceutical products safely.
i. Buildings - Support projects and constructions of green and healthy hospitals.
j. Shopping - Buying safer and more sustainable products and materials.

2.3 International assessment methods system for healthcare buildings

The rating system provides an effective framework for assessing building environmental performance and integrating sustainable development into building and construction processes, as it can be used as a design tool by setting sustainable design priorities and goals, developing appropriate strategies and determining performance measures to guide the design trough the decision making process. They are the best method to improve the education for a sustainable society and to promote understanding between the principles of sustainable construction and the user (Cars & West, 2014). These methods have contributed to the growth of the awareness about sustainability and become a reference to assess in buildings. Therefore, to clarify and emphasise the best design options, it became essential to integrate experts in the design team (Forsberg & Malmborg, 2004).

Several countries have developed their own methods for sustainability assessment adapted to their reality and presenting them as capable of guiding the overall performance of this sector. Most of these methods are based on local rules and legislation, conventional construction technologies, with the weight of each indicator set according to the actual local context (Crawley & Aho, 1999).

A growing number of sustainability assessment tools are developed for the building sector all over the world focusing on new constructions, existing buildings and rehabilitations. The needs of healthcare facilities are very unique, and buildings often have regulatory requirements, non-stop operations and demands. The following systems are chosen to be reviewed as they are influential and technically advanced rating tools available for healthcare-specific buildings: BREEAM New Construction; LEED v4 for Building Design and Construction; Green Star – Healthcare; CASBEE for

New Construction; HBSAtool-PT (Healthcare Building Sustainability Assessment tool – Portugal); and International Sustainable Building Tool (SBTool).

BREEAM (Building Research Establishment’s Environmental Assessment Method) is the leading and the most widely used environmental assessment method for buildings. Developed in the UK in 1990, is the longest track record into building environmental assessment method and can be used in any type of building anywhere in the world. It has more than 2,000,000 registered buildings among 83 countries (BREEAM, 2016). However, for healthcare buildings, was commissioned by the Department of Health and Welsh Health Estates, as the preferred method and certification scheme in the UK. All health authorities in the UK (i.e. Department of Health) require, as part of the Outline of Business Case approval, that new builds achieve an Excellent rating and refurbishments achieve a Very Good rating.

LEED (The Leadership in Energy and Environmental Design) green building rating system, developed by the U.S. Green Building Council (USGBC) in 1998, provides a suite of standards for environmentally sustainable construction. Since its inception in 1998, LEED has grown to encompass more than 93,000 projects in the US and 167 countries and territories covering 19.3 billion square feet of development area (USGBC, 2018). As an internationally recognised mark of excellence, LEED provides building owners and operators with a framework for identifying and implementing practical and measurable green building design, construction, operations and maintenance solutions. Thus, the LEED v4 for Building Design and Construction rating system acknowledges differences by modifying existing credits and creating new healthcare-specific. The goal is to help promote healthful, durable, affordable, and environmentally practices in the projects.

The GREEN STAR rating system has built on existing systems and tools in overseas market, by establishing individual environmental measurement criteria relevant to the Australian marketplace and environmental context. GREEN STAR is a voluntary environmental rating system and was launched in 2003 by the Green Building Council of Australia (GBCA), incorporating 2,200 projects currently (GBCA, 2019). The system considers a broad range of sustainable issues while also considering occupant health and productivity, and cost savings. The GBCA released the Green Star - Healthcare v1 tool to support sustainable planning, design and construction of high-performance healthcare facilities.

Comprehensive Assessment System for Built Environment Efficiency (CASBEE) was developed by a research committee in 2001 through the collaboration of academia, industry and governments, which established the Japan Sustainable Building Consortium (JSBC) under the auspice of the Ministry of Land, Infrastructure, Transport and Tourism. It has been designed to enhance the quality of people's lives and reduce the life-cycle resource use and environmental loads associated with the built environment, from a single home to a whole city. Consequently, various schemes are deployed over Japan and supported by the government (CASBEE, 2019).

HBSAtool-PT (Healthcare Building Sustainability Assessment tool – Portugal), developed according to the Portuguese context, is specific for Healthcare Buildings. This Method consider all of the existing recognised tools, gathering technical opinions in agreement to the national ambiance. Its grouping a larger area and higher quantity of indicators covering the requirements for this type of building (Castro, 2018).

International Sustainable Building Tool (SBTool), was developed by the International Initiative for a Sustainable Built Environment (iiSBE), to be used in different countries and to assess different building types. It can be used by owners and managers to express their own sustainability requirements to internal staff or as briefing material for competitions. The system covers a wide range of sustainable building issues, but the scope of the system can be modified to be as narrow or as broad as desired and takes into account region/site-specific context factors, used to adjust certain weights, as well as providing background information (SBTool, 2019).

Together, these tools have driven market transformations around the world and from the analysis of results from their application to real cases, the following conclusions can be drawn (Guenther and Vittori, 2013):

a. During the design phase, it is important to consider carefully every design decision, from the macro issues (e.g. construction systems) to the micro issues (e.g. lighting and ventilation control);

b. Suitable decisions from the very beginning of the design stage produce better outcomes;

c. Good management during the construction phase is mandatory;

d. Continuous monitoring during the commissioning and operation phases, and covering all seasons, is fundamental;
e. A sustainable building design will only result in a sustainable building if the operators and occupants are informed and educated about the sustainability aspects of the building;
f. Not every innovative system performs as anticipated and it is not the unique solution.

A “global” tool needs a prior adaptation of the sustainability benchmarks and priorities to the particular context of the country where the assessment is made, which is a very time-consuming process (Mateus and Bragança, 2011). On the other hand, some tools developed for a specific country are being applied abroad without any prior adaptation, causing distortions in the results of the sustainability assessment and producing wrong indications about the sustainable development of the construction industry, which brings the concept of sustainable construction into disrepute (Mateus and Bragança, 2012). The universe of tools for assessing the sustainability of the construction is already numerous, which owes its character to suit different purposes and type of buildings.

2.3.1 BREEAM

Within ten main categories to be considered during the evaluation of credits in BREEAM International New Construction 2016 sustainability assessment system. Each category has some different criteria related to it and depending on the type of the building and certification schemes these criteria can be different and even some of them might not be considered. BREEAM has 76 criteria. Mandatory minimum performance standards are set for some of the categories, which they must be met, whatever Code level is sought. In the calculation process credits are not awarded for the mandatory criteria. The ten main categories are: Energy (Ene); Materials (Mat); Innovation (Inn); Waste (Wst); Pollution (Pol); Health & well-being (Hea); Water (Wat); Transport (Tra); Management (Man); Land Use and Ecology (LE).

The assessment process should proceed in a logical order, beginning with a check that the mandatory criteria for which no credits are awarded have been achieved. The remaining tradable credits should be checked and confirmed so that they too contribute to the required sustainability level. If any of the standards for the non-creditable criteria do not met, then a zero rating will result, regardless of the other marks accomplish, including the mandatory criteria. For every category, the number of credits achieved is divided by the total available and multiplied by the weighting factor to give a percentage point score. The percentage of each category are then summed to record a total percentage count for the building, rounded down to the nearest whole number.

The sustainability Level is then derived from the Total percentage points according to Table 1.

Table 1: BREEAM certification levels

BREEAM Rating	Score
Outstanding	≥ 85%
Excellent	≥ 70%
Very Good	≥ 55%
Good	≥ 45%
Pass	≥ 30%
Unclassified	< 30%

2.3.2 LEED

The LEED sustainability assessment method is based on points, which are being given to individual credits. There are 43 different criteria in LEED. The credits are divided into seven main categories. The weight of categories is slightly different between the rating systems. These categories are the same in all of the LEED rating systems. The seven main categories are: Energy and Atmosphere (EA); Water Efficiency (WE); Sustainable Sites (SS); Materials and Resources (MR); Indoor Environment Quality (IEQ); Innovation & Design (ID); Regional Priority (RP).

The assessment is based on points and all LEED criteria are worth a minimum of 1 point. All LEED rating systems have 100 base points, and Innovation and Regional Priority credits provide opportunities for up to 10 bonus points. LEED guarantees minimum levels of sustainable practice through mandatory measures in different credit categories and there are no points for meeting the mandatory minimum requirements. All categories and criteria are listed with the number of available points, awarded directly and the sum of all the marks among the categories is equal to a total score.

The four performance tiers according to the number of points earned indicate the level of sustainability performance of the building according to Table 2.

Table 2: LEED certifications levels

LEED Rating	Score
Platinum	80 – 110
Gold	60 – 79
Silver	50 – 59
Certified	40 – 49

2.3.3 HBSAtool-PT

It can be applied to all Healthcare Providers, capable of evaluating new, existing and renovated buildings, allowing future adaptations to new guidelines, standards or national laws. Thus, the Method for Assessing the Sustainability of Hospital Buildings in Portugal (HBSAtool-PT) aims to make it practical, easily understandable and flexible enough to be simply adapted to different types of hospital buildings. This is important to promote the sustainable development, construction, operation and maintenance. The structure of the method is based on 52 indicators, divided into 22 categories, which are integrated into five areas: Environmental; Sociocultural and functional; Economic; Technical; Site.

The graphical output of the HBSAtool-PT is alike the labelling system used in the EU energy performance. Besides the Global Assessment, the label also communicates the performance at the level of each sustainability area and category, allowing a better comparison between different design approaches. The Sustainable Score and performance at the level of each sustainability area are ranked on a scale from A+ to E, demonstrated at Table 3. It is also possible to compare different design scenarios or healthcare buildings and to identify the priorities.

Table 3: HBSAtool-PT certifications level

HBSAtool - PT	Score
A +	x > 1,00

Table 3: HBSAtool-PT certifications level (cont.)

HBSAtool - PT	Score
A	0,71 < x ≤ 1,00
B	0,41 < x ≤ 0,70
C	0,10 < x ≤ 0,40
D	0,00 < x ≤ 0,10
E	x < 0,00

2.4 Comparative Matrix Healthcare Assessment Methods

The comparative analysis aims at contrasting the selected rating systems for assessing the performance of buildings with respect to the type of intervention. Regarding the life cycle stages, shown at Table 4, of a building, BREEAM and HBSAtool-PT cover all the four considered life cycle stages and LEED does not evaluate predesign or design.

Table 4: Life cycle stage of the building assessed by selected schemes

Rating System	*Predesign and Design*	*Construction*	*Post-construction*	*Use/maintenance*
BREEAM	•	•	•	•
LEED		•	•	•
HBSAtool-PT	•	•	•	•

Once the variables have been identified, the differences between the methods in each category is analysed. To this end, a set of criteria are required for a building and/or a project to be sustainable (Illankoon et al., 2017). These must be measurable, mutually independent, and must refer, whenever possible, to qualities or aspects related to the various environmental, economic and social aspects, either quantitative or qualitative (Al-Jebouri, Saleh, Raman, Rahmat, & Shaaban, 2017). Taking into account the criteria requirements and guidelines of the different methods used, it is able to identify, categorise and standardise the set of criteria as critical on the building performance (Lu, Geng, Liu, Cote, & Yu, 2017) and that will influence the decision-making process.

Regarding the original categories, different items refer to the same field and, sometimes, similar denominations do not assess exactly the same attributes. Therefore, thirteen major scopes were identified, in which the characteristic elements of all the categories have been grouped. According to this analysis, the categories most assessed are Energy (21%) and Indoor Environmental Quality (17%). Other important categories are Materials and Resources (13%), followed by Site Quality, Management, Water, Waste, Transport and Pollution, which are assessed by the great majority. To support the results, the scopes distribution among the schemes is presented graphically at Figure 8 with the core sustainability categories and its general scale to reach the entity.

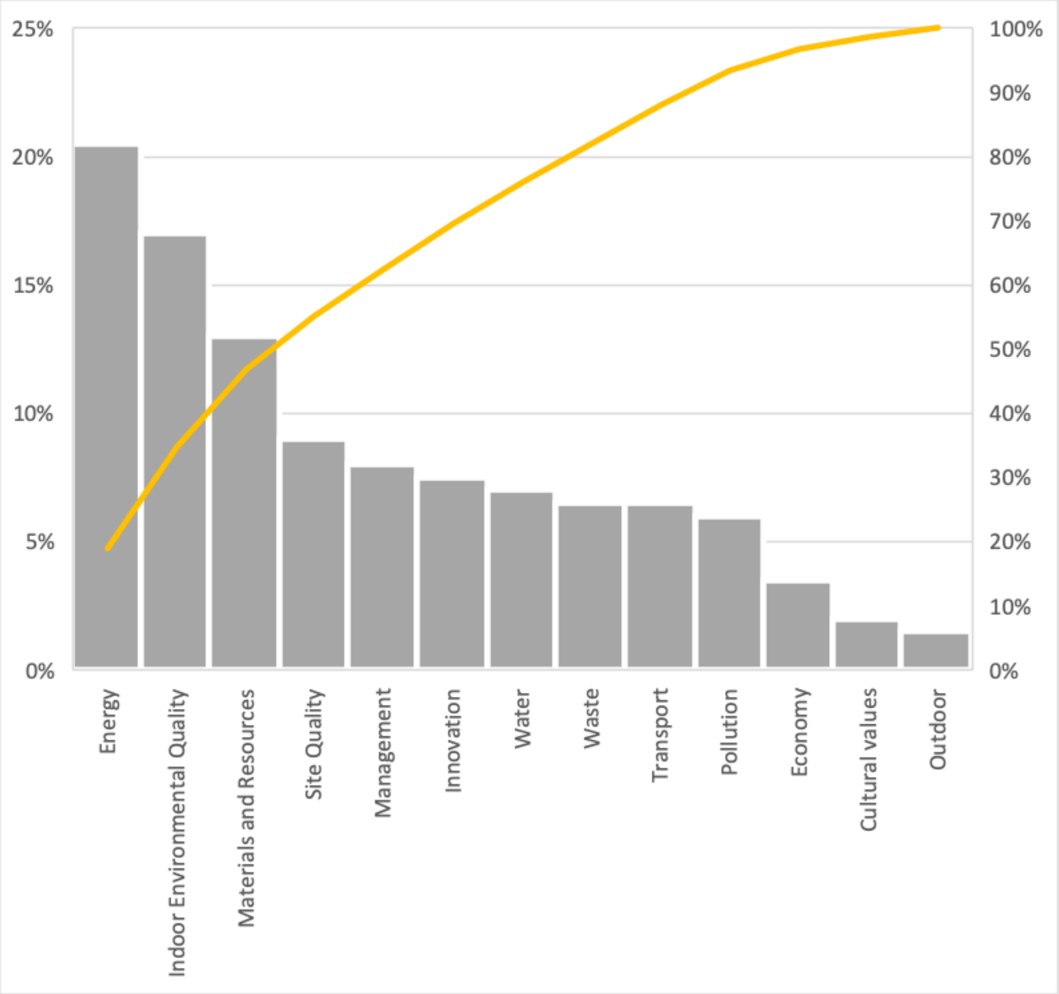

Figure 8: Scopes distribution among the analysed rating schemes

Based on the distribution of the most recognised categories presented above, they are more detailed into a brief list of indicators. These previous items are adapted to fit a wider panel within the assessment methods and to be used by comparison between the rating systems as illustrated at Table 5.

Table 5: Comparison of the scopes and criteria of the selected rating systems used for evaluating the sustainability of healthcare buildings

	Core Sustainability categories																												
	Energy					Indoor Environmental Quality				Management			Materials and Resources				Water	Pollution		Waste		Transport	Site Quality			Outdoor	Economy	Cultural values	Innovation
Rating system	Energy performance	Renewable Technologies	HVAC	Lighting	Reduction of Energy Use and Emissions	Visual Comfort	Thermal Comfort	Acoustic Comfort	Air quality	Management	Economic assessment	Integrative Design Process	Materials Reuse	Environmental Product Declaration	Materials	Land Use	Water	Noise Pollution	Light Pollution	Waste Water Management	Solid Waste Management	Transport	Outdoor Amenities and Facilities	Urban Planning	Ecology and Environmental Quality	Outdoor Quality	Economy	Cultural values	Innovation
BREEAM NC 2016	•			•	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•		•				•
LEED v4 for BD + C	•	•	•		•	•	•	•	•	•		•	•	•	•	•	•		•	•	•	•	•	•	•			•	•
HBSAtool-PT	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	
Global Agenda for Green and Healthy Hospitals	•	•	•		•	•	•	•	•	•				•	•	•	•			•	•	•	•		•				•

It shows that all of the Rating systems analysed have in common the Indoor Environmental Quality, Water, Waste and Transport categories. As well as the energy performance, reduction of energy use and emissions, management, and the majority of the materials and resources, and site quality category. On the other hand, the scopes that has two HBSA methods alike are lighting, economic assessment, integrative design process, pollution, cultural values and innovation. With that being said, outdoor quality and the economy are the most unique category represented at the HBSAtool-PT.

2.5 Weighting distribution

In general, the Healthcare Building Sustainable Assessment (HBSA) methods have a similar structure. They are based on sustainability assessment indicators, grouped into categories, and they present a single overall sustainability score. The weights are distributed according to the relevance of each category, and higher weights are attributed to indicators of greater importance (Cole, 1998; Croes & Vermeulen, 2016).

There is a large overlap between the three systems assessment criteria. The Figure 9 demonstrates the general emphasis of the major categories of BREEAM International New Constructions 2016, LEED v4 for Building Design and Construction (BD + C) and HBSAtool-PT, and their relative weights in each rating system. It also shows that there is a considerable overlap between the systems having its own particularities (Outdoor Quality and Economy in the case of HBSAtool-PT). For general comparison purposes, as it does not take into account point-less prerequisites, the names of some categories have been adjusted as some credits moved into categories to simplify the comparison.

There are shared concerns among these HBSA methods, such as: the use of energy; indoor environmental quality; materials and resources; water efficiency; transport and site qualities. On the other hand, each method highlights different criteria according to where they were aimed to be applied.

It is relevant to highlight that every method that gives much importance to one core sustainability category than others. In LEED BD + C, the performance at the level of the energy related to sustainability indicators has a weight of 33% in the global score, while in HBSAtool-PT it weighs less than 10%. On the other hand, BREEAM International New Construction has a more balanced weighting system between all core criteria. Moreover, in this method, ‘Economy’ is one leading sustainability category, although it is not considered in the other methods.

Similar to BREEAM (2016), LEED BD + C also specifies an extra 10% of credits in weighting. These extra 10% are awarded if it is demonstrated that the building suits a certain innovation criterion in terms of technology, market transformation and benchmarks (Figure 9).

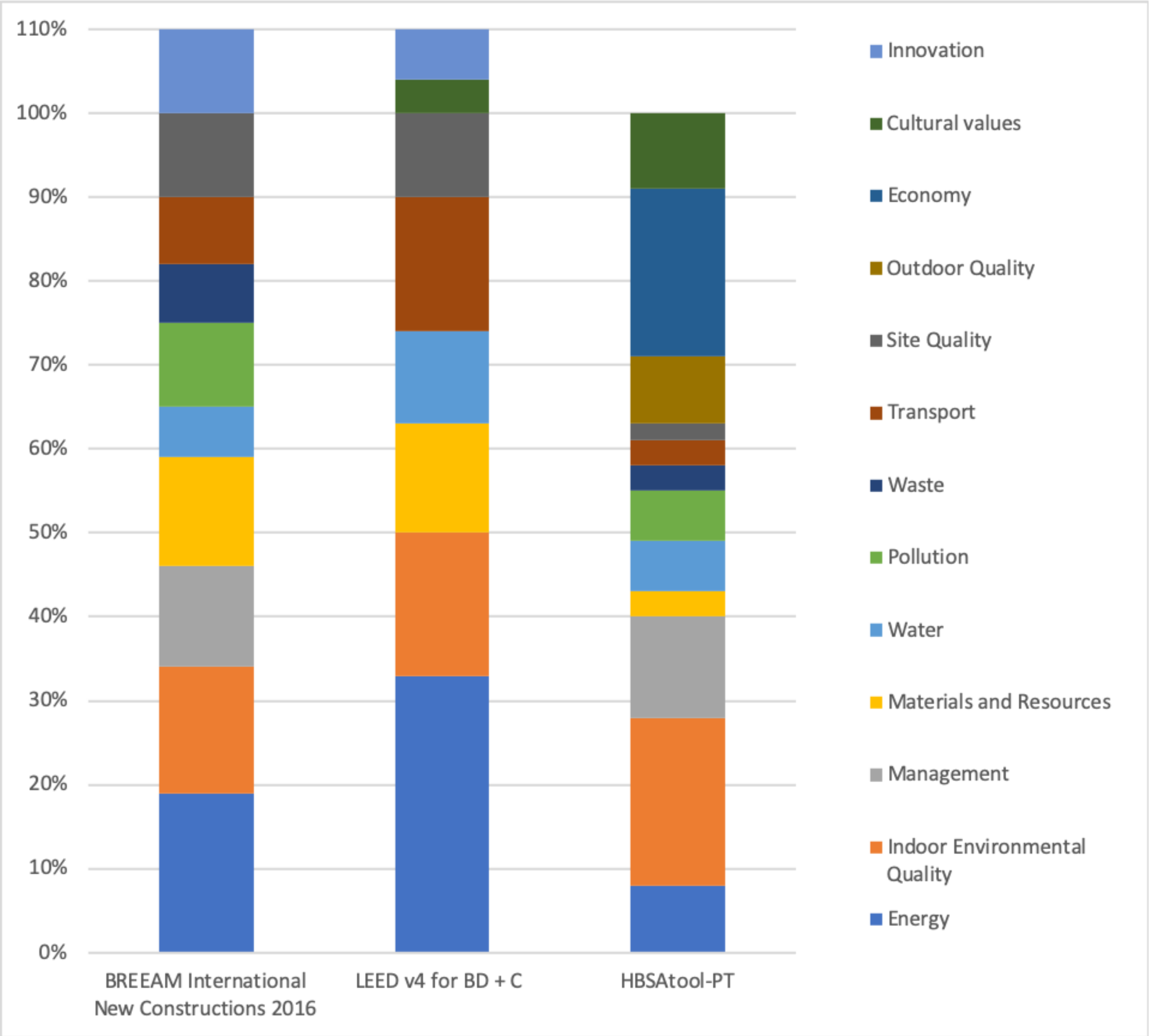

Figure 9: BREEAM, LEED and HBSAtool-PT weights distribution

2.6 List of indicators

The sustainable design of hospital buildings allows to achieve competitive strategies, as better economic and social efficiency. Thus, grouping the principles defended by Castro et al. (2012), the main objectives intended to achieve in the design and construction of healthcare buildings are:

a. To reduce patient recovery time;

b. To improve operational effectiveness and productivity;

c. To create increased facilities for users and neighbouring communities;

d. To contribute to the satisfaction and consequent fixation of the employees and to the patient's positive experience (complex performance evaluation system);

e. To increase the quality and safety of the indoor and outdoor environment;

f. To reduce operation risks associated with the project

g. To increase the lifetime of the building;

h. To reduce the operation, maintenance and construction costs;

i. To educate building users for a better awareness and understanding regarding the sustainable practices and the goal of the sustainability ratings.

In order to meet the objectives, the project should be based on a set of sustainability indicators, according to Table 6, introducing some indicators to be considered in the implementation of sustainable design practices in hospital buildings.

Table 6: Dimensions, categories and indicators to support the application of sustainable design practices in hospital buildings (source: Mateus & Bragança, 2019)

Dimension	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
		Heat island effect
	Energy	Non-renewable primary energy
		Energy produced locally from renewable sources
	Materials and Solid Waste	Reuse of materials
		Use of recycled materials
		Use of certified materials

Table 6: Dimensions, categories and indicators to support the application of sustainable design practices in hospital buildings (source: Mateus & Bragança, 2019) (cont.)

Dimension	Categories	Indicators
Environmental	Materials and Solid Waste	Use of cement substitutes in concrete
		Storage conditions of solid waste during the building's use phase
	Water	Water consumption
		Reuse and use of non-potable water
Social	Comfort and health of users	Efficiency of natural ventilation in indoor spaces
		Toxicity of finishing materials
		Thermal comfort
		Visual comfort
		Acoustic comfort
	Accessibility	Accessibility to public transport
		Accessibility to amenities
	Awareness and education for sustainability	Formation of occupants
Economic	Life cycle costs	Initial cost
		Operation costs

2.7 Brazilian context

In the last ten years, Brazil's population has grown by more than 21 million inhabitants, but with a geometric average annual growth rate of 1.17%. Currently, Brazil has approximately 208 million people, with the majority of the population concentrated in the urban area (84.4%). Highlight should be given to the Southeast region as the most populous (80 million), led by the state of São Paulo with 45 million inhabitants, representing 22% of the country's total population (IBGE, 2018). According to the World Health Organisation (2009), the lack of sanitation in Brazil is responsible for 80% of diseases and 65% of hospital admissions, implying expenses of US $ 2.5 billion.

The particular operation of hospitals involves a range of activities that present great potential of environmental impacts. These organisations operate 24 hours a day, 365 days a year, have different equipment for food production, consume non-renewable energy and also demand a variety of other common resources in considerable quantities, including plastics and paper products. In this context, hospitals perform similar to the industry, such as laundry, transportation, cleaning, food, among others. However, unlike other activities, it consumes a large amount of disposable medical products, used to prevent the transmission of disease to doctors, patients and employees (Castro, 2017).

2.7.1 Energy

Brazil has the third–largest electricity sector in the Americas whose matrix is based mainly on hydroelectric plants (61%), followed by thermal plants, means that are strongly impacting from a social and environmental point of view, depicted in Figure 10. Measures to reduce the demand for electricity production become an indispensable condition to guarantee, in addition to an adequate environment for the development of present and future generations, the viability of the economic development of the country (Ministry of Mines and Energy, 2011).

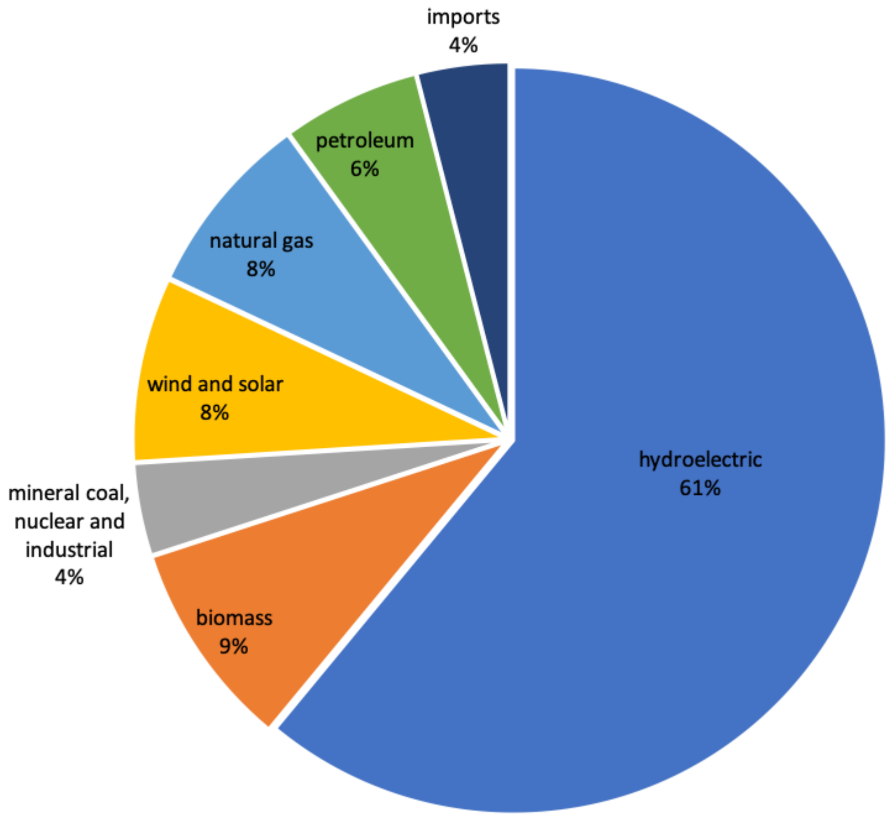

Figure 10: Power generation supply – year 2017 (adapted from: Ministry of Mines and Energy, 2018)

According to Lamberts et al. (2010), although hydroelectric plants are a renewable source of energy, the potential is limited, in addition to the limits to the growing demand, which depend on large financial investments and cause large environmental impacts. Increasing energy use, the consequential extraction of natural resources and the increasing elimination of tailings bring the idea that, besides being unsustainable, the current development model is also undesirable, under criteria of environmental preservation.

In addition to the environmental benefits of controlling the growing need for power generation, it is necessary to consider the economic advantages due to the reduction in the financial investments required to implement the energy transformation and transmission infrastructure.

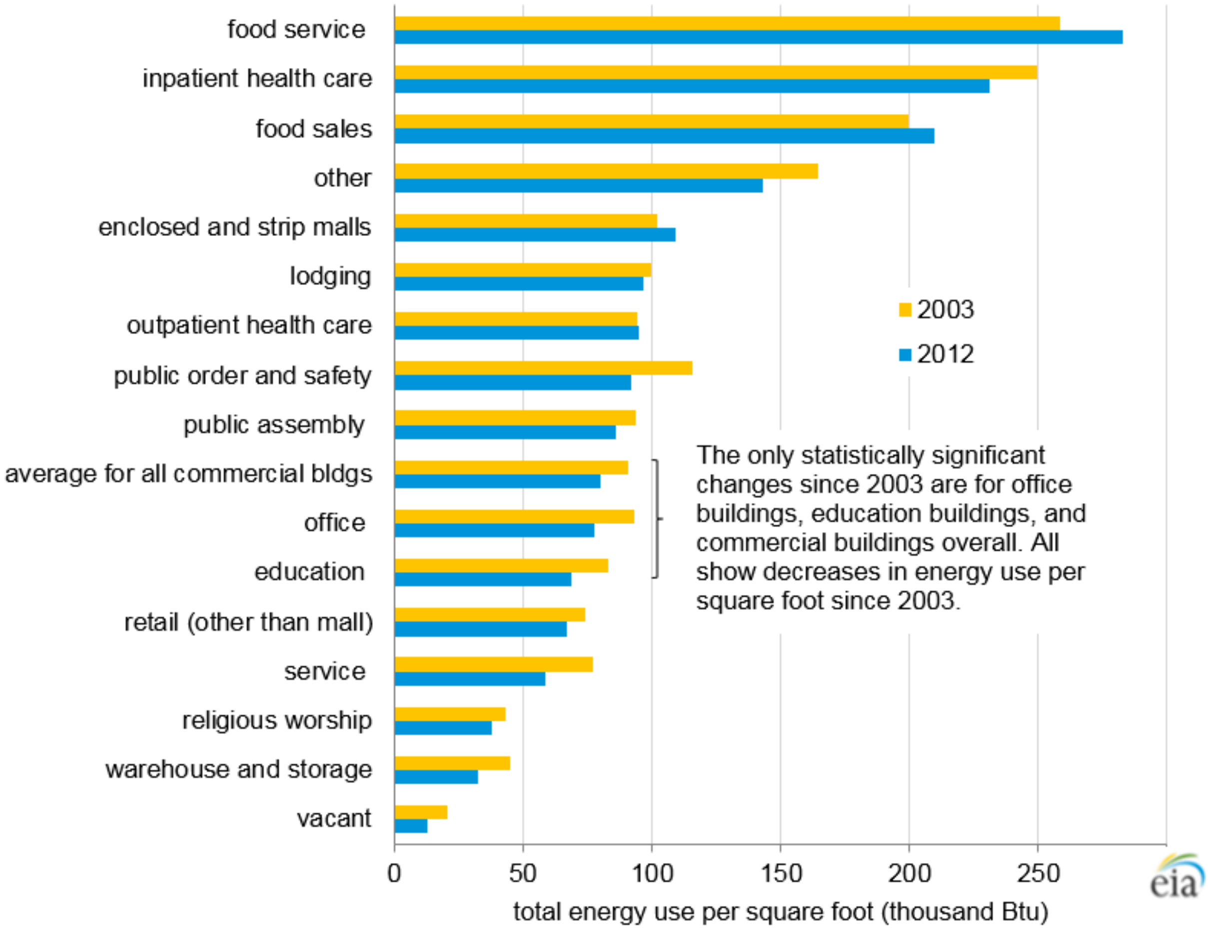

Figure 11: Energy use per square foot by category (adapted from: Commercial Buildings Energy Consumption Survey, 2016)

Food service and inpatient health care (hospitals), as shown at Figure 11, are the most intensive users of energy among the building types. Hospital energy use is high because of around-the-clock demand for all end uses and because of a wide variety of specialised, energy intensive equipment such as medical imaging equipment (CBECS, 2016). According to the Health Care Without Harm (2006), Brazilian hospitals use huge amounts of energy representing more than 10% of the country's total energy consumption.

A study elaborated by Eletrobrás (2008), indicates that 12.5% of the total operational costs of the hospital sector are related to the use of electricity. The same study indicates that the use of electro medical equipment, artificial acclimatisation and artificial lighting together account for about 88% of the total energy used in hospitals in Brazil - artificial acclimatisation represents 30% of the total electricity use. In this sense, it can be affirmed that the proposition of architectural solutions that consider the local bioclimatic conditions, materials used in the construction, among other factors that contribute to a lower thermal load and may represent great potential in reducing energy use.

2.7.2 Energy Efficiency

According to Vargas (2006) the consumption of electricity in hospitals is mainly due to lighting systems, air conditioning, ventilation, water pumping, hospital equipment, information systems and water heating. Fuel oil as well as Natural Gas is generally used in boilers for the generation of steam and hot water. Diesel fuel is not very representative and is generally used for emergency power generation.

The average percentage distribution of energy consumption in Brazilian hospitals, where most of the energy consumption comes from environmental conditioning systems (44%), followed by lighting (20%) (Vargas, 2006). This data is important because guides action plans on energy efficiency with a view to first targeting the largest consumers and to assess the biggest gains. As reported by Soares (2004), this economy can vary from 10% to 15% for lighting programs and from 10% to 12% for air conditioning. The author notes that 64% of energy consumption comes from water heating, environmental conditioning and lighting.

In the case of the hospital sector, there is a correlation between the number of hospitalisations and beds and the consumption of hot water. There is also a correlation between the complexity of the medical-hospital services and the demand for environmental conditioning.

2.7.3 Water

Brazil has 77% of the fresh water supply in South America and 11.6% of the world's reserves. These figures show that it is a privileged country with respect to the quantity of water, but its distribution is not uniform throughout the national territory, because 68% is located in the Amazon region, where there is only 8% of the total population. The remaining 32% are distributed across the country to serve 92% of citizens, displayed at Figure 12 (Water National Agency, 2018).

Studies show that global warming irregularly affects the rainfall regime by producing more frequent flooding and tends to increase the intensity of extreme weather events such as hot and cold waves. Regarding water, because it is a basic element for life, the concern related to HealthCare Buildings involves the sanitary conditions, hygiene and non-contamination.

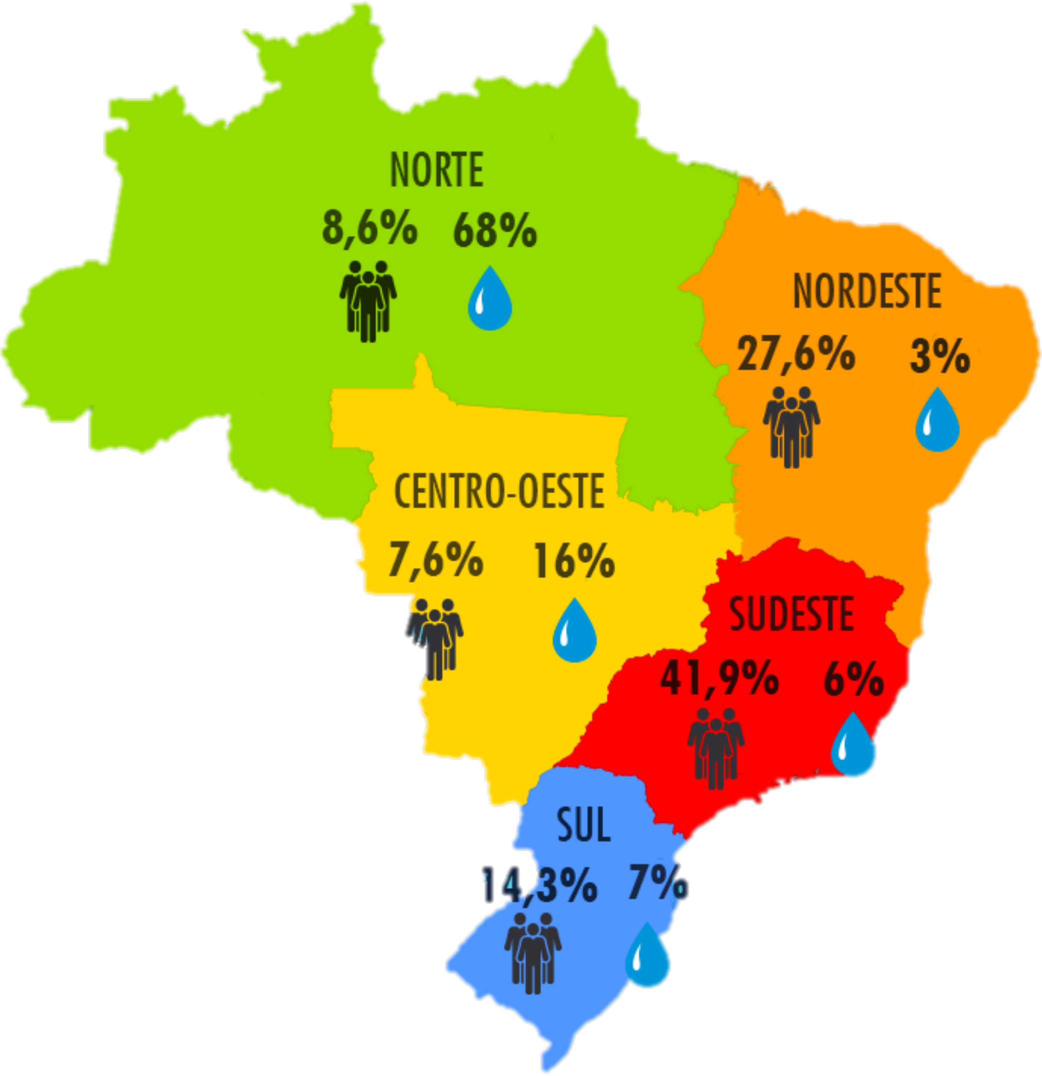

Figure 12: Water distribution in Brazil – population and water availability (percentage) (Water Nacional Agency, 2017)

Analysing the hospital building by sectors (Bittar, 2015), the water consumption indicates the infrastructure (laundry 22%, kitchen 18% and central of sterile material 16%), by far the largest consumer, followed by Clinical and surgical hospitalisation (14%) and Complementary diagnosis and therapy (13%), illustrated at Figure 13.

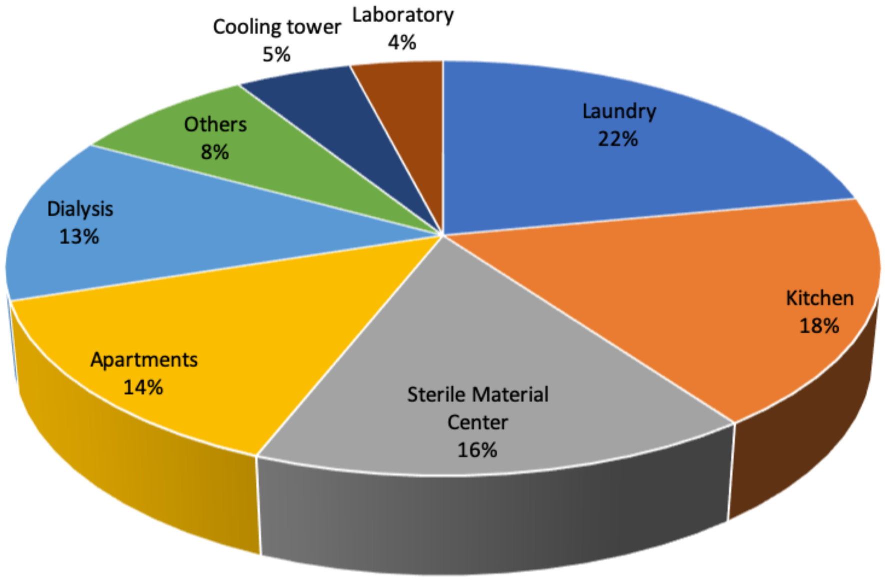

Figure 13: Consumers of water in the hospital environment (adapted from: Bittar, 2015)

Inserted within a context of optimisation in the use of these essential resources, the certification tools, specific to the area, become a great ally. The use of water saving devices and reuse are some possibilities to be implemented in buildings for water efficiency. Synergy options between infrastructure systems can collaborate during the process of integrated planning of physical resources, with the implementation of permanent measures that are long lasting and compatible with the technology used.

2.7.4 Solid waste

Brazil produces about 150 thousand tons of urban waste a day and it is estimated that 1 to 3% of this volume is represented by those produced in places that offer health services (Sanetran, 2016). Without the collection of hospital waste, besides the environmental risks, the population is exposed to the contagion of serious diseases to health. The Ministry of Health (MS), together with the National Sanitary Surveillance Agency (ANVISA), has prepared the Health Services Waste Management Manual, which indicates some indicators that may help the management of Health Service Waste and, consequently, associate the results of these indicators to the guidelines of the National Solid Waste Policy.

The volume presents the pertinent regulations, concepts and classification, potential risks, integrated management, necessary steps (segregation, collection, packaging, transportation, treatment, final destination) to implement the Health Services Waste Management Plan (PGRSS), health and job security and continuing education. The indicators proposed to monitor the PGRSS were grouped by area of interest (ANVISA, 2006).

It is fundamental that in the hospital there is a group of professionals who develop and manage the plan, preferably those directly linked to the hospital infection and occupational safety sectors, contemplating the guidelines of this policy so that the reverse logistics of solid waste is implanted, as one of the strategies for sustainability of the planet. Improve procedures and implement indicators such as those proposed in the manual as well as other forms of good management practices.

2.8 Ecoefficiency - improving the performance in healthcare units

The main objective of health facilities is to provide quality patient care. During this process, water and energy are constantly required, and different materials are used, generating effluents that need to be treated and a variety of solid wastes that need adequate management, as they constitute important sources of contamination for the environment and for the population. Implementing a healthcare waste management plan to meet legal requirements does not solve the problem. The smaller the amount of waste, the lower the cost for treatment will be, but alternatives that seek to reduce waste generation are still scarce.

Acting to mitigate the impacts of the entire hospital operation involves the mobilisation and commitment of employees, suppliers and other stakeholders directly involved in the operation. In this way, educating and raising awareness has been a long but adequate way for attitudes towards environmental sustainability to be strengthened and made permanent.

Eco-efficiency is achieved through the provision of competitively priced goods and services that meet human needs and bring quality of life, while at the same time pursuing the progressive reduction of environmental impact and resource consumption over the lifetime to a level that is at least equivalent to the Earth's estimated carrying capacity. However, the concept of eco-efficiency has still been little applied, the interest of health institutions in the quality programs is increasingly felt, but there is rarely a concern with the control of waste generation, as the mechanisms that focus the prevention of pollution and the non-generation of waste and effluents are still deferred to the treatment or final disposal systems.

With these characteristics present, hospitals in their operation, generate a great amount of waste and, on the other hand, demand great amount of resources like electrical energy and water. Velez (2004) points out that energy consumption is very diversified, including lighting, air conditioning, boilers and kitchens, which means that in the absence of any rationalisation plan, it can represent 15 to 30% of revenues organisation. In turn, Davies et al. (1999) report that the high energy consumption of US hospitals contributes to the fact that these units have the second highest consumption among all commercial buildings, and the available indicators show that average energy consumption is 240 kWh/m^2 per year.

The use of water is also diverse, including sanitary conveniences for both patients and visitors, laundry, cleaning facilities, restaurants and gardens. Available indicators show that total consumption varies greatly, depending on the degree of development of the country. In Denmark, for example, the consumption of cold water per bed per day reaches almost 600 litters, while in Austria this figure reaches 200 litters per day. When comparing hot water consumption in hospitals in the United States, the difference is from 340 to 110 litters/bed per day (Velez, 2004).

If the concern to construct indicators of environmental performance is already present in many countries, in the Brazilian case there is still a long way to correctly quantify the environmental impact associated with the hospital activity. Currently, Brazilian legislation, requires that any health unit has a Solid Health Waste Management Plan – RSS and, in order to comply with the legislation, hospitals normally delegate this management activity to the hygiene and cleaning service, considering the involvement of all employees. Professionals working in this process do not have an environmental approach in their training, and this technique is specific, and does not provide the necessary preparation that enables conditions that ensure the minimisation of environmental risks internal and external.

Evidencing the increase involvement of the hospital in environmental management is the participation in the Global Agenda for Healthy and Green Hospitals, which aims to support global initiatives related to sustainability and environmental respect in the health sector. The agenda operates with interlinked principles focused on reducing environmental impacts, such as those from waste and inputs. In 2013, the institution drew up a medium-term plan to meet all these principles, which requires an intense work of raising awareness among managers and employees. Today there is the adhesion of the institution to the objectives, but all will be implemented systematised in the future (Health Care Without Harm, 2016).

2.9 Why the existing methods are not appropriate to the Brazilian context?

Regarding the implementation of the sustainable healthcare building concept, several assessment methods determine the criteria that guide professionals to meet the standards and to follow the developments related to the update of the performance indicators used, but still some issues need to be taken into consideration to be more accurate to the reality. For example, larger databases related with the life cycle of buildings and materials are needed as well as more and better correlations between construction costs and operational costs. In the construction sector, the use of traditional and outdated processes leads to the use of multiple construction processes and to a large heterogeneity of products, regardless the low industrialisation and also the qualification of more professionals on assessment tools is needed (Barbosa & Almeida, 2017).

The type of tools used and its applicability may be influenced by many factors, therefore the requirement of a specific and more reliable method. It’s necessary the development of an assessment based upon methodologies and standardisation, a list of parameters where the most relevant construction impacts are considered, limited enough for practical use, considering the regional differences. The establishment of a balance between different dimensions of sustainable development (environmental, social and economic), limiting the qualitative indicators difficult to validate and improving reliability through the use of accepted life cycle methods.

According to Bellen (2002), the ranking systems helps to identify the main advantages and also the limitations of the different evaluation processes that exists and also provides a systematic review of the evaluated and compared methods. The comparative analysis allows different groups with different objectives to choose the most appropriate method to achieve their goals. Many countries either have or are in the process of developing sustainability assessment methods, which makes coordination increasingly relevant. In Brazil, the assessment tools for healthcare buildings, considering the differences within a country, nowadays the mostly used is LEED, developed in the United States and adapted to the context.

3 MATERIALS AND METHODS

3.1 Approach

This study seeks to investigate specific sustainability assessment methods for healthcare buildings, namely BREEAM International New Constructions 2016, LEED v4 for Building Design and Construction and HBSAtool-PT, in order to determine the key similarities / differences and consequently establish the essential sustainable criteria for potential consolidation adjustment to be used in the Brazilian context. These particular schemes have been selected according to the following criteria: BREEAM International New Constructions 2016 and LEED v4 for Building Design and Construction are the leading systems, both being operated by well-known organisations (BRE and USGBC) that have a proven record in the domain of sustainability development. On the other hand, HBSAtool-PT is a case of Method developed specifically for Portuguese healthcare buildings, considering the national context, the other existing recognised sustainability methods for this type of buildings.

This research is focused on the comparison of different rating systems in sustainability healthcare buildings. It provides some comprehensive criteria for the former list of indicators within the categories. Its identification is imperative to study on the pattern of sensitivity (weighting system) of each assessment method.

The proposed methodology is based on the study of several requirements and needs of hospital buildings, to understand the establishment and definition of a list of parameters to be followed and framed within the possible and necessary evaluation of this type of building. In this way, the intention is to structure sustainable project practices for health-related buildings, also by developing a hierarchy of the importance for the list of indicators. The evaluation and determination of sustainable best project practices will be based on the three dimensions of sustainable development (environmental, social and economic).

The study is based on the Sustainability Assessment Methods of Hospital Buildings most recognised in the market and its potential to support the decision making. Also, a comparison between the predefined weight of each method was given to illustrate best the preferences.

Considering the suitability for the context in which they were created, identifying the possibilities and potentialities of adaptation from the list of indicators of HBSAtool-PT to the Brazilian context by studying the need to comply (increasing or reducing) to assess, in a first phase, the changes that would be necessary to adapt into the weighting system.

At the end an online questionnaire was developed and applied in order to identify and collect the opinion from different healthcare stakeholders, namely managers and designers, to analyse if the list of indicators is suitable to the Brazilian reality.

3.2 Procedures

The first step of the implemented methodology is to identify the Sustainable Assessment Methods of Healthcare Buildings in the market around the world, to comparatively analyse the international application, at the level of the definition, structure, list of indicators, form of assessment and communication of results. This step is based on the analysis of the potential impacts and criteria proposed by:

a. The existing methods compared with each other at the level of the list of indicators;

b. The sustainable case studies: identifying sustainable principles considered in the design and operation of healthcare buildings.

Further, to analyse the potentialities of the HBSA methods, considering the application, and identify the added value as a mechanism to support decision making during the different phases of the construction life cycle. The analogy list of indicators proposed and the weighting system defined by the level of importance defined by the stakeholders comparable to the ones with international application is the goal of this process. To establish a juxtaposition between the classification levels of each method in the results.

The proposed criteria structure for a multi-dimensional approach, the process for the developing a list of parameters and the system of weights for the assessment indicators is flexible and comprehensive, based on the benefits and barriers of the different approaches. Combining the revealed possibilities of transformation from the HBSAtool-PT to the Brazilian context by studying the need for conversion of the list of indicators (reduction or increase) and evaluate, in a first phase, the modifications necessary to make in the weight system.

In this study, the potentialities of the adaptation of HBSAtool-PT method to the Brazilian reality, to support design makers, constructors and owners, reliable to the society context and actuality (ethical system), to increase the building performance and efficiency. For that, it will be used the questionnaire oriented to the key stakeholders involved in the context of healthcare buildings implemented in Brazil, to determine the recognition of the list of indicators and the weighting system developed and proposed for the Brazilian context.

At the end, the Analytical Hierarchy process (AHP) will be used in the interpretation of results obtained in the questionnaire, this process also allows the definition of weights to be assigned to each SED indicator (Saaty, 2008).

3.3 Research method and definition

In this topic, Brazilian hospital buildings among their regulation, recommendations and requirements will be studied. Existing evaluation methods and sustainable concerns will also be analysed, with a special focus on methods for healthcare. This task aims to establish a list of criteria for this type of building, where it will be defined by crossing various approaches and selecting points from the HBSAtool-PT method, which fits into this typology of buildings.

The objective is to adapt a list of indicators considering the support to healthcare buildings according to the Brazilian reality, measurable and associated with the goals of Sustainable Development. The indicators grouped into categories will integrate different areas of sustainability, that influence the building at a level, considering specific aspects (Castro, 2017a).

In the context of Healthcare Building Sustainability Assessment methods, the evaluation system is crucial since it allows for the aggregation of the performance obtained at the level of the different indicators and a comparison among the various buildings. Within this framework, a new method proposal includes a broader and comprehensive list indicators to support building stakeholders in the creation of a more sustainable healthcare sector established and also detailed information on healthcare buildings collected and organised that can be used by constructors, managers, owners and users to increase their performance.

3.4 Data collection

The evidence will be collected by interviews, within specialists in the hospital sector, to validate the proposed list of indicators and the method structure, among the opinion of each stakeholder's group from diverse fields (architects, engineers, hospital managers, etc.) at the level of each proposed sustainability indicator. This approach will gather the information needed to understand the relative importance of each indicator and to develop the relative weighting system.

Saaty (1988) recommends that when there are different levels of expertise and experience in an interviewed sample, it should be organised into three distinct groups and weights, meaning that the opinion weight is higher accordingly to the competencies in the field (Castro, 2018).

By gathering the opinion of the stakeholders, the validation of the list of sustainability criteria, can be used also to collect the opinion of healthcare building users (patients, visitors, medical and logistic staff), after its experimentation in the market.

3.5 Analytical Hierarchy Process (AHP)

Developed by Thomas L. Saaty in the 1970s, it is an organising and analysing mathematical method for complex priorities and decisions, used as a methodology for human decision maker's priorities in fields such as government, business, project selection, healthcare and education (Saaty, 2008).

AHP is considered as a simple technique that is able to translate the evaluations of both qualitative and quantitative data made by the decision maker into a multi-criteria ranking. In addition, the AHP includes a useful tool for checking the consistency of the decision maker's evaluations, thus reducing the bias in the decision making process (Hikmat H. Ali, 2009).

AHP involves the following three-step to make a decision in an organised way to find priorities of objects (Saaty, 2008):

a. Model building, structure the decision hierarchy from the top to bottom with the goal of the decision;

b. Create a set of pairwise comparison matrices, the matrix is a (m×m6) real matrix, where m is the number of evaluation criteria considered. Each entry (XY) of the matrix represents the importance of the (X) criterion relative to the (Y) criterion.

c. Use the priorities obtained from the comparisons to weigh the priorities of the alternatives, the higher in weight, and the more important correspondent criterion.

3.5.1 Group of stakeholders involved

Empirical research from around the world shows the benefits of engaging local communities in sustainability monitoring. Criteria developed within this type of approach are very helpful and usually contribute to improving the indicators developed by experts, because it helps the definition of priorities that answer to the particular local context (Reed, Fraser, & Dougill, 2006).

The sample is composed by a group of stakeholders, and they are from diverse fields: architects, engineers, sustainable construction experts and hospital managers. All participants were classified into three main groups:

- Group I - Sustainable construction and building experts (qualified evaluators of BSA methods, researchers, professionals and designers of building industry) and professionals with more than five years of construction and design experience in the healthcare context;
- Group II - Hospital managers;
- Group III - Professionals with less than five years of construction and design experience in the healthcare context or environmental and sustainable design (designers and building industry professionals).

Although the last group has less experience than others, it is assumed that it was important to consider their opinion in the weighting process since they are actors in the process of designing sustainable buildings.

3.5.2 Relative Importance Scale

In order to define the relative importance scale, the relative importance index (RII) was employed. Relative Importance Index or weight is a type of relative importance analyses. RII aids in finding the contribution a particular variable makes to the prediction of a criterion variable both by itself and in combination with other predictor variables which is best fit the goals of this study. RII creates values ranging from 0 to 1, where 0 denotes least significance and 1 denotes highest significance.

To calculate the Relative Importance Index (RII), the Equation 4.1 was used.

$$RII = \frac{\sum W}{A * N} \tag{4.1}$$

Where, W—weighting given to each statement by the respondents and ranges from 1 to 5; A—Higher response integer (5); and N—total number of respondents.

Based on the equation 4.1, RII was obtained for each indicator. Accordingly, the category index is the average of the relative importance index for the indicators in the various categories, as presented in the Equation 4.2 below.

$$\frac{\sum RII}{n} \tag{4.2}$$

Where, ΣRII – sum of RII of indicators in each category, and n—total number of category indicators.

3.5.3 Definition of the weight of each category or indicator

The AHP method can convert subjective human judgment into a quantitative analysis based on the principles of decomposition, comparative judgments and synthesis of priorities. To enable this method to be applied, it is necessary to make paired comparisons, which are executed between categories and between indicators belonging to each of these. Using the square Matrix structure, it is possible to establish the relative importance (relative weight) of each indicator and category (Hambali, Sapuan, Ismail, & Nukman, 2010).

To make paired comparison, a scale of numbers is required to indicate how many times more important one element is over another element at the level the criterion to which they are compared. The relative importance of two criteria is measured according to a numerical scale from 1 to 9 as shown at Table 7 and Figure 14.

Table 7: The fundamental scale of absolute numbers (Saaty, 2008)

Scalar value	Reciprocal scalar value	Definition	Explanation
1	**1**	Equal importance	Two activities contribute equally to the objective
2	**1/2**	Weak or slight	
3	**1/3**	Moderate importance	Experience and judgment slightly favour one activity over another
4	**1/4**	Moderate plus	

Table 7: The fundamental scale of absolute numbers (Saaty, 2008) (cont.)

Scalar value	Reciprocal scalar value	Definition	Explanation
5	**1/5**	Strong importance	Experience and judgment strongly favour one activity over another
6	**1/6**	Strong plus	
7	**1/7**	Very strong	An activity is favoured very strongly over another; its dominance demonstrated in practice
8	**1/8**	Very, very strong	
9	**1/9**	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation

For evaluating the result based on the relative scale, according to the definition of the method, the highest RII in each group is used as the number of extreme importance and, consequently, the lowest RII in each group as the minimum number. The relative scale is divided into 8 intervals, shown in Figure 14.

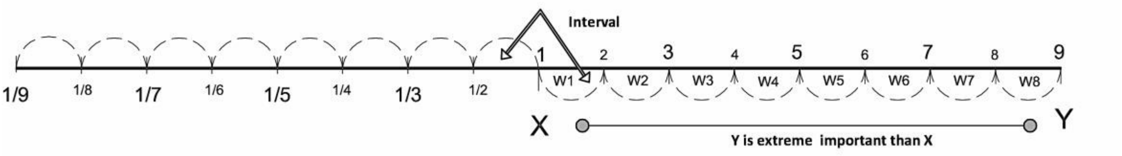

Figure 14: AHP scale for the study goals

When the matrix is built, it is possible to obtain the normalised pairwise comparison by making equal to 1 the sum of the entries in each column. Matrix norm is computed using Equation 4.3.

$$XY\ norm = \frac{XY}{\sum_{k=1}^{m} entries} \tag{4.3}$$

Finally, the criteria weight vector (w) is built by averaging the entries on each row of matrix norm, w is computed as in equation 4.4.

$$weight\ vector\ (w) = \frac{\sum_{k=1}^{m} entries\ norm}{m} \tag{4.4}$$

The consistency technique relies on the computation of a suitable consistency index, (CI), obtained by using Equation 4.5.

$$CI = \frac{z - m}{m - 1} \tag{4.5}$$

Where z = weight vector (w) divided by the total of the weight vectors.

RI is the Random Index, the consistency index when the entries of the matrix are completely random. The values of RI for small problems (m ≤ 36) are shown at Table 8.

Table 8: Values of the Random Index (RI) for small problems

m	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
RI	0	0.85	0.9	1.12	1.24	1.34	1.41	1.45	1.51

The value (weight vector) is considerate as consistent if in the Equation 4.6 below, CR is less than 10% (0.1).

$$CR = \frac{CI}{RI} \tag{4.6}$$

3.5.4 Averaging method used in the definition of the weight of each area

The mechanism chosen to obtain the final weights for the five proposed Areas is the sum of the average of the percentages derived from the responses of each group of experts, obtained in the RII. The weight of each area is the final numbers assigned by each area divided by the sum, meaning the proportion between them.

4 ADAPTATION PROPOSAL OF THE LIST OF SUSTAINABILTY INDICATORS AND WEIGHT SYSTEM FOR THE HEALTHCARE SECTOR IN BRAZIL

4.1 Development of the list of indicators and validation

The definition of the preliminary set of sustainability indicators included all different criteria identified in existing methods for the healthcare context and was based on literature survey and analysis of the following data:

a. Two most used assessment method, at the international level, to assess the sustainability of healthcare buildings, namely: BREEAM International New Constructions 2016 and LEED v4 for Building Design and Construction;

b. The list of areas, categories and indicators of the HBSAtool-PT.

c. Global Agenda for Green and Healthy Hospitals objectives.

The preliminary set of indicators included all different environmental, social, economic, technical and site indicators identified in the BSA methods mentioned before. The used approach is similar to the ones used by other authors in the development of BSA methods for specific contexts.

4.2 Experts analysis

The qualitative stage, related to measure the quality of the results rather than its quantity, was matured by an email invitation sent to sustainability experts from the Brazilian healthcare field and academia to voluntarily participate, totalising seventeen (17) people. A comprehensive of three (3) experts agreed to participate to evaluate the preliminary list of indicators and a guideline was sent in advance by email for them to reply. The validation with architects and researchers in the sector was carried out in December/January between 2019 and 2020.

The low expert’s adherence to the first validation might be explained by the period of the year where the questionnaire was conducted, which is a common vacation season in Brazil. But the ones that cooperated are experts with great expertise and influence in the healthcare architecture and sustainability. The profile among the professionals are an ex-president from the Brazilian Association for the Development of Hospital Building, a member of International Academy for Design and Health – South American Chapter, and also a professional consultant in the field of building sustainability assessment.

As a result, the interviews allowed the definition of the list of sustainability categories and related indicators. From these discussions, some indicators that were highlighted and considered as a priority according to the Brazilian reality were added or adjusted to the initial list by the justification presented and non-relevant or very difficult to evaluate indicators weren't mentioned, as detailed in the Table 9.

Table 9: Indicators that were suggested by the experts that were not included in the preliminary list of indicators

Suggested Indicators	Area	Justification
Corruption avoiding plan	Economy	Considering the Brazilian situation, the Economy area should have sustainable purchase policies in order to prevent extortions.
Olfactory Comfort	Sociocultural and functional	To enhance the comfort of users in hospitals by the minimisation of olfactory discomfort and improvement of indoor air quality.
Contingency Plan	Sociocultural and functional	A very punctual situation caused by emergencies in cases of serious claims (e.g., pandemics, floods).
Universal Design	Technical	Composition of an environment that can be accessed, understood and used by all people, regardless of their age, size, ability or disability.
Space flexibility and Space adaptability	Sociocultural and functional	Merge both because they talk about the possibility of adapting the area.

The experts also suggested that some indicators should be changed to accommodate the Brazilian's healthcare context, such as the adjustment of the term 'Facilities' to avoid misunderstandings, since this concept is used as operation and management. Therefore, it was changed to 'Conveniences'.

The corruption avoiding plan should be added to the previous set list of indicators presented by having a particular relation to the political context, by analysing if the healthcare institution does or doesn't comprise practices that oppose or inhibit corruption.

On the other hand, the criteria of olfactory comfort are used in the Haute Qualité Environnementale (HQE) and sub-targeted into objectives, as the provision of efficient ventilation, the minimisation of olfactory discomfort and the improvement of indoor air quality. These items are already embedded into the User's health and comfort category, therefore not being considerate as an indicator to be added.

The Contingency Plan is another item that wouldn't be interesting to include into the list presented because it is only used in odd circumstances and challenging to measure. Besides in Brazil there are no occurrences of natural disasters (e.g., hurricane, earthquakes and tsunamis). The Universal Design was not taken into consideration because the research is based on the added value, meaning that only the improvements compared to the standard Brazilian design practices will be considered. The Universal Design is already mandatory in the design of healthcare buildings (according to e.g., ANVISA – RDC 50/2002 and ABNT NBR 9050).

It was also suggested to merge two items into one, Space flexibility and Space adaptability, but one describes the changes that can happen during the period of a day, using furniture elements, doors, panels and curtains, while the other describes the adaptive capacity of the room in case of renovation.

With this method, it was possible to define the first draft of sustainability indicators and parameters which were after used to develop the questionnaire for architects, engineers, healthcare managers and superintendent/directors to produce the final indicators list.

4.3 List of indicators

As a result of the analysis from the existing assessment methods together with the opinion of the experts, the final list of indicators was developed, as depicted at Table 10. The list presents fifty-seven (57) indicators, organised into twenty-three (23)categories (C1 Environmental life cycle impacts assessment; C2 Energy; C3 Soil use and biodiversity; C4 Materials and Solid Waste; C5 Water; C6 User's health and Comfort; C7 Controllability by the user; C8 Landscaping; C9 Passive design; C10 Mobility plan; C11 Space flexibility and adaptability; C12 Life cycle costs; C13 Local economy; C14 Corruption avoiding plan; C15 Environmental management systems; C16 Technical systems; C17 Security; C18 Durability; C19 Awareness and education for sustainability; C20 Skills in sustainability; C21 Local community; C22 Cultural value; C23 Conveniences). This list was included in the questionnaire to healthcare buildings stakeholders.

Table 10: List of sustainability areas, categories and indicators included in the questionnaire

Areas	Categories	Indicators
A1 Environmental	C1 Environmental life cycle impacts assessment	I1 Assessment of the building's life cycle impacts
	C2 Energy	I2 Primary energy consumption
		I3 Local energy production
		I4 Minimum Energy Performance
	C3 Soil use and biodiversity	I5 Layout optimisation
		I6 Soil sealing
		I7 Reuse of previously built or contaminated areas
		I8 Ecological protection of the site
		I9 Rehabilitation of the surrounding
		I10 Use of native plants
		I11 Heat island effect
	C4 Materials and Solid Waste	I12 Construction waste
		I13 Reused products and recycled materials
		I14 Waste separation and storage
		I15 Responsible sourcing of materials
	C5 Water	I16 Potable water consumption
		I17 Recycling and recovery of effluents
		I18 Treatment of contaminated effluents
		I19 Water efficient equipment

Table 10: List of sustainability areas, categories and indicators included in the questionnaire (cont.)

Areas	Categories	Indicators
A2 Sociocultural and functional	C6 User's health and comfort	I20 Natural ventilation
		I21 Toxicity of finishing materials
		I22 Thermal comfort
		I23 Visual comfort
		I24 Acoustic comfort
		I25 Indoor air quality
	C7 Controllability by the user	I26 Ventilation and temperature
		I27 Natural light
	C8 Landscaping	I28 Visual link with the surrounding landscape
	C9 Passive design	I29 Layout and orientation
		I30 Passive systems
	C10 Mobility plan	I31 Accessibilities
	C11 Space flexibility and adaptability	I32 Availability and accessibility to social areas
		I33 Space optimisation
		I34 Space flexibility
		I35 Space adaptability
A3 Economy	C12 Life cycle costs	I36 Initial cost
		I37 Operational costs
	C13 Local economy	I38 Hiring local goods and services
	C14 Corruption avoiding plan	I39 Sustainable purchase policies
A4 Technical	C15 Environmental management systems	I40 Commissioning
		I41 Environmental management plan
		I42 Infection control
		I43 Reducing noise pollution
	C16 Technical systems	I44 Efficiency of lighting and air conditioning systems

Table 10: List of sustainability areas, categories and indicators included in the questionnaire (cont.)

Areas	Categories	Indicators
	C17 Security	I45 Occupants safety
		I46 Responsible construction practices
	C18 Durability	I47 Materials of high strength and durability
		I48 Proper selection of furniture
	C19 Awareness and education for sustainability	I49 Education of occupants
		I50 Education of service providers
		I51 Satisfaction surveys
	C20 Skills in sustainability	I52 Integration in the team of a qualified sustainability expert
A5 Site	C21 Local community	I53 Local community development
	C22 Cultural value	I54 Heritage framework
	C23 Conveniences	I55 Accessibility to public transport
		I56 Low impact mobility
		I57 Local amenities

4.4 Questionnaire

Regarding the questionnaire being headed to building designers and managers, a descriptive methodology was used. Descriptive research involves gathering data that describe events and then these data are organised, recorded and analysed. The questionnaires had the same structure and consisted of 57 questions, organised into six sections. The first section was a cover letter that explained the goals of the research and stated the privacy policies of the collected data, as exemplified at Appendix II.

The next two parts consisted of questions focusing on the identification of the person involved by selecting the occupation or position currently held and the specific zone of project development further to be, in the next part, assessed the importance of the several indicators proposed by this study. Respondents were asked to answer their opinion, regarding the importance of each indicator, using the Likert scale, organised into five levels of importance: not important (1); slightly important (2); neutral (3); important (4); and very important (5).

The final part of the questionnaire was, considering the proposed method presented, if any of the indicators should be joined or eliminated according to their personal experience or knowledge.

4.4.1 Sampling process

The population of professionals classified for the research are the ones who had history in sustainable development, healthcare building designers or managers. Based on the distribution with more respect to the designers (civil engineers and architects), to rise the applicability of the result to set the assessment tool, an internet-based questionnaire was sent with an attached letter to describe the reason for this study and express the response is voluntary, to a group of stakeholders by email, LinkedIn, Messenger or Instagram.

4.4.2 Delivery and Feedback

An online questionnaire was sent to a group of stakeholders within a letter describing the reasons for this study. The surveys were conducted from 1st to 27th of February 2020 and the feedback is considered in the results.

5 RESULTS

5.1 Online Questionnaire

The Microsoft Office Excel was applied to perform the statistical analysis and evaluate the data set based on frequency distributions and competitions. This section aims to investigate the empirical data which were collected through the questionnaire distribution, divided into two sections.

5.1.1 Sample characteristics analysis

The overall sample consisted of 55 respondents, 40% architects followed by 38% civil engineers, 18% hospital managers and 4% sustainable construction consultants or experts.

Table 11: Feedback number from each field

Field		Frequency	Percentage
Architect	Less than 5 years of experience	2	3.6%
	More than 5 years of experience	8	14.5%
	Specialist in the hospital sector	12	21.8%
Civil Engineer	Less than 5 years of experience	2	3.6%
	More than 5 years of experience	13	23.6%
	Specialist in the hospital sector	6	10.9%
Sustainable Construction Consultant / Expert		2	3.6%
Hospital Manager	Facilities and Equipment Services	2	3.6%
	Superintendence / Manager	4	7.3%
	Others	4	7.3%
TOTAL		55	100%

In response to the survey about the area of expertise or project development, the following Figure 15 was obtained. As presumed, the majority of people whom answered is from the Southeast (59%), where most hospitals are concentrated, followed by the South (15%) and Northeast (11%).

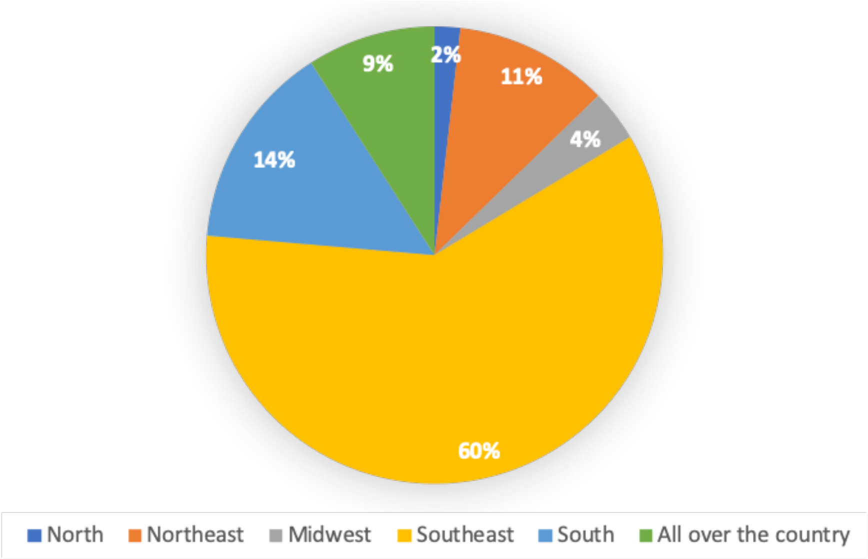

Figure 15: Demographic characteristics of the survey, geographic distribution.

5.1.2 Sustainability in Healthcare Building relevance of indicators

The questions part was divided into categories according to the list of indicators that were presented, organised into distinguish areas. The title was guided by some description of the designated parameter revealed in order to support and clarify possible doubts for the respondents. The graphs below emphasise the percentage between the level of significance of the indicators separately, while the table summarises the exact number of answers in every grade of the Likert scale.

The Table 12 shows that the respondents agreed that all the suggested indicators are important and that there was no necessity to add or remove ant indicator.

Table 12: Stakeholders opinion about the importance of sustainability indicator in healthcare

ID	Indicator	Not Important 1	2	3	4	Very Important 5
	Environmental					
1	Assessment of the building’s life cycle impacts	0	0	2	25	28
2	Primary energy consumption	0	0	6	21	28
3	Local energy production	0	1	4	23	27
4	Minimum Energy Performance	0	0	3	35	17
5	Layout optimisation	0	2	14	27	12

Table 12: Stakeholders opinion about the importance of sustainability indicator in healthcare (cont.)

ID	Indicator	Not Important 1	2	3	4	Very Important 5
	Environmental					
6	Soil sealing	0	1	8	23	23
7	Reuse of previously built or contaminated areas	0	1	14	21	19
8	Ecological protection of the site	1	0	5	18	31
9	Rehabilitation of the surrounding	0	0	6	25	24
10	Use of native plants	1	2	10	23	19
11	Heat island effect	0	0	11	25	19
12	Construction waste	0	1	6	14	34
13	Reused products and recycled materials	0	4	6	9	36
14	Waste separation and storage	0	0	4	13	38
15	Responsible sourcing of materials	0	3	4	27	21
16	Potable water consumption	0	0	3	15	37
17	Recycling and recovery of effluents	0	0	9	11	35
18	Treatment of contaminated effluents	0	0	3	13	39
19	Water efficient equipment	0	1	5	17	32
	Sociocultural and functional					
20	Natural ventilation	0	0	4	24	27
21	Toxicity of finishing materials	0	0	8	20	27
22	Thermal comfort	0	0	2	19	34
23	Visual comfort	0	0	12	23	20
24	Acoustic comfort	0	0	7	20	28
25	Indoor air quality	0	0	1	13	41
26	Ventilation and temperature	0	0	1	14	40
27	Natural light	0	0	1	19	35
28	Visual link with the surrounding landscape	0	1	14	21	19
29	Layout and orientation	0	0	7	30	18
30	Passive systems	0	0	13	24	18

Table 12: Stakeholders opinion about the importance of sustainability indicator in healthcare (cont.)

ID	Indicator	Not Important 1	2	3	4	Very Important 5
	Sociocultural and functional					
31	Accessibilities	0	1	2	12	40
32	Availability and accessibility to social areas	0	1	4	18	32
33	Space optimisation	0	0	3	25	27
34	Space flexibility	0	1	9	20	25
35	Space adaptability	0	1	9	17	28
	Economy					
36	Initial cost	0	3	9	21	22
37	Operational costs	0	1	3	16	35
38	Hiring local goods and services	1	3	7	23	21
39	Sustainable purchase policies	0	0	6	19	30
	Technical					
40	Commissioning	1	3	12	15	24
41	Environmental management plan	1	0	3	18	33
42	Infection control	1	0	1	10	43
43	Reducing noise pollution	1	0	3	27	24
44	Efficiency of lighting and air conditioning systems	1	0	0	15	39
45	Occupants safety	1	0	1	16	37
46	Responsible construction practices	1	0	4	26	24
47	Materials of high strength and durability	1	0	3	25	26
48	Proper selection of furniture	1	1	10	32	11
49	Education of occupants	1	0	7	29	18
50	Education of service providers	1	0	2	27	25
51	Satisfaction surveys	1	0	10	27	17
52	Integration in the team of a qualified sustainability expert	1	0	10	23	21

Table 12: Stakeholders opinion about the importance of sustainability indicator in healthcare (cont.)

ID	Indicator	Not Important 1	2	3	4	Very Important 5
	Site					
53	Local community development	0	0	12	28	15
54	Heritage framework	0	1	12	26	16
55	Accessibility to public transport	0	0	0	19	36
56	Low impact mobility	0	0	7	23	25
57	Local amenities	4	0	9	31	11

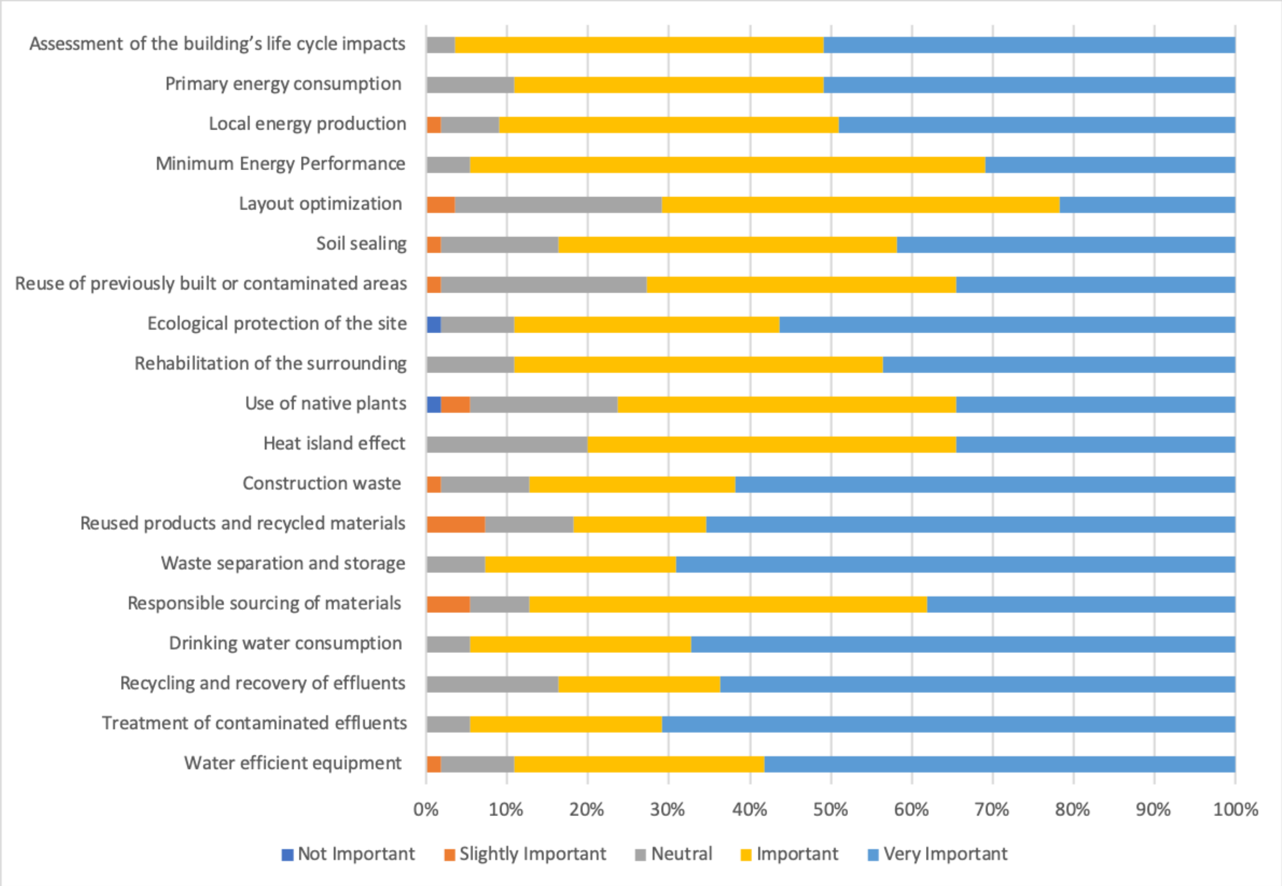

Figure 16: Respondents opinion about the importance of each indicator in the Environmental Area

The first part of the survey was about the Environmental Area and the results are presented in Figure 16. Environment is an essential issue according to the respondents and the treatment of contaminated effluents (72%) followed by waste separation and storage (70%) are the most important indicators. In contrast, the least important indicator in this category was the layout optimisation, according to the opinion of the participants. Only 6% of the participants felt that the responsible sourcing of materials and the reuse products and recycled materials are slightly important.

The second area was Sociocultural and Functional, presented in Figure 17, where the most important indicator was the indoor air quality (76%), being followed by the accessibilities (74%) and ventilation and temperature (72%). In contrast, the least voted parameter as 'very important' was the layout orientation together with the passive systems, both with 33%, close to the visual link with the surrounding landscape (35%) and the visual comfort (37%).

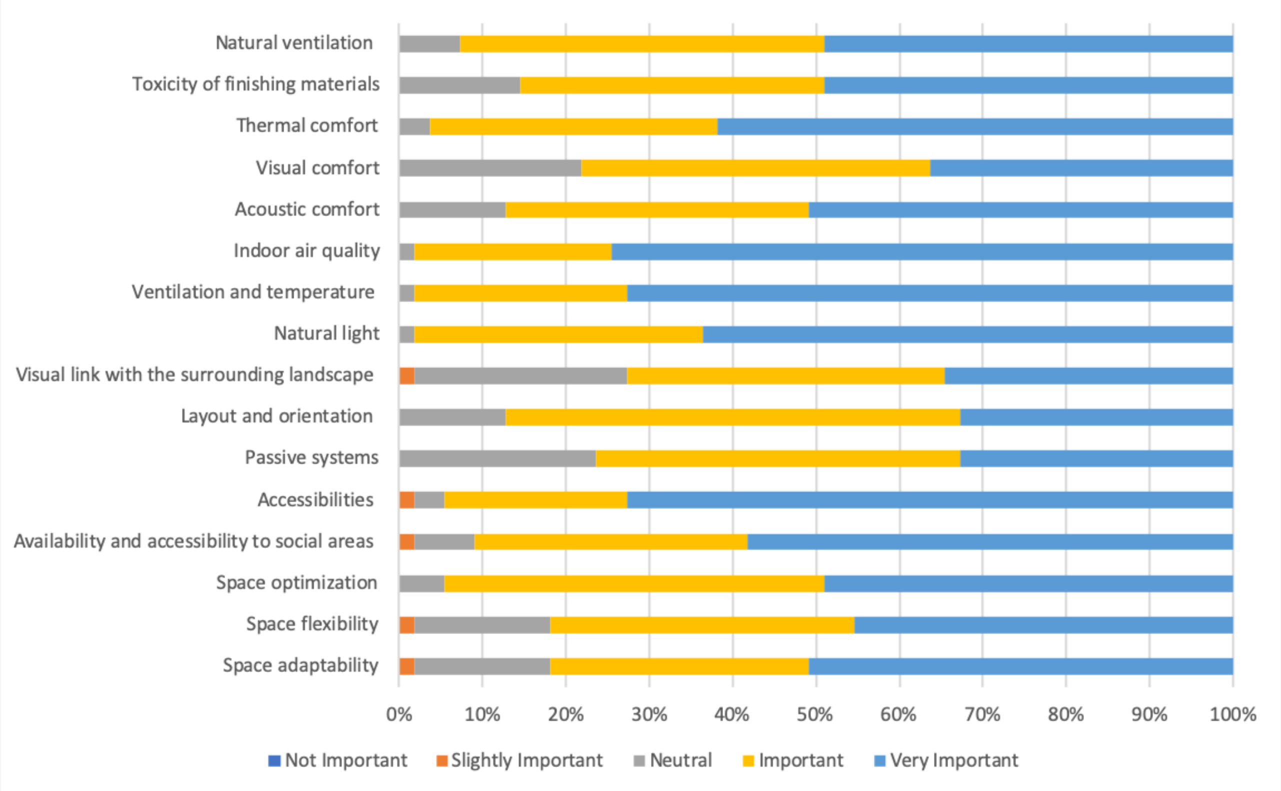

Figure 17: Respondents opinion about the importance of each indicator in the Sociocultural and Functional Area

The next area analyses the importance of the Economy issues and results are presented in Figure 18. 63% of the respondents believed that the operational costs were a very important parameter, while 54% stressed that sustainable purchase policies were very important. As previously mentioned, this indicator was added to the preliminary list of indicators after the interviews conducted to Brazilian sustainability experts. In this area the least voted as important was hiring local goods and services (37%). In this area the gap between the indicators is the smallest, being the most balanced at the level of the obtained weights.

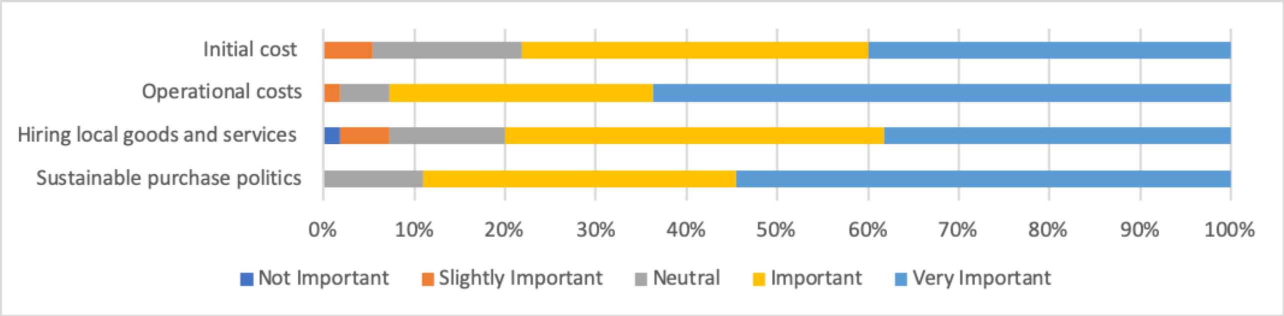

Figure 18: Respondents opinion about the importance of each indicator in the Economy Area

Only 7% of the respondent felt that hiring local goods and services indicator was between ‘not important’ and ‘slightly important’, while 6% argued that the initial costs were a ‘slightly important’ issue.

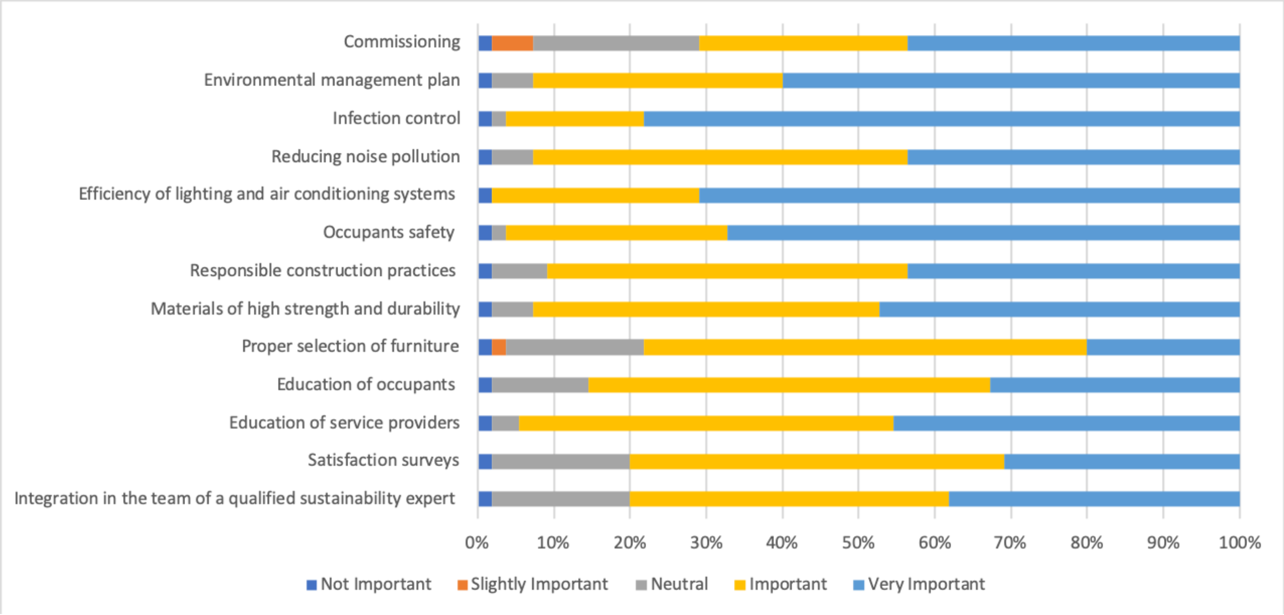

Figure 19: Respondents opinion about the importance of each indicator in the Technical Area

The Technical area has a crucial outcome as reported by the stakeholders, because of its parameters being mostly in the level between ‘important’ and ‘very important’. The highest level of importance was 80% for the infection control, as the indicator that has received the most ‘very important’ votes in the entire survey, followed by the efficiency of lighting and air conditioning systems (70%). The least voted parameter as ‘very important’ was the proper selection of furniture (20%). Separately, 7% believed that commissioning was between 'not important' and 'slightly important', as illustrated at Figure 19.

The last category tests the importance of the Site indicators, shown at Figure 20, where 65% agreed that accessibility to public transport was a very important indicator. The local amenities parameter has received, at the same time, the minimum votes for 'very important' (19%) and the maximum votes for 'not important' (7%), being the one with the minor impact according to the stakeholder's opinion.

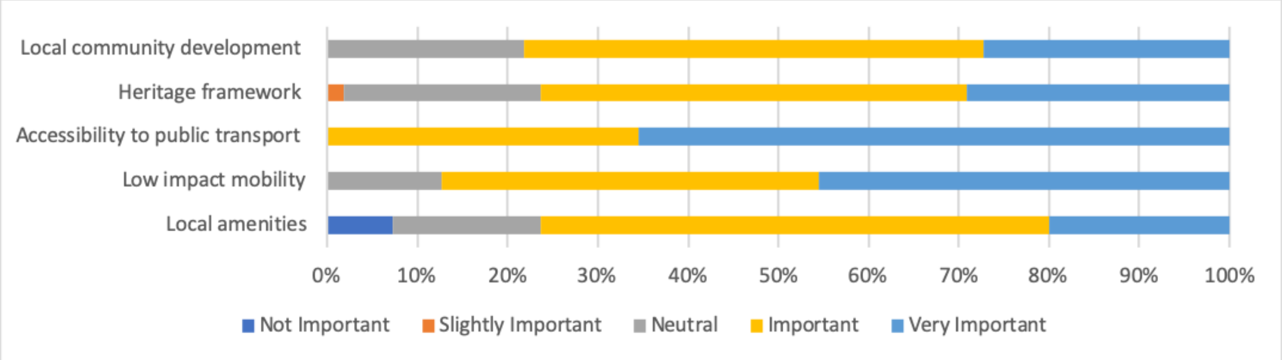

Figure 20: Respondents opinion about the importance of each indicator in the Site Category

5.2 Ranking the importance of each sustainability dimension – weighting system

Based on the expert's judgment, fifty-seven (57) indicators identified were presented to the stakeholders to analyse their point of view regarding the importance of each indicator. The results were used to support the implementation of the AHP method to develop the weighting system amid the list of indicators. On each variable, respondents were asked to indicate the importance of these criteria to the sustainable construction in Brazil, based on a five-point scale where: 1-not important, 2-slightly important, 3-neutral, 4-important and 5-very important. In order to define the relative importance scale, the relative importance index (RII) was employed, creating values ranging from 0 to 1, where 0 denotes least significance and 1 denotes highest significance.

5.2.1 AHP sampling process

The sample is composed by a group of stakeholders from diverse fields, classified into three main groups. The first group is composed of some sustainability experts and professionals identified by the Brazilian Council of Architects and Urban planners (CAU/BR) and the Brazilian Council of Engineers (CREA). The Hospital Managers provided the sampling frame for the second group. The third group includes members of the listed organisations that were not included in Group I and II but those who have experience in designing healthcare buildings or in sustainable and environmental design. Although this last group has less experience than the other groups' members, it is assumed that it was important to consider their opinion in the weighting process since they are also actors in the process of designing sustainable buildings.

From a universe of one hundred potential respondents, the total number of questionnaires received was fifty-four (54). The representativeness of each group was: 74% for the Group I, 19% for the Group II and 7% for the Group III. Saaty (1988) recommends that when there are different levels of expertise and experience in an interviewed sample, the sample should be organised into three different groups and the weight of the opinion of each group in the results should be different. Saaty (1988) proposes the following distribution of weights: the opinion of Group I in setting the average weighted mean was worth 45%; Group II was worth 31%; and Group III was worth 24%. This means that higher weight was given to the opinion of those that have higher competencies in the field being analysed.

5.2.2 Development of the Model

Fifty-seven (57) indicators which were identified in the interviews to the experts were presented to engineers, architects and hospital managers to gather their point of view. In order to define the relative importance scale, the relative importance index (RII) was employed. The results of applying the (RII) to each indicator, area and category are presented in Tables 13 and 14, respectively.

Table 13: Index of the relative importance for each area

	Area	IIR
A1	Environmental	0.880
A2	Sociocultural and functional	0.877
A3	Economy	0.858
A4	Technical	0.866
A5	Site	0.825

According to the areas the highest RII value was (0.88) for the environmental issues and the lowest was (0.82) for the site. The proportion concept was applied in order to determine the values from the RII results, shown at Table 15.

Table 14: Proportion concept for the area weight

ID	*RII*	*Final RII*	*Weight*
A1	0.880	80	26%
A2	0.877	77	25%
A3	0.858	58	19%
A4	0.866	66	22%
A5	0.825	25	8%
Total	4.307	307	100%

Table 15: Index of the relative importance of each indicator and categories

	Category / Indicator	**IRR**	**IRR Average**
C1	**Environmental life cycle impacts assessment**		**0.895**
I1	Assessment of the building's life cycle impacts	0.895	
C2	**Energy**		**0.869**
I2	Primary energy consumption	0.880	
I3	Local energy production	0.876	
I4	Minimum Energy Performance	0.851	
C3	**Soil use and biodiversity**		**0.842**
I5	Layout optimisation	0.851	
I6	Soil sealing	0.847	
I7	Reuse of previously built or contaminated areas	0.811	
I8	Ecological protection of the site	0.884	
I9	Rehabilitation of the surrounding	0.865	
I10	Use of native plants	0.807	
I11	Heat island effect	0.829	
C4	**Materials and Solid Waste**		**0.885**
I12	Construction waste	0.895	
I13	Reused products and recycled materials	0.880	
I14	Waste separation and storage	0.924	
I15	Responsible sourcing of materials	0.840	

Table 15: Index of the relative importance of each indicator and categories (cont.)

	Category / Indicator	IRR	IRR Average
C5	**Water**		**0.910**
I16	Potable water consumption	0.924	
I17	Recycling and recovery of effluents	0.895	
I18	Treatment of contaminated effluents	0.931	
I19	Water efficient equipment	0.931	
C6	**User's health and comfort**		**0.887**
I20	Natural ventilation	0.884	
I21	Toxicity of finishing materials	0.869	
I22	Thermal comfort	0.916	
I23	Visual comfort	0.829	
I24	Acoustic comfort	0.876	
I25	Indoor air quality	0.945	
C7	**Controllability by the user**		**0.933**
I26	Ventilation and temperature	0.942	
I27	Natural light	0.924	
C8	**Landscaping**		**0.811**
I28	Visual link with the surrounding landscape	0.811	
C9	**Passive design**		**0.829**
I29	Layout and orientation	0.840	
I30	Passive systems	0.818	
C10	**Mobility plan**		**0.931**
I31	Accessibilities	0.931	
C11	**Space flexibility and adaptability**		**0.874**
I32	Availability and accessibility to social areas	0.895	
I33	Space optimisation	0.887	
I34	Space flexibility	0.851	
I35	Space adaptability	0.862	

Table 15: Index of the relative importance of each indicator and categories (cont.)

	Category / Indicator	IRR	IRR Average
C12	**Life cycle costs**		**0.867**
I36	Initial cost	0.825	
I37	Operational costs	0.909	
C13	**Local economy**		**0.818**
I38	Hiring local goods and services	0.818	
C14	**Corruption avoiding plan**		**0.887**
I39	Sustainable purchase policies	0.887	
C15	**Environmental management systems**		**0.879**
I40	Commissioning	0.811	
I41	Environmental management plan	0.898	
I42	Infection control	0.942	
I43	Reducing noise pollution	0.865	
C16	**Technical systems**		**0.931**
I44	Efficiency of lighting and air conditioning systems	0.931	
C17	**Security**		**0.891**
I45	Occupants safety	0.920	
I46	Responsible construction practices	0.862	
C18	**Durability**		**0.829**
I47	Materials of high strength and durability	0.873	
I48	Proper selection of furniture	0.785	
C19	**Awareness and education for sustainability**		**0.839**
I49	Education of occupants	0.829	
I50	Education of service providers	0.873	
I51	Satisfaction surveys	0.815	
C20	**Skills in sustainability**		**0.829**
I52	Integration in the team of a qualified sustainability expert	0.829	
C21	**Local community**		**0.811**
I53	Local community development	0.811	

Table 15: Index of the relative importance of each indicator and categories (cont.)

	Category / Indicator	IRR	IRR Average
C22	**Cultural value**		**0.807**
I54	Heritage framework	0.807	
C23	**Conveniences**		**0.858**
I55	Accessibility to public transport	0.931	
I56	Low impact mobility	0.865	
I57	Local amenities	0.778	

According to the table above, all the indicators reached an RII of greater than 0.7, because this list only gathers the indicators that are considerate important.

The highest IRR value for the indicators was for the indoor air quality (0.945) while the lowest was (0.778) for local amenities. For the category, the highest number was for the controllability by the user (0.933) and the lowest is for the cultural value (0.807).

The calculation, average value from the relative scale is divided into 8 intervals as the AHP scale for the study goals, for the indicators and categories are presented in the equations 6.1 and 6.2, respectively.

$$\frac{(0.945 - 0.778)}{8} = 0.021 \tag{6.1}$$

$$\frac{(0.933 - 0.807)}{8} = 0.016 \tag{6.2}$$

5.2.3 Paired comparison matrix

To make paired comparison first it is necessary to compare each two items, as illustrated on equation 6.3, and measure the relative weight between them (e.g. I2 vs I3, I2 vs I4...etc.) using the relative scales was found in the last part.

$$\frac{(0.880 - 0.876)}{0.021} = 0.17 \tag{6.3}$$

The result from this equation should be rounded to a full number. In the case above, I2 is equal important to I3, represented at Table 16.

Table 16: Example of the built matrix

	2	*3*	*4*
2	1.00	1.00	2.00
3	1.00	1.00	2.00
4	0.50	0.50	1.00
Sum	2.50	2.50	5.00

The normalisation should be developed afterwards by dividing the result from the comparison by its sum. Table 17 shows the calculation already completed from the C2.

Table 17: Example of normalisation matrix

	2	*3*	*4*
2	0.40	0.40	0.40
3	0.40	0.40	0.40
4	0.20	0.20	0.20
Sum	1.00	1.00	1.00

The weight vector (Eigenvector) was built by averaging the entries in each row of the normalisation matrix divided by the number of comparisons, illustrated at Table 18.

Table 18: Example of calculating weight vector

	Sum	*%*
2	1.20	40%
3	1.20	40%
4	0.60	20%

Finally, checking the consistency of the evaluations was made using the AHP technique, equation 6.4, where the matrix will be consistent if the ratio is less than 10%.

$$\frac{\frac{0}{2}}{0.58} = 0{,}00 \tag{6.4}$$

With regards to calculated CR in table the results are consistent, CR values were less than 10% in the example, as well to the whole calculation.

5.2.4 Weighting result

The way each indicator influences the performance at the level of each sustainability category is different. Respondents argued that all the presented indicators are essential and representative for the category they belong. So, they agree that this list should be considered in the proposed assessment method.

It was found that the environmental and sociocultural and functional areas are the most important for the stakeholders. It was possible to assign the following weights for the sustainability areas: 19% for economy; 22% for technical; 25% for sociocultural and 26% is the highest rate for the environmental sustainability. While the site issue is considered with residual importance, having the total score of 8%, illustrated at Table 19.

Table 19: Weighting system at the sustainability areas level

Area		Weight
		100%
A1	Environmental	26%
A2	Sociocultural and functional	25%
A3	Economy	19%
A4	Technical	22%
A5	Site	8%

The respective weights at the Categories and Indicators level is represented at Tables 20 and 21 respectively. The calculations were developed and confirmed as shown in the previous equations.

Table 20: Weighting system at the categories level

	Category / Indicator	Weight
A1	**Environmental**	**100%**
C1	Environmental life cycle impacts assessment	26%
C2	Energy	14%
C3	Soil use and biodiversity	7%
C4	Materials and Solid Waste	19%
C5	Water	34%
A2	**Sociocultural and functional**	**100%**
C6	User's health and comfort	13%
C7	Controllability by the user	34%
C8	Landscaping	3%
C9	Passive design	5%
C10	Mobility plan	34%
C11	Space flexibility and adaptability	11%
A3	**Economy**	**100%**
C12	Life cycle costs	33%
C13	Local economy	10%
C14	Corruption avoiding plan	57%
A4	**Technical**	**100%**
C15	Environmental management systems	18%
C16	Technical systems	46%
C17	Security	20%
C18	Durability	5%
C19	Awareness and education for sustainability	6%
C20	Skills in sustainability	5%
A5	**Site**	**100%**
C21	Local community	17%
C22	Cultural value	17%
C23	Conveniences	67%

Table 21: Weighting system at the indicators level

	Category / Indicator	Weight
C1	**Environmental life cycle impacts assessment**	**100%**
I1	Assessment of the building's life cycle impacts	100%
C2	**Energy**	**100%**
I2	Primary energy consumption	40%
I3	Local energy production	40%
I4	Minimum Energy Performance	20%
C3	**Soil use and biodiversity**	**100%**
I5	Layout optimization	4%
I6	Soil sealing	16%
I7	Reuse of previously built or contaminated areas	8%
I8	Ecological protection of the site	29%
I9	Rehabilitation of the surrounding	23%
I10	Use of native plants	8%
I11	Heat island effect	12%
C4	**Materials and Solid Waste**	**100%**
I12	Construction waste	24%
I13	Reused products and recycled materials	19%
I14	Waste separation and storage	47%
I15	Responsible sourcing of materials	10%
C5	**Water**	**100%**
I16	Potable water consumption	33%
I17	Recycling and recovery of effluents	17%
I18	Treatment of contaminated effluents	33%
I19	Water efficient equipment	17%
C6	**User's health and comfort**	**100%**
I20	Natural ventilation	12%
I21	Toxicity of finishing materials	10%
I22	Thermal comfort	24%

Table 21: Weighting system at the indicators level (cont.)

Category / Indicator		Weight
I23	Visual comfort	5%
I24	Acoustic comfort	11%
I25	Indoor air quality	39%
C7	**Controllability by the user**	**100%**
I26	Ventilation and temperature	50%
I27	Natural light	50%
C8	**Landscaping**	**100%**
I28	Visual link with the surrounding landscape	100%
C9	**Passive design**	**100%**
I29	Layout and orientation	67%
I30	Passive systems	33%
C10	**Mobility plan**	**100%**
I31	Accessibilities	100%
C11	**Space flexibility and adaptability**	**100%**
I32	Availability and accessibility to social areas	36%
I33	Space optimization	33%
I34	Space flexibility	15%
I35	Space adaptability	16%
C12	**Life cycle costs**	**100%**
I36	Initial cost	20%
I37	Operational costs	80%
C13	**Local economy**	**100%**
I38	Hiring local goods and services	100%
C14	**Corruption avoiding plan**	**100%**
I39	Sustainable purchase policies	100%
C15	**Environmental management systems**	**100%**
I40	Commissioning	6%
I41	Environmental management plan	25%

Table 21: Weighting system at the indicators level (cont.)

	Category / Indicator	Weight
I42	Infection control	55%
I43	Reducing noise pollution	14%
C16	**Technical systems**	**100%**
I44	Efficiency of lighting and air conditioning systems	100%
C17	**Security**	**100%**
I45	Occupants safety	75%
I46	Responsible construction practices	25%
C18	**Durability**	**100%**
I47	Materials of high strength and durability	83%
I48	Proper selection of furniture	17%
C19	**Awareness and education for sustainability**	**100%**
I49	Education of occupants	20%
I50	Education of service providers	60%
I51	Satisfaction surveys	20%
C20	**Skills in sustainability**	**100%**
I52	Integration in the team of a qualified sustainability expert	100%
C21	**Local community**	**100%**
I53	Local community development	100%
C22	**Cultural value**	**100%**
I54	Heritage framework	100%
C23	**Conveniences**	**100%**
I55	Accessibility to public transport	69%
I56	Low impact mobility	24%
I57	Local amenities	7%

However, the stakeholders argued that all indicators were essential, where at least six out of the indicators have the extremely important score in the opinion of 70% or more of the interviewees. In summary, Figure 21 presents he weighting system at the categories level. Being the Conveniences (C23), Corruption avoiding plan (C14) and Technical systems (C16) as the most important ones, according to the stakeholder's opinion.

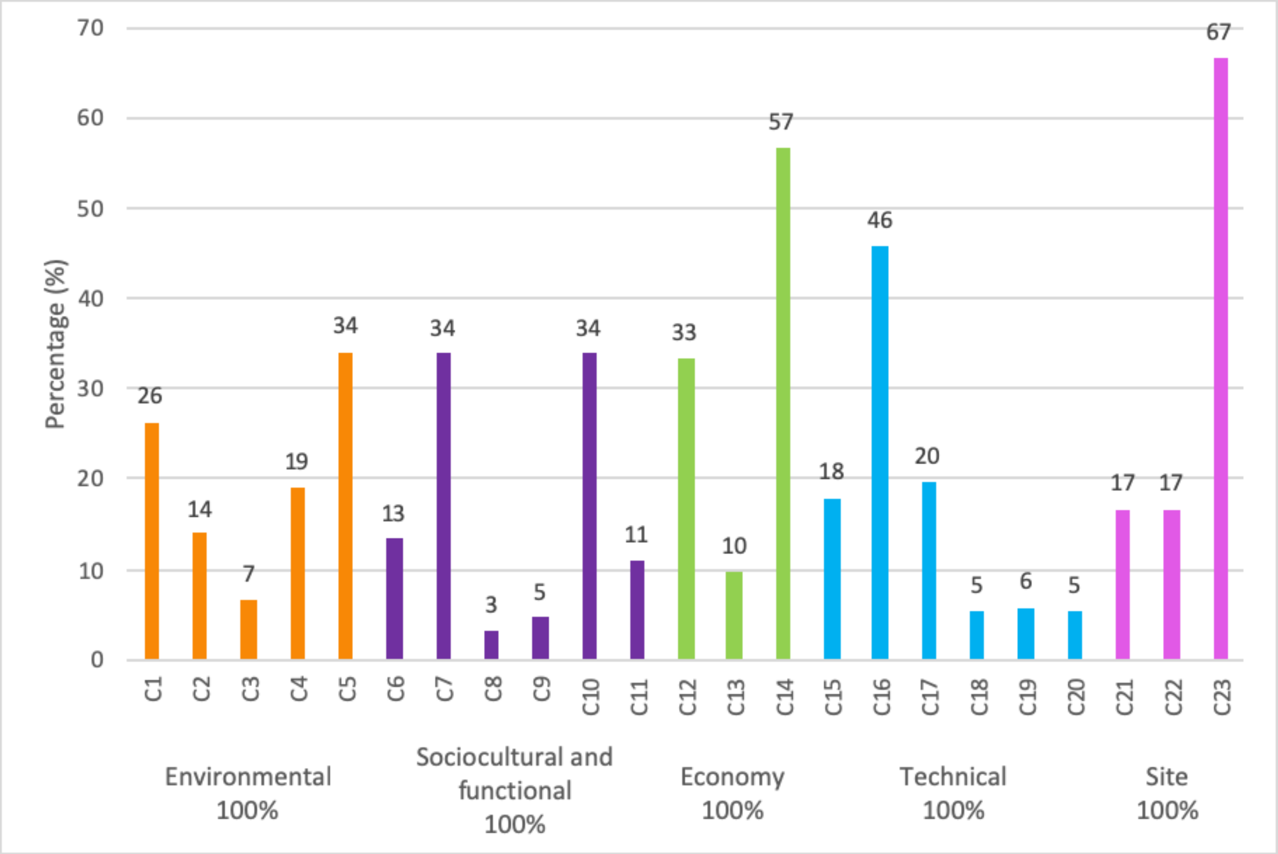

Figure 21: Weighting system at the categories level

Compared to other healthcare building sustainability assessment methods, 57 indicators are a huge number of indicators for the proposed method and reducing the number of indicators is a solution to make the assessment more practical. To solve that it was decided to compare the weight of the indicators with lowest weight given by the international tools in Table 22, where 0.2% was the lowest weight given for “Use of native plants” indicators, in HBSAtool-PT.

Table 22: The lowest weight awarded by international assessment tool

Assessment Tool	**BREEAM**	**LEED**	**HBSAtool-PT**
Lowest weight	0.4%	0.9%	0.2%
Indicator	Travel Plan, Recycled aggregates, Operational waste, Adaptation to climate change and Functional adaptability.	Enhanced Refrigerant Management and Advanced Energy Metering.	Use of native plants

To make the comparison between the lowest weight given by the international tools and the method presented, it was necessary to calculate the final indicators weight where equation 6.4 was used to define the final weight of indicator 1, as example equation 6.6.

$$Indicator\ final\ weight = [(indicator\ weight * category\ weight) * \ area\ weight] \qquad (6.5)$$

$$[(100 * 26) * 26] = 6.9 \qquad (6.6)$$

With the previous approach, the list was cut off to 48 indicators where the indicators highlighted in red at Table 23 were the excluded indicators, since they have a very low weight compared to the other indicators. The excluded indicators were: layout optimisation; reuse of previously built or contaminated areas; use of native plants; heat island effect; visual comfort; commissioning; proper selection of furniture; education of occupants; satisfaction surveys.

Table 23: Identification of the indicators that were excluded from the proposed method

	Category / Indicator	Indicator weight	
I1	Assessment of the building's life cycle impacts	6.9	
I2	Primary energy consumption	1.5	
I3	Local energy production	1.5	
I4	Minimum Energy Performance	0.7	
I5	Layout optimisation	0.1	≤ 0.2
I6	Soil sealing	0.3	
I7	Reuse of previously built or contaminated areas	0.1	≤ 0.2
I8	Ecological protection of the site	0.5	
I9	Rehabilitation of the surrounding	0.4	
I10	Use of native plants	0.1	≤ 0.2
I11	Heat island effect	0.2	≤ 0.2
I12	Construction waste	1.2	
I13	Reused products and recycled materials	1.0	
I14	Waste separation and storage	2.3	

Table 23: Identification of the indicators that were excluded from the proposed method (cont.)

	Category / Indicator	Indicator weight	
I15	Responsible sourcing of materials	0.5	
I16	Potable water consumption	3.0	
I17	Recycling and recovery of effluents	1.5	
I18	Treatment of contaminated effluents	3.0	
I19	Water efficient equipment	1.5	
I20	Natural ventilation	0.4	
I21	Toxicity of finishing materials	0.3	
I22	Thermal comfort	0.8	
I23	Visual comfort	0.2	≤ 0.2
I24	Acoustic comfort	0.4	
I25	Indoor air quality	1.4	
I26	Ventilation and temperature	4.3	
I27	Natural light	4.3	
I28	Visual link with the surrounding landscape	0.8	
I29	Layout and orientation	0.8	
I30	Passive systems	0.4	
I31	Accessibilities	8.5	
I32	Availability and accessibility to social areas	1.0	
I33	Space optimisation	0.9	
I34	Space flexibility	0.4	
I35	Space adaptability	0.5	
I36	Initial cost	1.3	
I37	Operational costs	5.0	
I38	Hiring local goods and services	1.8	
I39	Sustainable purchase policies	10.7	
I40	Commissioning	0.2	≤ 0.2
I41	Environmental management plan	1.0	
I42	Infection control	2.1	

Table 23: Identification of the indicators that were excluded from the proposed method (cont.)

	Category / Indicator	Indicator weight	
I43	Reducing noise pollution	0.6	
I44	Efficiency of lighting and air conditioning systems	9.9	
I45	Occupants safety	3.2	
I46	Responsible construction practices	1.1	
I47	Materials of high strength and durability	1.0	
I48	Proper selection of furniture	0.2	≤ 0.2
I49	Education of occupants	0.2	≤ 0.2
I50	Education of service providers	0.8	
I51	Satisfaction surveys	0.2	≤ 0.2
I52	Integration in the team of a qualified sustainability expert	1.2	
I53	Local community development	1.4	
I54	Heritage framework	1.4	
I55	Accessibility to public transport	3.8	
I56	Low impact mobility	1.3	
I57	Local amenities	0.4	

Based on the AHP procedure, the weights for the rest indicators and categories were recalculated using the same intervals to find the final weights, as shown in Table 24 the final weighting of the sustainability assessment tool.

Table 24: Final system of weights at the level of the sustainability indicators

Category	Indicator	Total weight
C1. Environmental life cycle impacts assessment	I1. Assessment of the building's life cycle impacts	6.3
C2. Energy	I2. Primary energy consumption	1.3
	I3. Local energy production	1.3
	I4. Minimum Energy Performance	0.7

Table 24: Final system of weights at the level of the sustainability indicators (cont.)

Category	Indicator	Total weight
C3. Soil use and biodiversity	I5. Soil sealing	0.7
	I6. Ecological protection of the site	1.2
	I7. Rehabilitation of the surrounding	0.9
C4. Materials and solid waste	I8. Construction waste	1.1
	I9. Reused products and recycled materials	0.9
	I10. Waste separation and storage	2.3
	I11. Responsible sourcing of materials	0.5
C5. Water	I12. Potable water consumption	2.8
	I13. Recycling and recovery of effluents	1.4
	I14. Treatment of contaminated effluents	2.8
	I15. Water efficient equipment	1.4
C6. User's health and comfort	I16. Natural ventilation	0.5
	I17. Toxicity of finishing materials	0.4
	I18. Thermal comfort	0.9
	I19. Acoustic comfort	0.4
	I20. Indoor air quality	1.6
C7. Controllability by the user	I21. Ventilation and temperature	4.0
	I22. Natural light	4.0
C8. Landscaping	I23. Visual link with the surrounding landscape	0.7
C9. Passive design	I24. Layout and orientation	0.7
	I25. Passive systems	0.4
C10. Mobility plan	I26. Accessibilities	8.0
C11. Space flexibility and adaptability	I27. Availability and accessibility to social areas	0.9
	I28. Space optimisation	0.8
	I29. Space flexibility	0.4
	I30. Space adaptability	0.4
C12. Life cycle costs	I31. Initial cost	1.2
	I32. Operational costs	4.7

Table 24: Final system of weights at the level of the sustainability indicators (cont.)

Category	Indicator	Total weight
C13. Local economy	I33. Hiring local goods and services	1.7
C14. Corruption avoiding plan	I34. Sustainable purchase policies	9.9
C15. Environmental management systems	I35. Environmental management plan	1.2
	I36. Infection control	3.1
	I37. Reducing noise pollution	0.7
C16. Technical systems	I38. Efficiency of lighting and air conditioning systems	9.9
C17. Security	I39. Occupants safety	3.3
	I40. Responsible construction practices	1.1
C18. Durability	I41. Materials of high strength and durability	2.1
C19. Awareness and education for sustainability	I42. Education of service providers	2.5
C20. Skills in sustainability	I43. Integration in the team of a qualified sustainability expert	1.3
C21. Local community	I44. Local community development	1.3
C22. Cultural value	I45. Heritage framework	1.3
C23. Conveniences	I46. Accessibility to public transport	3.5
	I47. Low impact mobility	1.3
	I48. Local amenities	0.3

Figure 22 illustrate the priority between the Areas, being chosen Environmental (A1), Technical (A2) and Sociocultural and Functional (A2) with a same level of relative importance. Subsequently the Economy (A3) Area represents 17% of the total weight in the sustainability rating system, and the Site (A5) was appointed as the least relevant, with 8% of the total.

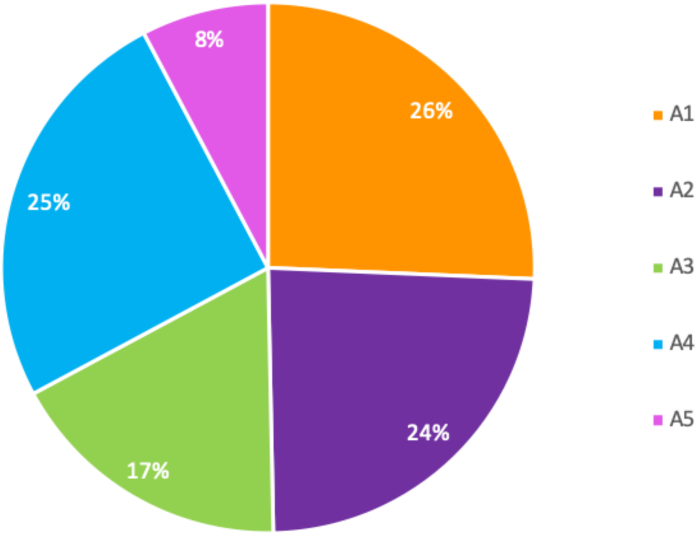

Figure 22: Final weight of sustainability areas

By analysing the final weights, the technical systems and corruption avoiding plan were both ranked as the most important factors in the economy and technical sustainability areas, respectively, accounting almost for about 10% of the total weight in each category. The third category that should be considered in the sustainable healthcare buildings was water. By that, potable water consumption and treatment of contaminated effluents were the most important indicators under this category.

Sociocultural and functional was ranked the third most important area for healthcare buildings, individually, the highest rate was 33% for the accessibilities and controllability by the users which means it is the most important category at the indicated area. Furthermore, the fourth-ranked category was Environmental life cycle impacts assessment, closely followed by the life cycle costs category. Operational costs within the life cycle costs category has the highest score. Finally, 3% and 4% were the least categories weighted for sociocultural and functional area and with the lowest number of indicators, respectively for landscaping and passive design categories.

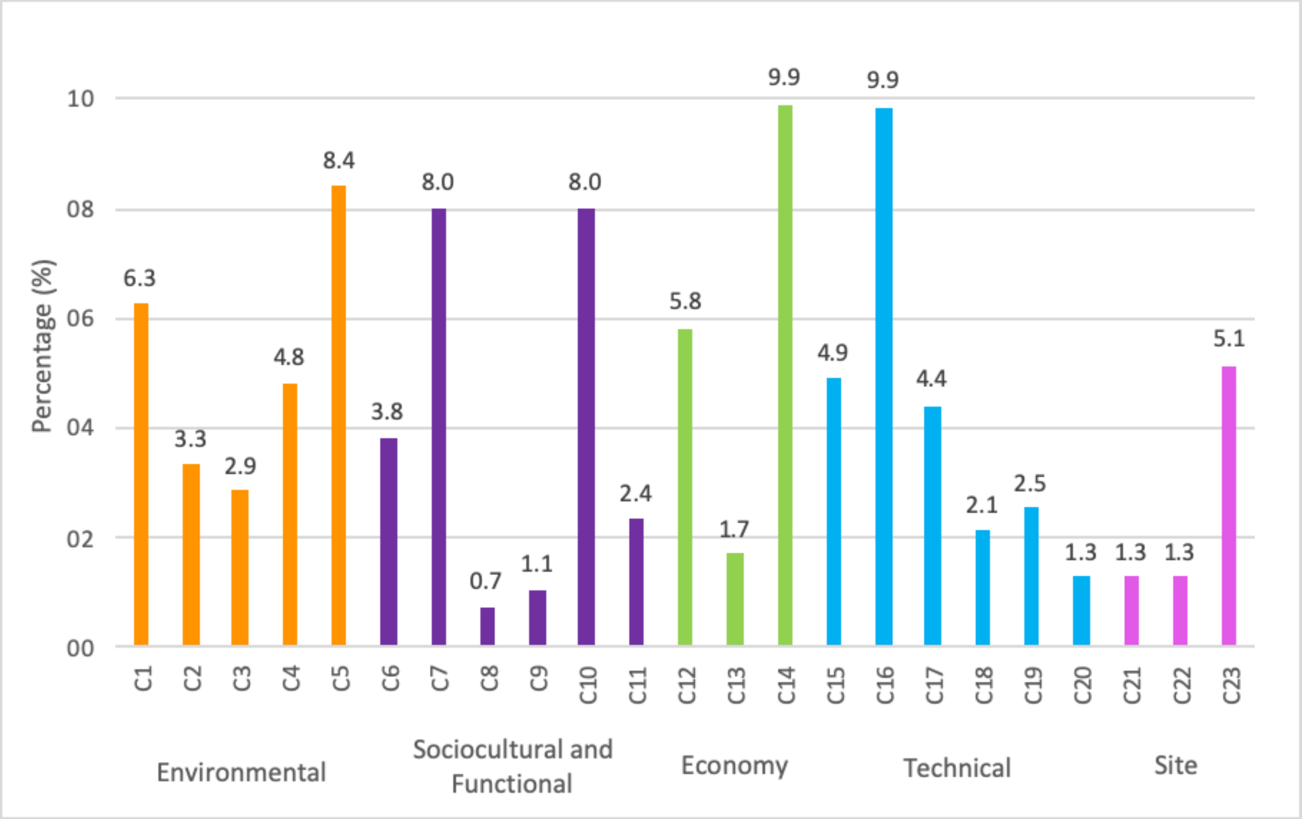

Figure 23: Final weight of sustainability categories

Individually, by indicators, the highest rate was 9.9% for the sustainable purchase policies which mean it is the most important indicator within the assessment tool., together with 9.9% of the Technical area, being represented by the efficiency of lighting and air conditioning systems indicator, succeeded by accessibilities characterising 33% of the Sociocultural and Functional area, illustrated at Figure 24.

The categories proposed for the Environmental Area, was defined to allow, in a holistic way, assessing the most common life-cycle environmental impacts according to national priorities. The Social and Functional Area presents a list of indicators divided into six categories that include the key aspects of building occupants' health and comfort, also considering the importance of mobility and space design quality. The Economy Area was defined in order to consider the most relevant building life-cycle costs and the impact on the local economy. The Technical Area reflects the issues about security, durability, the management of the systems and its efficiency and the occupants' education and awareness regarding the sustainability concerns. While the Site Area main issues is regarding the community and cultural values.

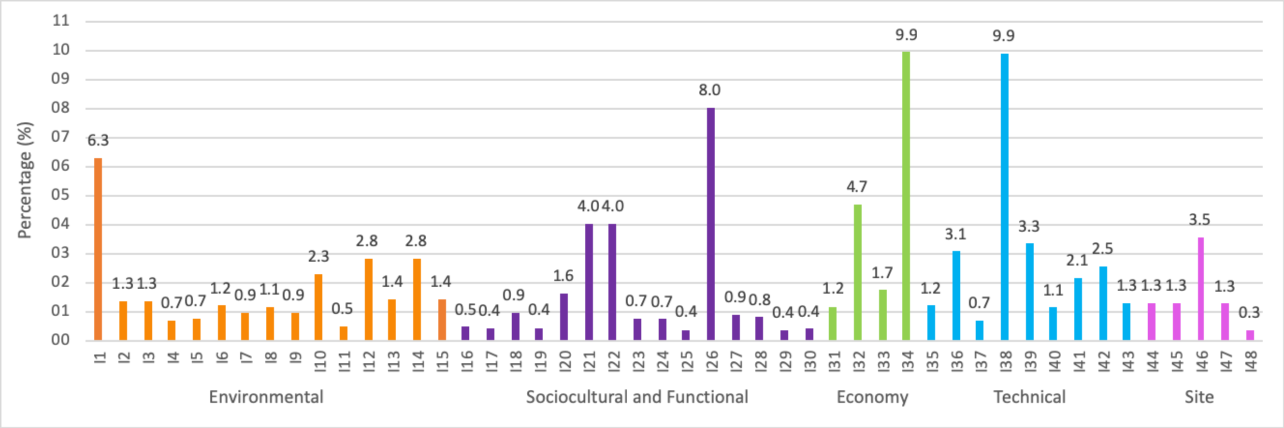

Figure 24: Final weight of sustainability indicators

Analysing Table 25, it is important to highlight that in the case of categories that only have one indicator, the weight of the category equals the weight of the indicator. By analysing each category, it is possible to highlight the most important Indicator according to the opinion of the respondents.

Table 25: Weighting system of the proposed list of sustainability indicators

Area	Category	Indicator	Weight		
			Indicator	Category	Area
A1. Environmental	C1. Environmental life cycle impacts assessment	I1. Assessment of the building's life cycle impacts	100%	24%	26%
	C2. Energy	I2. Primary energy consumption	40%	13%	
		I3. Local energy production	40%		
		I4. Minimum Energy Performance	20%		
	C3. Soil use and biodiversity	I5. Soil sealing	26%	11%	
		I6. Ecological protection of the site	41%		
		I7. Rehabilitation of the surrounding	33%		
	C4. Materials and solid waste	I8. Construction waste	24%	19%	
		I9. Reused products and recycled materials	19%		
		I10. Waste separation and storage	47%		
		I11. Responsible sourcing of materials	10%		
	C5. Water	I12. Potable water consumption	33%	33%	
		I13. Recycling and recovery of effluents	17%		
		I14. Treatment of contaminated effluents	33%		
		I15. Water efficient equipment	17%		
A2. Sociocultural and functional	C6. User's health and comfort	I16. Natural ventilation	12%	16%	24%
		I17. Toxicity of finishing materials	10%		
		I18. Thermal comfort	24%		

Table 25: Weighting system of the proposed list of sustainability indicators (cont.)

Area	Category	Indicator	Weight		
			Indicator	Category	Area
A2. Sociocultural and functional	C6. User's health and comfort	I19. Acoustic comfort	11%	16%	24%
		I20. Indoor air quality	42%		
	C7. Controllability by the user	I21. Ventilation and temperature	50%	33%	
		I22. Natural light	50%		
	C8. Landscaping	I23. Visual link with the surrounding landscape	100%	3%	
	C9. Passive design	I24. Layout and orientation	67%	4%	
		I25. Passive systems	33%		
	C10. Mobility plan	I26. Accessibilities	100%	33%	
	C11. Space flexibility and adaptability	I27. Availability and accessibility to social areas	36%	10%	
		I28. Space optimisation	33%		
		I29. Space flexibility	15%		
		I30. Space adaptability	16%		
A3. Economy	C12. Life cycle costs	I31. Initial cost	20%	33%	17%
		I32. Operational costs	80%		
	C13. Local economy	I33. Hiring local goods and services	100%	10%	
	C14. Corruption avoiding plan	I34. Sustainable purchase policies	100%	57%	
A4. Technical	C15. Environmental management systems	I35. Environmental management plan	24%	19%	25%
		I36. Infection control	62%		
		I37. Reducing noise pollution	14%		

Table 25: Weighting system of the proposed list of sustainability indicators (cont.)

Area	Category	Indicator	Weight		
			Indicator	Category	Area
A4. Technical	C16. Technical systems	I38. Efficiency of lighting and air conditioning systems	100%	39%	25%
	C17. Security	I39. Occupants safety	75%	18%	
		I40. Responsible construction practices	25%		
	C18. Durability	I41. Materials of high strength and durability	100%	9%	
	C19. Education	I42. Education of service providers	100%	10%	
	C20. Skills in sustainability	I43. Integration of a qualified sustainability expert	100%	5%	
A5. Site	C21. Local community	I44. Local community development	100%	17%	8%
	C22. Cultural value	I45. Heritage framework	100%	17%	
	C23. Conveniences	I46. Accessibility to public transport	69%	67%	
		I47. Low impact mobility	24%		
		I48. Local amenities	7%		

In Category C2 (Energy), the weight of Indicators is balanced, whereas indicator I4 (Minimum energy performance) carries less weight. In Category C3 (Soil use and biodiversity), the most important is I6 (Ecological protection of the site), closely followed by I7 (Rehabilitation of the surrounding). On the other hand, in Category C4 (Materials and Solid Waste), I10 (Waste separation and storage) achieved the highest score, but the other three indicators have a balanced weight, and in Category C5 (Water), I12 (Potable water consumption) and I14 (Treatment of contaminated effluents) are the most important. Category C6 (User's health and comfort), shows that the most important is I20 (Indoor air quality), but the other three indicators have a balanced weight, and in Category C7 (Controllability by the user), the same weight was obtained for the two indicators. In Category C9 (Passive design), I24 (Layout and Orientation) is clearly greater than I25 (Passive Systems) and in Category C11 (Space flexibility and adaptability), the most important is I27 (Availability and accessibility to social areas), closely followed by I28 (Space optimisation). Furthermore, in Category C12 (Life cycle costs), I32 (Operational costs) is clearly more important than I31 (Initial cost). In Category C15 (Environmental management systems), the most important indicator is I36 (Infection control) and in Category C17 (Security), I39 (Occupants safety) is clearly more important than I40 (Responsible construction practices). Finally, in Category C23 (Conveniences), the most important indicator is I46 (Accessibility to public transport).

The Category C14 (Corruption avoiding plan) within the indicator I34 (Sustainable purchase policies) was suggested by a sustainability assessment expert during the validation phase and afterwards the necessity was confirmed by the opinion of the healthcare buildings stakeholders. This indicator had, by itself, the highest rate inside a category reaching 57% of total A3 (Economy area). Other category that reached a high percentage within its category was C23 (Conveniences), although it has three indicators to split among them, accessibility to public transport, low impact mobility and local amenities, the values of 67% of the A5 (Site area).

The goal of the sustainability categories is to summarise the performance of a healthcare building at the level of some key sustainability aspects. The categories are organised into the sustainability areas. The proposed list of sustainability areas, categories and indicators are presented in Table 25 together with the weights assigned to each sustainability category and area by the respondents.

At last, the weight of each category within the areas are presented in Figure 25. The category that has the most significant impact into an area is the C23 (Conveniences), representing 67% of the total A5. Besides the Site area has an importance of only 8% in the whole Sustainability score. The categories with least influence are C8 (Landscaping) and C9 (Passive design), which belong to the Sociocultural and functional area, representing 3% and 4% respectively.

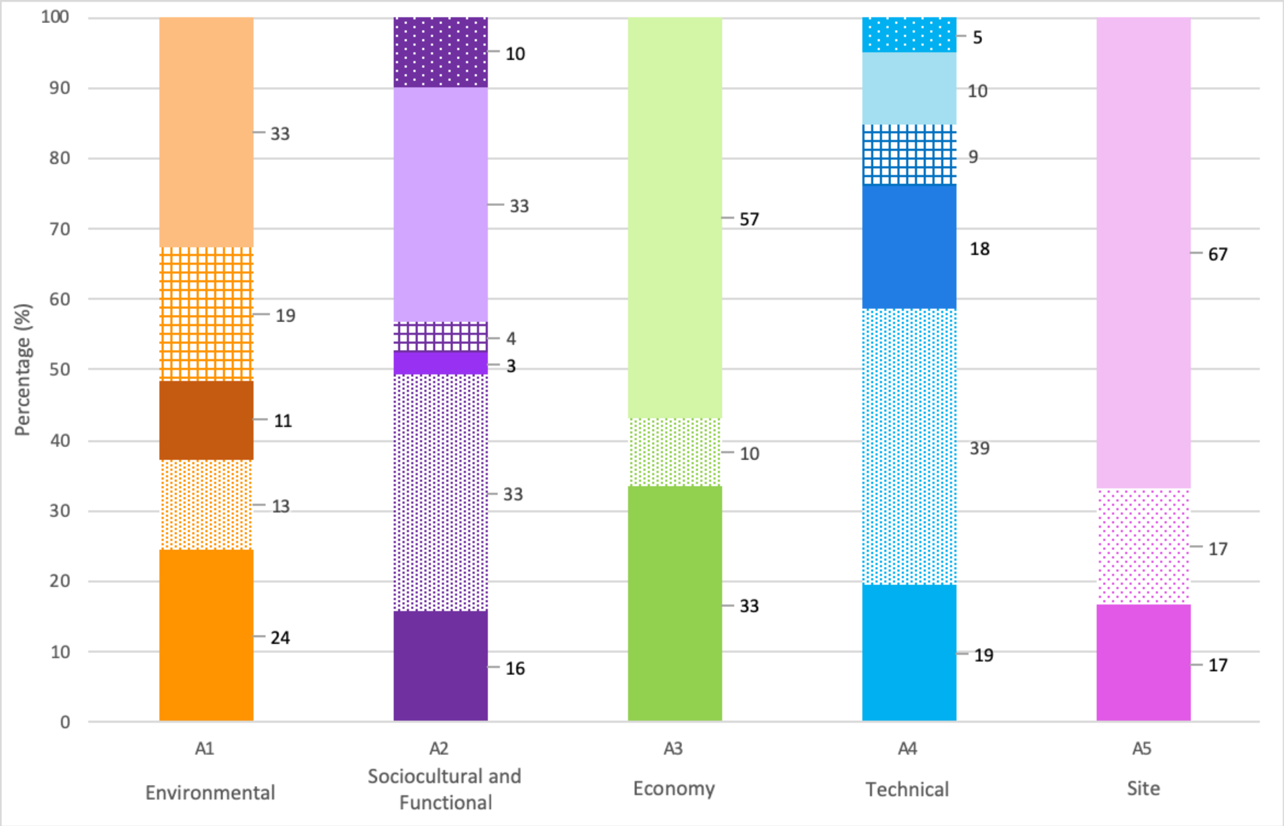

Figure 25: Final weight of categories within each area

6 DISCUSSION

6.1 Current standadisation and HBSA methods

The evolution of the methods developed to recognise the commitment between the project and the objectives of the sustainable development concept, called “Building Sustainability Assessment Methods”. On healthcare buildings, this thesis proposes the list of indicators and the weighting systems of a new HBSA method adapted from the HBSAtool-PT to the Brazilian context. The practical implementation of the outcomes can produce significant benefits to the ones usually achieved by using standard design practices.

The issues mostly common in existing methods are related to environmental life cycle assessment, modelling of energy flows, lighting. These methods should support the design teams in all phases of the project. Thus, in addition to conventional issues, it would also be interesting for these methods to consider potential embodied life cycle impacts. This is possible through the development and integration of a Life Cycle Assessment (LCA) database with values associated with commonly used building elements.

The HBSA methods are evolving and starting to have impact on the promotion of sustainable healthcare building design. The proposed list of indicators aimed to contribute to the evolution of these methods. State of the art analysis showed that the use of the HBSA methods is not yet widespread but, based on recent research and ongoing development of standards, the practical application of different frameworks is growing. The difficulty in integrating quantitative and qualitative aspects in the same assessment method is a challenge, but it is also the path forward. This will bring more and more stakeholders to the discussion and will promote the inclusion of more important aspects related to the sustainability of healthcare buildings at the different life cycle stages. BSA methods intend to promote the integration and a better balance between all needs, to achieve more and more sustainable design practices every day (Marimuthu & Paulose, 2016).

6.2 Comparison of weights between the proposed assessment and others HBSA existing methods

Table 25 summarises the structure proposed for the healthcare assessment method and the respective weights for each category, indicator and area. At this level, it is interesting to compare the proposed system of weights with other studies, to identify differences at the level of sustainability priorities.

It is possible to identify some recognised existing methods in the market that are focused or can be used in the assessment of healthcare buildings: BREEAM International New Construction; LEED BD+C (Building Design and Construction); and HBSAtool-PT. All of them have a similar structure and an equal weighting system (Castro et al., 2015a).

There are shared concerns among these three HBSA methods, such as: the use of energy; water efficiency; indoor and outdoor environmental quality; resources and material; service quality, and site strategies. Therefore, the proposed criteria presented in this study uses a similar approach since those concerns are also considered. On the other hand, each method highlights different criteria according to where they were aimed to be applied, as represented on Figure 26.

Regarding this analysis, it is necessary to highlight that BREEAM International New Construction, LEED BD+C, HBSAtool-PT and the proposed list of indicator by-product from the Portuguese method, use a similar approach in the aggregation of the global sustainability score. Therefore, they can be compared.

It is important to note that there is a method that gives much more importance to one core sustainability category than to others. In LEED BD + C, the performance at the level of the energy related indicators weights 33% in the global sustainability score. On the other hand, in BREEAM International New Construction there is a more balanced weighting between all core criteria.

Compared with the other methods, in the proposed list of indicators the “Economy” area is one of the three leading sustainability categories, while it is not considered in other methods. Additionally, in the Brazilian context, the importance given to the economy category is more accordingly to the weight that the healthcare sector plays in the Brazilian economy, and it reflects the stakeholders’ opinions gathered in the survey.

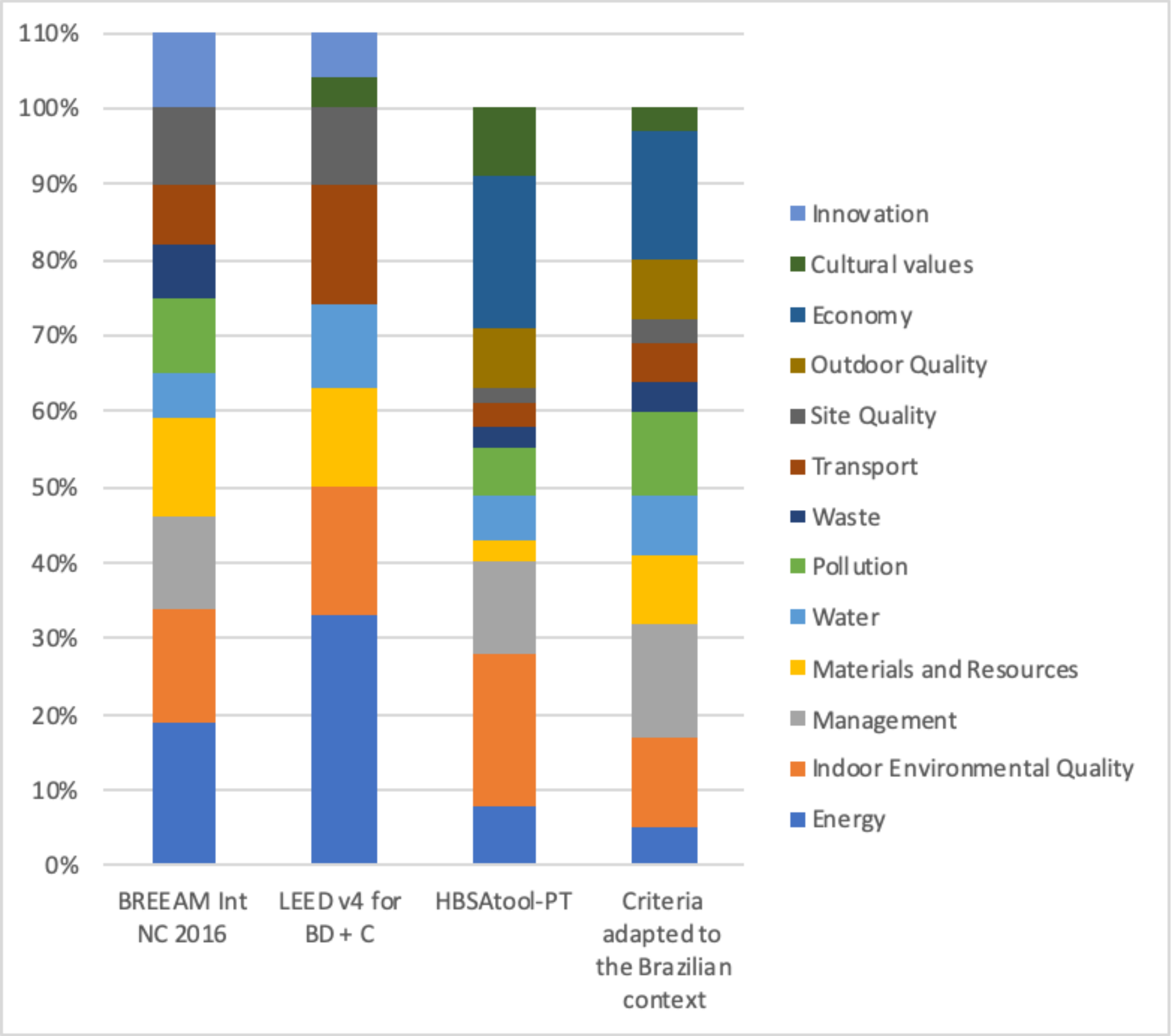

Figure 26: Comparison between the weights at the level of each sustainability category of different HBSA methods and the ones of the proposed criteria adapted to the Brazilian context

Based on these differences, it is possible to conclude that this study is a great contribution to the development of new HBSA method in the Brazilian context because it sets a more comprehensive list of sustainability priorities, suitable to the environmental, societal and economy contexts, that is in line with the ongoing standardisation works.

7 CONCLUSIONS

Healthcare buildings are much more complex systems due to the specific and higher technical and functional requirements, and due to the number of different health services they can cover. Additionally, based on the number of services they cover and population they serve, there are different types of healthcare buildings. Many initiatives related to environmental sustainability in the healthcare sector present important steps for hospitals to deal with the eminent global crisis of exceeding consumptions of natural resources and arising issues related to the treatment of originated wastes.

Buildings do not have the inherent capacity for regeneration, but the built environment can be designed to contribute and support such regeneration, offering the opportunity to align the ecological profile of the built environment with the health sector's core mission - to heal - providing essential health services and, at the same time, a wide-range of environmental services. Modernising health systems to focus on prevention and primary care in the community is a way in which the structure can be reformulated to go beyond the less harmful, as it reduces the sector's ecological footprint by the need for energy and services, considered as forms of regenerative design.

If decisions are made at the early design stage, using comprehensive and systematic approaches, it is possible to integrate sustainability principles, with a greater probability of success and reduced cost. It is also important to highlight that the approach must be aligned with the environmental, societal and economic contexts of the country/region where it is going to be applied, as a target for its reality. In this sense, the assessment presents a structured list of sustainability indicators with respective weights in the overall sustainability and is aimed at promoting the development of more sustainable healthcare buildings in Brazil, based on the limitations of the recognised existing methods and on ongoing standardisation.

Healthcare building sustainability assessment methods can help to produce significant benefits in standard design and building management practices by allowing the integration of more wide spread social and economic concerns, besides reducing the environmental impacts. Using these methods will be possible to assess the performance of a healthcare building at the level of the most important aspects to archive the sustainable construction goals. An indicator, measurable or observable property, provides information about a phenomenon or area, containing a complex message, but simple to understand, quantifiable, and communicative (Cole, 2005).

Regarding the methodology used, since there is no common international understanding regarding the weight of each indicator, it was based on the results of a questionnaire that involved the main Brazilian healthcare stakeholders. This concept is relevant for the reason that it considers the knowledge and experience of different experts in the process of designing, validates the proposed framework and evaluates the relative importance of each sustainability area, category and indicator in global sustainability. This will allow for setting the priorities in the design of more sustainable healthcare buildings in Brazil.

This kind of initiatives has a significant advantage in seeking improvement to the performance of healthcare buildings because the assessment method can be used for both raising awareness to promote sustainable practices and reducing consumptions, costs and, as a consequence, reducing the environmental and economic impacts. Additionally, by considering the main stakeholders' opinion to evaluate the list of indicators, the weighting system is more aligned to their expectations, therefore increasing the potential effectiveness.

As a recommendation, the Environmental issues and strategies must be the major focus, but it is also important to not forget other important issues such as societal needs and requirements, economic aspects, and technical. As result of the questionnaire, is proposed an of sustainability indicators, as well as the weighting system that suits the Brazilian context. The outcome is different from the other HBSA frameworks presented in this study, highlight the specificity of the Brazilian construction and healthcare sector.

To plan a sustainable healthcare building in Brazil, the designer has to focus on the concepts that are most pertinent, like the efficiency in the technical systems and be aware of sustainable purchase politics and the accessibility by all means. The life cycle impacts and cost must be taken into consideration, as well as the aspects related to the controllability by the user, security and environmental management.

7.1 Work limitations

Among the options present in this research, the point of view of the sustainable assessment method for healthcare is taken into consideration, which in this study does not consider the user's opinion. The questionnaire was made thinking about design-making decision and its impact on the building sustainability, as a more appropriate and effective way of implementing sustainable practices in the early design stages. Likewise, architects, civil engineers, managers and sustainability consultants, can influence the design of buildings in order to achieve maximum performance and, at the same time, less impact as possible. Finally, related to the pre validation within the experts the survey culture is not settled in the Brazilian reality, being hard the achievement of a considerate number of people.

7.2 Future works

The research developed culminated in a method that aims to promote sustainable design practices in healthcare buildings. This evaluation can take place in the design and use phases of hospital buildings and allows the evaluation of how different decisions by the stakeholders in these phases can impact the performance in the environmental, social and economic aspects.

In the sense and proposal for future work, the main objectives are summarised below:

a. Development of the benchmarks (good and standard practices) for each indicator;

b. Development of the assessment methodology for each indicator;

c. Practical application of the proposed method in healthcare buildings located in different regions of Brazil;

d. Periodic update of the proposed method, according to standards, regulation and legislative requirements, the introduction of new indicators, when necessary, and the adaptation of the weighing system, according to the increasing needs of this type of buildings.

e. Development of a software tool, based on the method, to enable a straightforward consultation, understanding and classification;

f. Creation of a Guide to define a set of criteria adopted by the designers in the earlier phases of the project, allowing a satisfactory level of sustainability at the beginning.

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APPENDIX I

Indicators Validation

In the context of the Master's Dissertation entitled “Building Sustainability Assessment Methods for Healthcare – critical comparative analysis to apply in Brazilian context” the indicators validation was formulated representing a proposal to develop indicators structure based on international rating systems (LEED v4 for Building Design and Construction, BREEAM New Construction and Healthcare Building Sustainability Assessment tool – Portugal).

It aims to check the sustainability level of Hospitals in Brazil in order to contribute to the applicability of the indicator itself to a broader context, making it more reliable and robust for practical applications. Also contributing to the development of the measurement of Sustainable Assessment Method for Healthcare Buildings.

1. The proposed Hospital Building Method is a Design Support that consists of three levels to position the selected assessment criteria. Thus the fifty-seven Indicators presented are grouped into twenty-two Categories, framed into five Areas.

Table 26: List of indicators – for the experts validation

Areas	Categories	Indicators
A1 Environmental	C1 Environmental life cycle impacts assessment	I1 Assessment of the building’s life cycle impacts
	C2 Energy	I2 Primary energy consumption
		I3 Local energy production
		I4 Minimum Energy Performance
	C3 Soil use and biodiversity	I5 Layout optimisation
		I6 Soil sealing
		I7 Reuse of previously built or contaminated areas
		I8 Ecological protection of the site
		I9 Rehabilitation of the surrounding
		I10 Use of native plants
		I11 Heat island effect
	C4 Materials and Solid Waste	I12 Construction waste
		I13 Reused products and recycled materials
		I14 Waste separation and storage
		I15 Responsible sourcing of materials
	C5 Water	I16 Potable water consumption
		I17 Recycling and recovery of effluents
		I18 Treatment of contaminated effluents
		I19 Water efficient equipment
A2 Sociocultural and functional	C6 User’s health and comfort	I20 Natural ventilation
		I21 Toxicity of finishing materials
		I22 Thermal comfort
		I23 Visual comfort
		I24 Acoustic comfort
		I25 Indoor air quality
	C7 Controllability by the user	I26 Ventilation and temperature
		I27 Natural light
	C8 Landscaping	I28 Visual link with the surrounding landscape

Table 26: List of indicators – for the experts validation (cont.)

Areas	Categories	Indicators
A2 Sociocultural and functional	C9 Passive design	I29 Layout and orientation
		I30 Passive systems
	C10 Mobility plan	I31 Accessibilities
	C11 Space flexibility and adaptability	I32 Availability and accessibility to social areas
		I33 Space optimisation
		I34 Space flexibility
		I35 Space adaptability
A3 Economy	C12 Life cycle costs	I36 Initial cost
		I37 Operational costs
	C13 Local economy	I38 Hiring local goods and services
A4 Technical	C14 Environmental management systems	I39 Commissioning
		I40 Environmental management plan
		I41 Infection control
		I42 Reducing noise pollution
	C15 Technical systems	I43 Efficiency of lighting and air conditioning systems
	C16 Security	I44 Occupants safety
		I45 Responsible construction practices
	C17 Durability	I46 Materials of high strength and durability
		I47 Proper selection of furniture
	C18 Awareness and education for sustainability	I48 Education of occupants
		I49 Education of service providers
		I50 Satisfaction surveys
	C19 Skills in sustainability	I51 Integration in the team of a qualified sustainability expert
A5 Site	C20 Local community	I52 Local community development
	C21 Cultural value	I53 Heritage framework
	C22 Conveniences	I54 Accessibility to public transport
		I55 Low impact mobility
		I56 Local amenities

Environmental area

Assessment of the building's life cycle impacts
This item intent to evaluate the environmental life cycle impact to promote the use, by the design teams, of low environmental impact solutions, associated with the life cycle of various constructive elements and building materials. The database includes, beyond renewable and non-renewable energy embodied, the accounting of the categories: Global warming potential (GWP) Destruction of the ozone layer (ODP); Potential acidification (PA), Photochemical oxidation potential (POP) and Eutrophication potential (EP). To contribute to a reduction in national NOx emission levels through the use of low emission heat sources in the building.

Primary energy consumption
Total primary energy consumption during the use phase to promote the reduction of energy consumption in healthcare buildings.

Local energy production
Amount of energy produced in the building through renewable sources to reward renewable energy consumption through the incorporation of systems that enable clean energy. The use of renewable energy allows the reduction of greenhouse gas emissions and other pollutants and contributes to the conservation of global resources of fossil fuels and to the development for technologies that allow their exploitation. Additionally, results in a reduction on life cycle costs of the building.

Minimum Energy Performance
Demonstrate an improvement in the proposed building performance rating compared with the baseline building performance rating to reduce the environmental and economic harms of excessive energy use by achieving a minimum level of energy efficiency for the building and its systems.

Layout optimisation
Number of beds available per square meter of built area to recognise the efficient use of the built area.

Soil sealing
Waterproofing Index to promote the soil permeability in urban areas to ensure aquifer recharge and decrease peak flow in stormwater drainage systems. The impermeable areas can have a major impact on ecosystems as the ground covered by constructions, streets and other occupations, reduces the soil surface available to support natural habitats and to perform the absorption of rainwater. The increased area of impermeable soil has a negative effect on sustainable development and most common are nature conservation and the absence of flood control.

Reuse of previously built or contaminated areas
Percentage of intervention area previously contaminated or built to reward the choice of location of these buildings in areas previously contaminated or previously built. The main solution to slow the destruction of natural habitats and wildlife they support, but also to prevent the loss of soil suitability is the reuse.

Ecological protection of the site
Protection of the ecological and natural resources of the site aiming the implementation of measures to preserve the ecological and natural resources of the building construction site. The ecological value is affected by the type of existing flora and fauna and their interactions, number of different species, vegetation strata, the existence of water courses, among others.

Rehabilitation of the surrounding
Potential development of the surroundings by rewarding the rehabilitation of deteriorated or/and abandoned from surrounding areas. The principle to be adopted when studying the implementation of a building is to minimise the impacts on the ecology of the area or, where possible, contributing to its improvement.

Use of native plants
Percentage of green area occupied by native plants aiming the promotion of the integration of pre-existing native plants and the planting of local plants in green spaces. Native plants are originated in one specific area where live for many generations, differently from the introduced plant, when a specie have resulted from subsequent introductions. The spontaneous plants grow in community with other species, providing protection and nourishment, but at the same time, can interfere with the natural habitat, competing with native plants.

Heat island effect
Percentage of coverage area and surrounding paved areas with reflectance in order to reduce the heat island effect in urban areas by promoting the use of high reflectance materials or vegetation in outdoor spaces and roofs. The heat island effect indicates the existence of a higher temperature in urban areas, compared with the forest and rural areas. Caused mainly due to the removal of

vegetation and its replacement by asphalt and concrete buildings and structures that store and release thermal energy, which have high solar absorption due to its low reflectance. The heat island effect results in extra energy needs of buildings in urban areas and consequently resulting in the increased emissions of pollutants into the atmosphere.

Construction waste
Measurements to reduce the production of Solid Construction and Demolition Waste and a percentage is destined for reuse or recycling to promote the reduction of waste production and reward its recycling.

Reused products and recycled materials
Percentage of the cost of reused products and materials with recycled content aiming the promotion of its usage from the construction site or outside, specific for each material type within its components. The reuse of building materials or elements that result from the end of a building's life cycle consists into the use of them incorporated into new materials for construction or rehabilitation.

Waste separation and storage
The building’s performance at the level of this parameter is evaluated by the value of the Potential of the Building's Conditions for Promoting the Separation of Solid Waste (PRSU), which results from criteria related to the indoor and outdoor existing conditions for the deposition and storage of household waste. Usually composed by organic material, paper, cardboard, plastic, glass, metals, infectious, pathological, sharps, chemical, among others.

Responsible sourcing of materials
To recognise and encourage the specification and procurement of responsibly sourced construction products by using timber/timber-based products legally harvested and traded, a documented policy and procedure that sets out procurement requirements for all suppliers and trades to adhere to relating to the responsible sourcing of construction products and to available the responsible sourcing credits awarded where the applicable construction products are responsibly sourced in accordance with the methodology.

Potable water consumption
Annual volume of water consumed per square meter inside the building aiming the promotion of the reduction of water consumption, depending on the efficiency of devices and the average consumption patterns. The quality of water supply, the drainage and wastewater treatment have a strong impact on public health, due to drinking water supplies are diminishing, opposed to the consumption that increases, is necessary to take measures to make its use more efficient.

Recycling and recovery of effluents
Percentage reduction of drinking water consumption rewarding the use of effluents and systems that contributes to the reduction of the unnecessary consumption of potable water. As a precious resource and quality of life, potable water should be used only for functions that require all its qualities. However, it is currently used in applications that can be satisfied with recycled or lower quality water.

Treatment of contaminated effluents

Separation of contaminated effluents and local wastewater treatment giving space for the existence of premises in the building for wastewater treatment and an appropriate contaminated effluent drainage system. Hospital effluents can be classified into household effluents (kitchens, laundries and toilets) and specifically hospital effluents (from analyses, patient care and medicines). Hospital wastewater is classified according to the Generic Recommendations for Hospital Wastewater Management into groups that should be treated appropriately and differentiated according to their category.

Water efficient equipment
To reduce the water consumption by encouraging specification of water efficient equipment by systems or processes identified to reduce the water demand, and demonstrate, through either good practice design or specification, a meaningful reduction in the total water demand of the building.

Sociocultural and functional

Natural ventilation
Efficiency of natural ventilation indoors in order to promote the existence of conditions that allow natural ventilation of the interior space of the building to the exclusive detriment of mechanical ventilation. The levels of indoor air renewal must be guaranteed, safeguarding its quality and reducing occupant exposure to indoor pollutants. The main influence for the natural ventilation is the depth of the floor drawings plans, also courtyards and inner courts favors. When natural ventilation strategy is properly conceived, this can be as effective as a mechanical ventilation system, with all the advantages associated with the fact that there is no power consumption.

Toxicity of finishing materials
Weight the percent of low Volatile Organic Compounds (VOC) finishing materials aiming the reward of using materials that do not cause occupant health problems. Several studies reveal the connection of high concentrations of VOC to the Sick Building Syndrome (SBS). Some examples are formaldehyde, benzene, toluene and xylene. Inside the buildings, the main sources are products derived from wood produced through the use of adhesives and used as solvents in paints mainly from based synthetic, adhesives, carpeting and polyurethane foams. These compounds are often accidentally released into the atmosphere and are therefore responsible for significant environmental impacts.

Thermal comfort
Average annual thermal comfort level to ensure the conditions within the healthcare providers to meet occupant needs. The thermal environment of the interior spaces has physical and psychological effects on its occupants as well as great importance in building design. When designing a building, the creation of a microclimate in the interior spaces, despite the weather conditions outside, largely responds to the needs and expectations of occupants. The climate in Brazil is divided in 5 sub-types – equatorial, semi-arid, highland tropical, and subtropical – and during much of the year, indoor temperatures within a comfortable range use cooling systems, this situation explains that most of the buildings produce large thermal energy.

Visual comfort
This item measures the contribution of natural lighting to the proper lighting of the interior environment by promoting the adoption of criteria to improve the visual comfort of occupants through the proper use of natural lighting, which will contribute to the recovery of patients and the

reduction of energy consumption inside the building. Natural lighting is one of the factors most conditioning to the quality of the environment and has to provide a comfortable visual interior environment, through the minimum energy consumption (artificial lighting). The increasing importance of aspects related to the environment, sustainable development and interior comfort, have contributed to natural light as a leading role in the healing process.

Acoustic comfort

Average level of sound insulation aiming to promote the option for constructive solutions that improve the acoustic comfort of patients and team works. Taking into account the problems that noise causes in humans, it is crucial the society to be aware and take necessary measures for preservation of the health of building occupants. Thus, it is necessary that those responsible for the design of buildings develop techniques in order to provide acoustic comfort conditions, creating a suitable environment for the activities developed.

Indoor air quality

Evaluation of pollutants measured in indoor air aiming the recognition and to encourage the search for a healthy indoor environment by controlling the airborne concentration of existing pollutants. The indoor air is a spread source of microorganisms, which in healthcare units leads to the origin of hospital infections.

Ventilation and temperature

The possibility of room’s control of temperature and openings (windows) to encourage the installation of systems that guarantee the indoor air quality (IAQ) conditions in order to reduce the energy consumption allowing occupants to control the conditions. The Increasing efficiency of natural ventilation and controlling the solar incidence are linked with the conditions of IAQ and thermal comfort, as well as the potential for reducing energy consumption.

Natural light

The possibility of controlling the entrance of natural light inside the building, through elements for this purpose according to functional needs of the spaces aiming the recognition of daylight control systems to reduce energy consumption allowing users to administer the visual comfort of space.

Visual link with the surrounding landscape

The next item persuades the visual contact with the exterior from the main compartments of the building by promoting the design that values the relationship between interior/exterior through the visual contact with the outside.

Layout and orientation

Proper implementation and orientation of the building, taking into account the territorial and landscape framing of the place, promoting the quality of the interior environment to promote and reward a building implementation and orientation that allow the adequate use of solar radiation in the different heating and cooling stations and the appropriate use of wind for natural ventilation.

Passive systems

Integration of building systems for passive heating, ventilation and cooling, upgrading the indoor air quality by promoting the design of bioclimatic buildings that encourages comfort conditions of its users, reducing energy consumption.

Accessibilities

Accessibility and ease circulation area for patients, visitors and service providers by rewarding the existence of efficient accessibility and mobility plan that covers as many people and path as possible.

Availability and accessibility to social areas

To evaluate the existence and accessibility, by users, to activities, living, leisure and outdoor spaces by aiming the existence of living spaces that provide the well-being of patients and work teams.

Space optimisation

The maximisation of the usable floor area inside the building and reduction of the total construction area by promoting the adoption of space design forms and construction solutions that facilitate the optimisation of the construction area, reducing the environmental impacts associated with the floor area and increasing the efficiency.

Space flexibility

The need of spatial solutions that contributes to the versatility of the area, analysing the level of flexibility, allowing the increase and adaptation to the continuous need for alteration of spatial functions into rewarding the option for a design that promotes the flexibility of spaces, so that it can adapt to different operations according to the different needs of everyday life.

Space adaptability

The assessment of adaptive capacity of spaces to changes functionalities in order to promote the adoption of design and construction solutions that simplify their adaptation to different uses, in case of need or rehabilitation of the building.

Economy

Initial cost

The value of initial investment cost per square meter of total construction area to promote the design of sustainable buildings whose initial investment are at least equivalent to conventional buildings.

Operational costs

The value of utilisation costs per square meter of Total construction area aiming the appreciation to the design of sustainable buildings whose utilisation costs are lower than conventional buildings.

Hiring local goods and services

The next item goes into the local community promotion by contracting national and local goods and services addressing the development of the local economy by contracting local goods and services.

Technical

Commissioning

Assessment of building systems and components throughout the different phases of their life cycle in order to identify the existence of a properly planned commissioning process that ensures the proper functioning of all building systems and components.

Environmental management plan

The adoption of a Sustainable Management Plan aiming reward the existence of an Environmental Management System to ensure the design and construction phase and that lasts throughout the use phase.

Infection control
Monitor and evaluate the infection control by promoting an adequate cleaning, disinfection, decontamination and sterilisation of all areas, equipment and instruments of the hospital.

Reducing noise pollution
Mitigation measures of noise production pleasing the reduction within healthcare buildings.

Efficiency of lighting and air conditioning systems
The next item is about the maintenance plan's evaluation, ensuring the proper functioning and efficiency of existing or designed mechanical systems enabling the proper operation of all mechanical systems and building components.

Occupants safety
The indicator below evaluates measures to ensure occupant safety by limiting the risk of hatching and fire hazard; favour the action of firefighters whenever their intervention is necessary; and provide means for users to initiate combat measures before the firefighter's arrival.

Responsible construction practices
To recognise and encourage construction sites which are managed in an environmentally and socially considerate, responsible and accountable manner by using legally harvested and traded timber, considering and implementing health and safety legislation and regulations for construction sites and the monitoring, recording and reporting the energy use, water consumption and transport data resulting from all on site processes throughout the programme.

Materials of high strength and durability
Assessment of the durability and required level of maintenance of finishing materials and other constituents of building elements in order to benefit the use of durable materials that are suitable for their intended use, reducing the complexity and periodicity of maintenance.

Proper selection of furniture
Suitability of furniture and general equipment, mobile and fixed to the functions for which they are intended by promoting the highest durability and eligibility.

Education of occupants
Availability and content of the Building's User Manual by rewarding guidelines for occupants to use it efficiently. Regardless of the design of a building, its efficiency and operating costs are strongly influenced by the daily behaviour of its users. These, with guidance and access to information, can make the best use of the systems. On the other hand, the malfunctioning can lead to levels of discomfort, operating and maintenance costs different from those estimated, resulting a waste of resources.

Education of service providers
Availability and content of the Building's Maintenance and Management Manual by ensuring the proper maintenance for better use, as well as preservation and increase of its useful life.

Satisfaction surveys

Existence of periodic surveys made to building users to assess their satisfaction with the building performance.

Integration in the team of a qualified sustainability expert

The indicator below evaluates the existence of a qualified evaluator on the sustainability construction field in order to promote and value the integration of designers and building management or maintenance from a qualification of the experts.

Site

Local community development

The next item is about the development of urban and local community by promoting the creation of new public space areas, access and service.

Heritage framework

The indicator below evaluates the urban context and valorisation of the surrounding space by promoting and enhancing the architectural, landscape and urban design according to the cultural value of the location.

Accessibility to public transport

Public transport accessibility index aiming the promotion and value of solutions that meet most of the building users' travel needs by urban transportation service.

Low impact mobility

Potential of the building's sustainable mobility conditions to provide facilities which encourage building users to travel using low carbon modes of transport, by stimulating the usage of bicycles and pedestrian’s accessibility, minimise individual journeys, as well as the use of vehicles with less environmental impact.

Local amenities

Accessibility to amenities index intending to enhance the existence of sustainable and integrated communities by establishing basic amenities in the immediate vicinity of the healthcare building.

2. Considering the proposed Method presented above, are there any indicators that have not been presented and that you think should be addressed? Which? Justify

3. Considering the proposed Method presented above, is there any indicator that you think could be eliminated? Which? Justify

APPENDIX II

Questionnaire

In the context of the Master's Dissertation entitled “Building Sustainability Assessment Methods for Healthcare – critical comparative analysis to apply in Brazilian context” the questionnaire was formulated representing a proposal to develop indicators structure based on international rating systems (LEED v4 for Building Design and Construction, BREEAM New Construction and Healthcare Building Sustainability Assessment tool – Portugal).

The survey aims to check the sustainability level of Hospitals in Brazil. The objective of the evaluation is to contribute to the applicability of the indicator itself to a broader context, making it more reliable and robust for practical applications. Also contributing to the development of the measurement of Sustainable Assessment Method for Healthcare Buildings. This evaluation is carried out through the expert’s judgment using specific criteria divided into categories: Environmental, Sociocultural and Functional, Economy, Technical and Site.

The answers will be critical to the credibility of the final results and should be given the most genuine opinions on all the questions presented. All data processing will be performed for the purposes of the Dissertation mentioned, respecting their anonymity and confidentiality.

The estimated time to complete the survey is 20 minutes.

Thank you in advance for your cooperation!

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1. In order to identify the individual expectations of each involved, identify the group to which they belong. If you belong to more than one of the groups listed, please select as many options as necessary.

1.1. Occupation or position currently held (choose one or more of the following):

- Architect
  - ☐ With less than five years of experience
  - ☐ With over five years of experience
  - ☐ With experience in hospital projects
- Civil engineer
  - ☐ With less than five years of experience
  - ☐ With over five years of experience
  - ☐ With experience in hospital projects
- Sustainable Construction Consultant / Expert
  - ☐ With less than five years of experience
  - ☐ With more than five years of experience
- Qualified Sustainable Construction Appraiser
  - ☐ AQUA-HQE
  - ☐ Leader
  - ☐ Procel Edifica
  - ☐ BREEAM
  - ☐ LEED
  - ☐ CASBEE

☐DGNB
☐Other, which one?

- Hospital Manager
  - ☐Facilities and Equipment Services
  - ☐Superintendent / Director
  - ☐Other, which one?
- Other
  - ☐What?

2. Identification

2.1. Area of expertise and / or project development:

- Brazil

☐North
☐Northeast
☐Midwest
☐Southeast
☐South
☐All over the country

3. The proposed Hospital Building Method is a Design Support that consists of three levels to position the selected assessment criteria. Thus the fifty-seven Indicators presented are grouped into twenty-two Categories, framed into five Areas.

3.1. Considering the following tables show the indicators of each category, define the relative importance that each INDICATOR should present in the statement scale.

The criteria are in the form of statements; the evaluator should verify if each of the statements is consistent with the indicator that is being evaluated through a five-level scale (Likert scale):
1 – Not important
2 – Slightly important
3 – Neutral
4 – Important
5 – Very important

Environmental area

This item intent to evaluate the environmental life cycle impact to promote the use, by the design teams, of low environmental impact solutions, associated with the life cycle of various constructive elements and building materials. The database includes, beyond renewable and non-renewable energy embodied, the accounting of the categories: Global warming potential (GWP) Destruction of the ozone layer (ODP); Potential acidification (PA), Photochemical oxidation potential (POP) and Eutrophication potential (EP). To contribute to a reduction in national NOx emission levels through the use of low emission heat sources in the building.

Environmental life cycle impacts assessment						
ID	Description	Evaluation				
		Not important	Slightly important	Neutral	Important	Very important
I1	Assessment of the building’s life cycle impacts	☐	☐	☐	☐	☐

Primary energy consumption

Total primary energy consumption during the use phase to promote the reduction of energy consumption in healthcare buildings.

Local energy production

Amount of energy produced in the building through renewable sources to reward renewable energy consumption through the incorporation of systems that enable clean energy. The use of renewable energy allows the reduction of greenhouse gas emissions and other pollutants and contributes to the conservation of global resources of fossil fuels and to the development for technologies that allow their exploitation. Additionally, results in a reduction on life cycle costs of the building.

Minimum Energy Performance

Demonstrate an improvement in the proposed building performance rating compared with the baseline building performance rating to reduce the environmental and economic harms of excessive energy use by achieving a minimum level of energy efficiency for the building and its systems.

Energy						
ID	Description	Evaluation				
		Not important	Slightly important	Neutral	Important	Very important
I2	Primary energy consumption	☐	☐	☐	☐	☐
I3	Local energy production	☐	☐	☐	☐	☐
I4	Minimum Energy Performance	☐	☐	☐	☐	☐

Layout optimisation

Number of beds available per square meter of built area to recognise the efficient use of the built area.

Soil sealing

Waterproofing Index to promote the soil permeability in urban areas to ensure aquifer recharge and decrease peak flow in storm water drainage systems. The impermeable areas can have a major impact on ecosystems as the ground covered by constructions, streets and other occupations, reduces the soil surface available to support natural habitats and to perform the absorption of rainwater. The increased area of impermeable soil has a negative effect on sustainable development and most common are nature conservation and the absence of flood control.

Reuse of previously built or contaminated areas

Percentage of intervention area previously contaminated or built to reward the choice of location of these buildings in areas previously contaminated or previously built. The main solution to slow the destruction of natural habitats and wildlife they support, but also to prevent the loss of soil suitability is the reuse.

Ecological protection of the site

Protection of the ecological and natural resources of the site aiming the implementation of measures to preserve the ecological and natural resources of the building construction site. The ecological value is affected by the type of existing flora and fauna and their interactions, number of different species, vegetation strata, the existence of water courses, among others.

Rehabilitation of the surrounding

Potential development of the surroundings by rewarding the rehabilitation of deteriorated or/and abandoned from surrounding areas. The principle to be adopted when studying the implementation of a building is to minimise the impacts on the ecology of the area or, where possible, contributing to its improvement.

Use of native plants
Percentage of green area occupied by native plants aiming the promotion of the integration of pre-existing native plants and the planting of local plants in green spaces. Native plants are originated in one specific area where live for many generations, differently from the introduced plant, when a specie have resulted from subsequent introductions. The spontaneous plants grow in community with other species, providing protection and nourishment, but at the same time, can interfere with the natural habitat, competing with native plants.

Heat island effect
Percentage of coverage area and surrounding paved areas with reflectance in order to reduce the heat island effect in urban areas by promoting the use of high reflectance materials or vegetation in outdoor spaces and roofs. The heat island effect indicates the existence of a higher temperature in urban areas, compared with the forest and rural areas. Caused mainly due to the removal of vegetation and its replacement by asphalt and concrete buildings and structures that store and release thermal energy, which have high solar absorption due to its low reflectance. The heat island effect results in extra energy needs of buildings in urban areas and consequently resulting in the increased emissions of pollutants into the atmosphere.

Soil use and biodiversity						
ID	Description	Evaluation				
		Not important	Slightly important	Neutral	Important	Very important
I5	Layout optimisation	☐	☐	☐	☐	☐
I6	Soil sealing	☐	☐	☐	☐	☐
I7	Reuse of previously built or contaminated areas	☐	☐	☐	☐	☐
I8	Ecological protection of the site	☐	☐	☐	☐	☐
I9	Rehabilitation of the surrounding	☐	☐	☐	☐	☐
I10	Use of native plants	☐	☐	☐	☐	☐
I11	Heat island effect	☐	☐	☐	☐	☐

Construction waste
Measurements to reduce the production of Solid Construction and Demolition Waste and a percentage is destined for reuse or recycling to promote the reduction of waste production and reward its recycling.

Reused products and recycled materials
Percentage of the cost of reused products and materials with recycled content aiming the promotion of its usage from the construction site or outside, specific for each material type within its components. The reuse of building materials or elements that result from the end of a building's life cycle consists into the use of them incorporated into new materials for construction or rehabilitation.

Waste separation and storage
The building’s performance at the level of this parameter is evaluated by the value of the Potential of the Building's Conditions for Promoting the Separation of Solid Waste (PRSU), which results from criteria related to the indoor and outdoor existing conditions for the deposition and storage of

household waste. Usually composed by organic material, paper, cardboard, plastic, glass, metals, infectious, pathological, sharps, chemical, among others.

Responsible sourcing of materials
To recognise and encourage the specification and procurement of responsibly sourced construction products by using timber/timber-based products legally harvested and traded, a documented policy and procedure that sets out procurement requirements for all suppliers and trades to adhere to relating to the responsible sourcing of construction products and to available the responsible sourcing credits awarded where the applicable construction products are responsibly sourced in accordance with the methodology.

Materials and Solid Waste						
ID	Description	Evaluation				
		Not important	Slightly important	Neutral	Important	Very important
I12	Construction waste	☐	☐	☐	☐	☐
I13	Reused products and recycled materials	☐	☐	☐	☐	☐
I14	Waste separation and storage	☐	☐	☐	☐	☐
I15	Responsible sourcing of materials	☐	☐	☐	☐	☐

Potable water consumption
Annual volume of water consumed per square meter inside the building aiming the promotion of the reduction of water consumption, depending on the efficiency of devices and the average consumption patterns. The quality of water supply, the drainage and wastewater treatment have a strong impact on public health, due to drinking water supplies are diminishing, opposed to the consumption that increases, is necessary to take measures to make its use more efficient.

Recycling and recovery of effluents
Percentage reduction of drinking water consumption rewarding the use of effluents and systems that contributes to the reduction of the unnecessary consumption of potable water. As a precious resource and quality of life, potable water should be used only for functions that require all its qualities. However, it is currently used in applications that can be satisfied with recycled or lower quality water.

Treatment of contaminated effluents
Separation of contaminated effluents and local wastewater treatment giving space for the existence of premises in the building for wastewater treatment and an appropriate contaminated effluent drainage system. Hospital effluents can be classified into household effluents (kitchens, laundries and toilets) and specifically hospital effluents (from analyses, patient care and medicines). Hospital wastewater is classified according to the Generic Recommendations for Hospital Wastewater Management into groups that should be treated appropriately and differentiated according to their category.

Water efficient equipment
To reduce the water consumption by encouraging specification of water efficient equipment by systems or processes identified to reduce the water demand, and demonstrate, through either good practice design or specification, a meaningful reduction in the total water demand of the building.

Water		
ID	Description	Evaluation

		Not important	Slightly important	Neutral	Important	Very important
I16	Potable water consumption	☐	☐	☐	☐	☐
I17	Recycling and recovery of effluents	☐	☐	☐	☐	☐
I18	Treatment of contaminated effluents	☐	☐	☐	☐	☐
I19	Water efficient equipment	☐	☐	☐	☐	☐

Sociocultural and functional

Natural ventilation

Efficiency of natural ventilation indoors in order to promote the existence of conditions that allow natural ventilation of the interior space of the building to the exclusive detriment of mechanical ventilation. The levels of indoor air renewal must be guaranteed, safeguarding its quality and reducing occupant exposure to indoor pollutants. The main influence for the natural ventilation is the depth of the floor drawings plans, also courtyards and inner courts favours. When natural ventilation strategy is properly conceived, this can be as effective as a mechanical ventilation system, with all the advantages associated with the fact that there is no power consumption.

Toxicity of finishing materials

Weight the percent of low Volatile Organic Compounds (VOC) finishing materials aiming the reward of using materials that do not cause occupant health problems. Several studies reveal the connection of high concentrations of VOC to the Sick Building Syndrome (SBS). Some examples are formaldehyde, benzene, toluene and xylene. Inside the buildings, the main sources are products derived from wood produced through the use of adhesives and used as solvents in paints mainly from based synthetic, adhesives, carpeting and polyurethane foams. These compounds are often accidentally released into the atmosphere and are therefore responsible for significant environmental impacts.

Thermal comfort

Average annual thermal comfort level to ensure the conditions within the healthcare providers to meet occupant needs. The thermal environment of the interior spaces has physical and psychological effects on its occupants as well as great importance in building design. When designing a building, the creation of a microclimate in the interior spaces, despite the weather conditions outside, largely responds to the needs and expectations of occupants. The climate in Brazil is divided in 5 sub-types – equatorial, semi-arid, highland tropical, and subtropical – and during much of the year, indoor temperatures within a comfortable range use cooling systems, this situation explains that most of the buildings produce large thermal energy.

Visual comfort

This item measures the contribution of natural lighting to the proper lighting of the interior environment by promoting the adoption of criteria to improve the visual comfort of occupants through the proper use of natural lighting, which will contribute to the recovery of patients and the reduction of energy consumption inside the building. Natural lighting is one of the factors most conditioning to the quality of the environment and has to provide a comfortable visual interior environment, through the minimum energy consumption (artificial lighting). The increasing importance of aspects related to the environment, sustainable development and interior comfort, have contributed to natural light as a leading role in the healing process.

Acoustic comfort

Average level of sound insulation aiming to promote the option for constructive solutions that improve the acoustic comfort of patients and team works. Taking into account the problems that noise causes in humans, it is crucial the society to be aware and take necessary measures for preservation of the health of building occupants. Thus, it is necessary that those responsible for the design of buildings develop techniques in order to provide acoustic comfort conditions, creating a suitable environment for the activities developed.

Indoor air quality
Evaluation of pollutants measured in indoor air aiming the recognition and to encourage the search for a healthy indoor environment by controlling the airborne concentration of existing pollutants. The indoor air is a spread source of microorganisms, which in healthcare units leads to the origin of hospital infections.

User's health and comfort						
ID	Description	Evaluation				
		Not important	Slightly important	Neutral	Important	Very important
I20	Natural ventilation	☐	☐	☐	☐	☐
I21	Toxicity of finishing materials	☐	☐	☐	☐	☐
I22	Thermal comfort	☐	☐	☐	☐	☐
I23	Visual comfort	☐	☐	☐	☐	☐
I24	Acoustic comfort	☐	☐	☐	☐	☐
I25	Indoor air quality	☐	☐	☐	☐	☐

Ventilation and temperature
The possibility of room's control of temperature and openings (windows) to encourage the installation of systems that guarantee the indoor air quality (IAQ) conditions in order to reduce the energy consumption allowing occupants to control the conditions. The Increasing efficiency of natural ventilation and controlling the solar incidence are linked with the conditions of IAQ and thermal comfort, as well as the potential for reducing energy consumption.

Natural light
The possibility of controlling the entrance of natural light inside the building, through elements for this purpose according to functional needs of the spaces aiming the recognition of daylight control systems to reduce energy consumption allowing users to administer the visual comfort of space.

Controllability by the user						
ID	Description	Evaluation				
		Not important	Slightly important	Neutral	Important	Very important
I26	Ventilation and temperature	☐	☐	☐	☐	☐
I27	Natural light	☐	☐	☐	☐	☐

The next item persuades the visual contact with the exterior from the main compartments of the building by promoting the design that values the relationship between interior/exterior through the visual contact with the outside.

Landscaping						
ID	Description	Evaluation				
		Not important	Slightly important	Neutral	Important	Very important
I28	Visual link with the surrounding landscape	☐	☐	☐	☐	☐

Layout and orientation

Proper implementation and orientation of the building, taking into account the territorial and landscape framing of the place, promoting the quality of the interior environment to promote and reward a building implementation and orientation that allow the adequate use of solar radiation in the different heating and cooling stations and the appropriate use of wind for natural ventilation.

Passive systems

Integration of building systems for passive heating, ventilation and cooling, upgrading the indoor air quality by promoting the design of bioclimatic buildings that encourages comfort conditions of its users, reducing energy consumption.

Passive design						
ID	Description	Evaluation				
		Not important	Slightly important	Neutral	Important	Very important
I29	Layout and orientation	☐	☐	☐	☐	☐
I30	Passive systems	☐	☐	☐	☐	☐

Accessibilities

Accessibility and ease circulation area for patients, visitors and service providers by rewarding the existence of efficient accessibility and mobility plan that covers as many people and path as possible.

Mobility plan						
ID	Description	Evaluation				
		Not important	Slightly important	Neutral	Important	Very important
I31	Accessibilities	☐	☐	☐	☐	☐

Availability and accessibility to social areas

To evaluate the existence and accessibility, by users, to activities, living, leisure and outdoor spaces by aiming the existence of living spaces that provide the well-being of patients and work teams.

Space optimisation

The maximisation of the usable floor area inside the building and reduction of the total construction area by promoting the adoption of space design forms and construction solutions that facilitate the optimisation of the construction area, reducing the environmental impacts associated with the floor area and increasing the efficiency.

Space flexibility

The need of spatial solutions that contributes to the versatility of the area, analysing the level of flexibility, allowing the increase and adaptation to the continuous need for alteration of spatial functions into rewarding the option for a design that promotes the flexibility of spaces, so that it can adapt to different operations according to the different needs of everyday life.

Space adaptability

The assessment of adaptive capacity of spaces to changes functionalities in order to promote the adoption of design and construction solutions that simplify their adaptation to different uses, in case of need or rehabilitation of the building.

Space flexibility and adaptability						
ID	Description	Evaluation				
		Not important	Slightly important	Neutral	Important	Very important
I32	Availability and accessibility to social areas	☐	☐	☐	☐	☐
I33	Space optimisation	☐	☐	☐	☐	☐
I34	Space flexibility	☐	☐	☐	☐	☐
I35	Space adaptability	☐	☐	☐	☐	☐

Economy

Initial cost
The value of initial investment cost per square meter of total construction area to promote the design of sustainable buildings whose initial investment are at least equivalent to conventional buildings.

Operational costs
The value of utilisation costs per square meter of Total construction area aiming the appreciation to the design of sustainable buildings whose utilisation costs are lower than conventional buildings.

Life cycle costs						
ID	Description	Evaluation				
		Not important	Slightly important	Neutral	Important	Very important
I36	Initial cost	☐	☐	☐	☐	☐
I37	Operational costs	☐	☐	☐	☐	☐

The next item goes into the local community promotion by contracting national and local goods and services addressing the development of the local economy by contracting local goods and services.

Local economy						
ID	Description	Evaluation				
		Not important	Slightly important	Neutral	Important	Very important
I38	Hiring local goods and services	☐	☐	☐	☐	☐

The risk of corruption is transversal, good practices management helps to prevent situations of infractions and, therefore, it is essential to identify the risks of deviation from good practices and their consequences in terms of management. Reducing corruption is essential for strengthening democratic institutions, promoting relations between citizens and public or private administration, economic development and growth and the regular functioning of markets. The problem of corruption is associated with many situations, which spoil the functioning of institutions and markets, such as abuse of power, bribery, embezzlement, influence peddling, economic participation in business and concussion. All of these constitute related crimes, and there is an undue advantage or compensation to be obtained. Sustainable purchase policies aim the identification of risks, resources, actions and responsibilities to mitigate them, as well as the process of implementation, monitoring, evaluation and reporting. The risk can be defined as an event that, if occurs, will have a negative impact on the achievement of the organisation's mission and objectives. Missed opportunities can also be considered a risk.

Corruption avoiding plan		
ID	Description	Evaluation

		Not important	Slightly important	Neutral	Important	Very important
I39	Sustainable purchase policies	☐	☐	☐	☐	☐

Technical
Commissioning
Assessment of building systems and components throughout the different phases of their life cycle in order to identify the existence of a properly planned commissioning process that ensures the proper functioning of all building systems and components.

Environmental management plan
The adoption of a Sustainable Management Plan aiming reward the existence of an Environmental Management System to ensure the design and construction phase and that lasts throughout the use phase.

Infection control
Monitor and evaluate the infection control by promoting an adequate cleaning, disinfection, decontamination and sterilisation of all areas, equipment and instruments of the hospital.

Reducing noise pollution
Mitigation measures of noise production pleasing the reduction within healthcare buildings.

Environmental management systems						
ID	Description	Evaluation				
		Not important	Slightly important	Neutral	Important	Very important
I40	Commissioning	☐	☐	☐	☐	☐
I41	Environmental management plan	☐	☐	☐	☐	☐
I42	Infection control	☐	☐	☐	☐	☐
I43	Reducing noise pollution	☐	☐	☐	☐	☐

The next item is about the maintenance plan’s evaluation, ensuring the proper functioning and efficiency of existing or designed mechanical systems enabling the proper operation of all mechanical systems and building components.

Technical systems						
ID	Description	Evaluation				
		Not important	Slightly important	Neutral	Important	Very important
I44	Efficiency of lighting and air conditioning systems	☐	☐	☐	☐	☐

Occupants safety
The indicator below evaluates measures to ensure occupant safety by limiting the risk of hatching and fire hazard; favour the action of firefighters whenever their intervention is necessary; and provide means for users to initiate combat measures before the firefighter’s arrival.

Responsible construction practices
To recognise and encourage construction sites which are managed in an environmentally and socially considerate, responsible and accountable manner by using legally harvested and traded timber, considering and implementing health and safety legislation and regulations for construction

sites and the monitoring, recording and reporting the energy use, water consumption and transport data resulting from all on site processes throughout the programme.

Security						
ID	Description	Evaluation				
		Not important	Slightly important	Neutral	Important	Very important
I45	Occupants safety	☐	☐	☐	☐	☐
I46	Responsible construction practices	☐	☐	☐	☐	☐

Materials of high strength and durability

Assessment of the durability and required level of maintenance of finishing materials and other constituents of building elements in order to benefit the use of durable materials that are suitable for their intended use, reducing the complexity and periodicity of maintenance.

Proper selection of furniture

Suitability of furniture and general equipment, mobile and fixed to the functions for which they are intended by promoting the highest durability and eligibility.

Durability						
ID	Description	Evaluation				
		Not important	Slightly important	Neutral	Important	Very important
I47	Materials of high strength and durability	☐	☐	☐	☐	☐
I48	Proper selection of furniture	☐	☐	☐	☐	☐

Education of occupants

Availability and content of the Building's User Manual by rewarding guidelines for occupants to use it efficiently. Regardless of the design of a building, its efficiency and operating costs are strongly influenced by the daily behaviour of its users. These, with guidance and access to information, can make the best use of the systems. On the other hand, the malfunctioning can lead to levels of discomfort, operating and maintenance costs different from those estimated, resulting a waste of resources.

Education of service providers

Availability and content of the Building's Maintenance and Management Manual by ensuring the proper maintenance for better use, as well as preservation and increase of its useful life.

Satisfaction surveys

Existence of periodic surveys made to building users to assess their satisfaction with the building performance.

Awareness and education for sustainability						
ID	Description	Evaluation				
		Not important	Slightly important	Neutral	Important	Very important
I49	Education of occupants	☐	☐	☐	☐	☐
I50	Education of service providers	☐	☐	☐	☐	☐
I51	Satisfaction surveys	☐	☐	☐	☐	☐

The indicator below evaluates the existence of a qualified evaluator on the sustainability construction field in order to promote and value the integration of designers and building management or maintenance from a qualification of the experts.

Skills in sustainability						
ID	Description	Evaluation				
		Not important	Slightly important	Neutral	Important	Very important
I52	Integration of a qualified sustainability expert	☐	☐	☐	☐	☐

Site

The next item is about the development of urban and local community by promoting the creation of new public space areas, access and service.

Local community						
ID	Description	Evaluation				
		Not important	Slightly important	Neutral	Important	Very important
I53	Local community development	☐	☐	☐	☐	☐

The indicator below evaluates the urban context and valorisation of the surrounding space by promoting and enhancing the architectural, landscape and urban design according to the cultural value of the location.

Cultural value						
ID	Description	Evaluation				
		Not important	Slightly important	Neutral	Important	Very important
I54	Heritage framework	☐	☐	☐	☐	☐

Accessibility to public transport

Public transport accessibility index aiming the promotion and value of solutions that meet most of the building users' travel needs by urban transportation service.

Low impact mobility

Potential of the building's sustainable mobility conditions to provide facilities which encourage building users to travel using low carbon modes of transport, by stimulating the usage of bicycles and pedestrian’s accessibility, minimise individual journeys, as well as the use of vehicles with less environmental impact.

Local amenities

Accessibility to amenities index intending to enhance the existence of sustainable and integrated communities by establishing basic amenities in the immediate vicinity of the healthcare building.

Conveniences						
ID	Description	Evaluation				
		Not important	Slightly important	Neutral	Important	Very important
I55	Accessibility to public transport	☐	☐	☐	☐	☐
I56	Low impact mobility	☐	☐	☐	☐	☐
I57	Local amenities	☐	☐	☐	☐	☐

4. Considering the proposed Method presented above, are there any indicators that have not been presented and that you think should be addressed? Which? Justify

5. Considering the proposed Method presented above, is there any indicator that you think could be eliminated? Which? Justify

Comments:

Thanks for the collaboration!