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ISTANBUL GEDİK UNIVERSITY
INSTITUTE OF GRADUATE STUDIES

A FRAMEWORK FOR SELECTICTION SUSTAINABLE MATERIALS IN IRAQI CONSTRUCTION PROJECTS

MASTER THESIS

Bushra Qader Oliwi AZZAWI

Engineering Management Department

Engineering Management Master in English Program

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DECLARATION

I am, Bushra Qader Oliwi Azzawi , do hereby declare that this thesis titled as “A framework for selecting sustainable materials in Iraqi construction projects” is original work done by me for the award of the master’s degree in the faculty of Engineering Management. I also declare that this thesis or any part of it has not been submitted and presented for any other degree or research paper in any other university or institution. (25/05/2023)

Bushra Qader Oliwi AZZAWI

To my parents, family and friends

PREFACE

In the name of God, the most gracious, the most merciful. I would like to express my deepest thanks, appreciation and respect to the honorable supervisors Assoc. Prof. Dr. Redvan Ghasemlounia and Asst. Prof. Dr. Maysoon Abdullah Mansor, who have been my best assistants throughout the writing of this letter, who have given me advice and guidance while writing this humble work. To the woman who raised me, supported me, and helped me get to where I am, my mother. To my dear father (may God have mercy on him), that great man who was and still is a role model for me. I want to thank that person who has always supported me and stood by me . The hardest times, my dear husband, I would like to thank all of my teachers. Those who made me a research science student . To my dear brothers and sister Zina , who supported me in all stages of my life, and showered me with their love. To all of you my sincere thanks appreciation and respect.

May 2023 Bushra Qader Oliwi AZZAWI

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ABBREVIATIONS

MCDA	: Multi-Criteria Decision Analysis
AHP	: Analytic Hierarchy Process
Fuzzy AHP	: fuzzy analytical hierarchy Process
SPSS	: Statistical Package for the Social Sciences
GHGs	: Greenhouse Gases
W0	: Relative Weights
TFN	: Triangular Fuzzy Number
LCCA	: Life Cycle Cost Analysis
WWDR	: World Water Development Report
ACOSS	: Australian Council for Social Services
LCCA	: Life-Cycle Costing Analysis
(RII)	: Relative Importance Index
W	: Weighting Given to Each Factor
A	: The Highest Weight, In The Research
N	: The Total Number Of Respondents
H	: High
M –H	: Medium - High
M	: Medium
L - M	: Low - Medium
L	: Low
ANP	: Analytical Network Practical Techniques
TOPSIS	: Technique for Order Preference by Similarity to an Ideal Solution
ELECTRE	: Elimination and Choice Expressing Reality
DEA	: Data Envelopment Analysis

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A FRAMEWORK FOR SELECTICTION SUSTAINABLE MATERIALS IN IRAQI CONSTRUCTION PROJECTS

ABSTRACT

Choosing sustainable building materials is an important strategy in designing sustainable buildings, especially in Iraq due to the nature of the environment and atmosphere. This study helps in the selection of building materials by providing appropriate solutions to two main issues: (identifying the most important criteria for selecting sustainable building materials and the process of prioritizing and determining weights for these criteria).. Evaluation criteria are determined based on sustainable criteria for selecting building materials and the need for sustainable construction that serves everyone, especially engineers and stakeholders

The criteria were determined through previous studies and through theoretical examination. Indicators were collected from the former research, studies and literature review as well as from theoretical topics relevant to the issue of selecting sustainable building materials used in construction projects, where a survey of construction experts was conducted, where the criteria were divided into four main criteria and (31) sub-criteria, and the SPSS method was used to analyze the data obtained through the experts' questionnaire. In this field, the Fuzzy Hierarchical Analytical Process (Fuzzy AHP) method was used to analyze the data. To calculate the relate criteria weights to use the significance of these criteria for selecting a particular material alternative. On the ground, this model can provide guidance to building designers in selecting sustainable building materials to contribute to the sustainable building process

For the purpose of applying this framework (a framework for the sustainable selection of building materials used in construction projects in Iraq), a case study was conducted for the purpose of making multi-criteria decisions using the fuzzy AHP method to solve the problem of selecting sustainable materials. Where the case study includes the selection of three types of bricks used in construction in Iraq, which are red bricks (red), yellow bricks (yellow), and solid yellow bricks (yellow s). And to apply. The framework that was proposed in this study for the purpose of selecting the most sustainable types of bricks .The same criteria and sub-criteria used in this research were used and applied to alternative subjects

It emerged from the general evaluation of the three materials using the Fuzzy AHP technique, which aims to find the best materials, and it was found that the importance of red bricks is the highest rank (1), the second importance of yellow perforated bricks (yellow) rank (2) and the third importance of solid yellow bricks (yellow s) rank (3).

These results correspond to reality, according to the opinion of experts. It can also help stakeholders, project managers and contractors to choose sustainable building materials and eliminate weaknesses by taking action at an early stage in order to obtain a building with a high level of sustainability

Keywords: *Framework, Sustainable material, Construction project, Fuzzy AHP*

IRAK İNŞAAT PROJELERİNDE SÜRDÜRÜLEBİLİR MALZEME SEÇİMİ İÇİN BİR ÇERÇEVE

ÖZET

Sürdürülebilir yapı malzemelerinin seçimi, çevrenin ve atmosferin doğası gereği özellikle Irak'ta sürdürülebilir binaların tasarlanmasında önemli bir strateji olmaktadır. Bu çalışma, yapı malzemelerinin seçiminde iki ana konuya uygun çözümler sunarak yardımcı olmaktadır: sürdürülebilir yapı malzemelerinin seçiminde en önemli kriterlerin belirlenmesi ve bu kriterlerin önceliklendirilmesi ve ağırlıklarının belirlenmesi süreci. Değerlendirme kriterleri, yapı malzemelerinin seçiminde sürdürülebilir kriterler ve başta mühendisler ve paydaşlar olmak üzere herkese hizmet eden sürdürülebilir inşaat ihtiyacı temel alınarak belirlenir.

Kriterler önceki çalışmalar incelenerek ve teorik araştırma yapılması yoluyla belirlendi. Göstergeler, önceki araştırmalardan, çalışmalardan ve literatür taramasından ve ayrıca inşaat projelerinde kullanılan sürdürülebilir yapı malzemelerinin seçilmesi konusuyla ilgili teorik konulardan, inşaat uzmanları anketinin yapıldığı ve kriterlerin dört ana kritere ayrıldığı yerden toplanmış olup, 31 alt kriteri olup, uzman anketinden elde edilen verilerin analizinde SPSS yöntemi kullanılmıştır. Bu alanda verilerin analizinde Fuzzy Hiyerarşik Analitik Proses (Fuzzy AHP) yöntemi kullanılmıştır. Belirli bir malzeme alternatifini seçmek için bu kriterlerin önemini kullanmak üzere ilgili kriter ağırlıkları hesaplanmıştır. Temelde bu model, sürdürülebilir yapı sürecine katkıda bulunmak için sürdürülebilir yapı malzemelerinin seçilmesinde yapı tasarımcılarına rehberlik sağlayabilir.

Bu çerçeveyi (Irak'taki inşaat projelerinde kullanılan yapı malzemelerinin sürdürülebilir seçimi için bir çerçeve) uygulamak amacıyla, bu tez kapsamında seçim problemini çözmek için bulanık AHP yöntemini kullanarak çok kriterli kararlar vermek amacıyla bir vaka çalışması yapılmıştır. Sürdürülebilir malzemeler için örnek vaka incelemesi olarak, Irak'ta inşaatta kullanılan kırmızı tuğlalar (kırmızı), sarı tuğlalar (sarı) ve katı sarı tuğlalar (sarılar) olmak üzere üç tip tuğlanın seçimini içermektedir. Bu çalışmada en sürdürülebilir tuğla türlerinin seçilmesi amacıyla önerilen çerçeve. Bu araştırmada kullanılan kriterlerin ve alt kriterlerin aynıları kullanılmış ve alternatif konulara uygulanmıştır.

En iyi malzemeleri bulmak amacıyla Fuzzy AHP tekniği kullanılarak üç malzemenin genel olarak değerlendirilmesinden ortaya çıkmış ve kırmızı tuğlaların önem sıralamasında birinci, ikinci sırada ise sarı delikli tuğlaların olduğu tespit edilmiştir.

Uzmanların görüşüne göre bu sonuçlar gerçeğe uygundur. Ayrıca paydaşların, proje yöneticilerinin ve müteahhitlerin sürdürülebilir yapı malzemelerini seçmelerine ve sürdürülebilirliği yüksek bir bina elde etmek için projenin başlangıç aşamasında harekete geçerek zayıflıkları ortadan kaldırmalarına yardımcı olabilir.

Anahtar Kelimeler: *Çerçeve, İnşaat projesi, Sürdürülebilir malzemeler, Fuzzy AHP*

1 INTRODUCTION

1.1 Study Topic

Sustainability in the selection of materials for construction projects is a broad and complex concept, and it has grown to be one of the most important concepts and key issues in the construction industry. Thus, this type of sustainability has spread. Therefore, there is a need for a holistic and applicable approach that applies the principles of sustainability in the material selection decision in construction projects

The construction, equipping, use and eventual demolition of buildings are important environmental factors that affect people both directly (through the use of materials and energy) and indirectly (often through pressure on infrastructure and the resulting pollution and waste). Organizations dedicated to environmental performance goals are increasingly in agreement that, as a result of these effects, effective strategies and actions are needed to make the construction industry more sustainable.

The construction sector consumes natural resources and produces large amounts of waste. Researchers have experimented with different methods and design ideas over the years to achieve a better environment. However, sustainability requires the interaction of a tripartite framework consisting of social, economic and environmental aspects. It does not focus only on environmental issues. In addition, there are a lot of stakeholders involved in the construction project, which leads to a variety of information sources, which creates uncertainty. The choices about sustainable building that are made before the start of the project are very important. Thus, methods and tools that enable these decisions to be made for the building are required [1].

Sustainable Building: It seeks to adapt the principles of sustainable improvement in manufacturing, and it is one of the most important principles of sustainable building, which includes:

1. Increasing the efficiency of using resources, by reducing the use of natural raw materials, using less energy, which leads to less pollutants and waste

2. Improving lifestyle and providing customer or buyer satisfaction.
3. There is flexibility in selecting, changing or using resources ,alternatives during the construction life stage
4. Providing and supporting an appropriate economic and social environment regularly
5. Within a certain time frame, it is possible to enhance the efficiency of construction and throughout the life of the building, through the use of sustainable materials [2].

Decisions made by a variety of construction actors determine how quickly steps towards sustainable implementation can be adopted. Owners, managers and designers are the most important people who can make this choice of using environmentally friendly building materials in construction projects. And the best way for designers to start is to carefully select sustainable building designers. To ensure the application of environmental practices in construction projects [3].

Although many definitions relate to sustainable buildings, the main principles and .Theories and goals remain the same which is a stable economy and a harmless environment as well .The general culture that will enhance the modern and future view of sustainable buildings .Considering the negative impact of the construction on the surrounding area ,Building materials need to change the current perspective to choose materials of a sustainable nature that lead to sustainable building, It is the beginning of any successful project, and this study benefits engineers and designers Those who do not have experience in this field. It also allows designers, owners and engineers to assess the sustainability of selected building materials.

The selection of building materials is a multifactorial process based mostly on faith in experience rather than using a static approach. Since there are no formal measurement standards or techniques, we must use and develop a digital approach. Moreover, creating and running several recent assessments . Since the old approach was heavily criticized for overemphasizing environmental concerns, the current sustainability assessment will include social criteria as well. Also, technical, environmental and economic factors are taken into account at every step of the decision-making process. It must be emphasized that to do so in practice would need to develop and demonstrate this pure form of sustainability assessment [4].

Another difficulty raised is the fact that the bulk of assessment methods have focused on the built structures' architecture because they were designed for new construction. Although the tools adequately addressed energy, water, and occupant comfort, there was little attention paid to the impact of a building system's life throughout operation. Particularly in the case of envelope performance. Due to this propensity, many assessment techniques have failed to adequately take into account additional assessment criteria, including as durability, lifetime costs, and the consequences of early building envelope failures. Assessment techniques will need to Reframe it in the context of sustainability - environmental, social, technical and economic in order for it to be truly sustainable. This is to broaden the focus of designers and decision makers beyond the environment. In order to be able to trade off environmental, economic, social and technological aspects, it is necessary to design a systematic and comprehensive procedure for the selection of sustainable materials. An appropriate solution can be determined through the use of multi-criteria decision analysis (MCDA) approaches, according to the description of the material selection process as a multi-criteria problem which by its very nature contains diverse considerations, often with complex trade-offs between them [4][5].

The Analytic Hierarchy Process AHP developed by Saaty was taken into consideration as a potential foundation for the sustainable material selection method envisaged the selection problem has been further profiled, and the desirable qualities of the solution methodologies have been identified. is commonly utilized in practical situations to address multi-criteria decision-making problems (AHP) [6].

There is widespread use of the Analytical Hierarchy Process (AHP). addressing real-world multicriteria decision-making issues An AHP based multi-criteria approach has been employed. continued assessment. The vast majority of academics concur that the AHP program offers a framework for choice-making that is strong and in line with sustainable building standards. Utilizing AHP for environmentally friendly goals.

AHP is a technique for rating the options and choosing the best one when the decision maker must take into account many factors. By assigning each option a numerical score based on how well it satisfies his choice criteria, the decision maker selects the alternative that best does so [7].

Pairwise comparisons are used in AHP to determine preferences between options. In a pairwise comparison, the decision-maker looks at two options while taking into account one criterion, then expresses a preference. A preference scale, which gives numerical values to various levels of preference, is used to make these comparisons.[8]

A complex issue is broken down into a hierarchy using the method's central strategy, which places a goal (or criterion) at the top, followed by criteria and sub-criteria at levels and sub-levels, and decision possibilities at the bottom. Elements at specific hierarchy levels are examined in pairs to discover their relative criterion in respect to each element at the level above. The method computes and aggregates the eigenvectors of each option until the final composite vector of weight coefficients for alternatives is obtained. The entries in the final weight coefficients vector depict how important (valuable) each option is in respect to the overall objective.[9]

Even while AHP has been often used to address multicriterion decision making challenges, its use of a discrete scale of one to nine, which cannot handle the uncertainty and ambiguity present in identifying the priority of many attributes, has led to considerable criticism.[10]

Despite its widespread use and ease of use, evaluation has been taken into account in various ways. This method is frequently criticized from a theoretical standpoint since it can't handle the underlying uncertainty and accompanying imprecision very well.

A decision maker's impression of numbers must be precise (or crisp, in fuzzy logical terms).[11][12][13].

The triangular fuzzy numbers are a pair-wise comparison scale that the proposed Fuzzy AHP utilizes to determine the relative importance of various selection criteria and sub - criteria. The concept of the comparison of fuzzy numbers is used to construct the weight vectors for each element under a specific condition. The priority weights of each material are therefore determined, and the most sustainable material is chosen as a result. The method was specifically intended to handle the inherent ambiguity and imprecision of human decision making while also giving the decision maker the flexibility and resilience they require to comprehend the decision problem. These advantages of the method would make it easier to apply it to actual situations and make wise decision. [14].

This thesis uses a fuzzy extended AHP (Fuzzy AHP) approach to improve the AHP method and streamline the selection of sustainable materials. Triangular fuzzy numbers are used to represent decision makers' comparison judgments, and a fuzzy synthetic extent analysis method is used to determine the final priority of various decision criteria. Similar to how people think, the fuzzy set theory draws conclusions from rough data and uncertainty. It has the advantage of being able to quantify uncertainty and ambiguity and provides specific approaches for dealing with the imprecision prevalent in many problems..

1.2 Research Hypothesis

The hypothesis of this study is that:.

1. There are main criteria and sub criteria that can be used for the purpose of selecting sustainable building materials
2. Finding a framework for selecting sustainable materials in construction projects based on these sustainable criteria

1.3 Purpose of Thesis

The main objective of this study is to find a framework for selecting sustainable materials in Iraqi construction projects through the following sub-objectives

1. To find a framework for decision-making in the selection of sustainable materials in construction projects in Iraq
2. Finding the most important economic, environmental, technical and social criteria and their sub criteria and finding the best way to choose materials by discovering the most important criteria

1.4 Importance of the Research

This framework helps decision makers to make critical decisions when choosing a sustainable building material, by setting a framework for selecting sustainable building materials used in construction projects, defining criteria and choosing the most important ones, and it is considered a step in the process of developing building projects towards sustainable construction. When appropriately developed and

applied, these indicators can play a major role in the selection of sustainable building materials, which can solve many environmental, economic, social and technical problems of the project.

1.5 Research Justification

The reasons for adopting this study are as follows:

1. The construction sector suffers from the inability to identify and select sustainable building materials for a project. Where there is no agreement among researchers on a comprehensive scale for selecting sustainable building materials, the main reason is the use of random selection and old methods for selecting
2. Building materials for construction projects in Iraq that suffer from poor accuracy
3. There are few previous studies in defining criteria for selecting sustainable building materials, and its impact on construction projects Iraq
4. This study adds to the field of knowledge of academics and researchers and empowers stakeholders, consultants, contractors and project managers. Learn about these standards and use them in the development of sustainable construction projects
5. The use of criteria for the selection of sustainable building materials for construction projects in Iraq is very little, almost non-existent. So the need arose to get to ,The best indicators that are used to choose these materials in order to improve the level of construction projects and reduce their harmful impact on the environment .By relying on the latest methods used globally, namely the SPSS (Statistical Package for the Social Sciences) for statistical analysis method ,and the fuzzy hierarchical analysis method (Fuzzy AHP) method

1.6 Limits of Research

1. This framework helps decision makers to make sustainable decisions when choosing a building material.

2. To create sustainable buildings, which means buildings that use less water, energy, and natural materials at a lower cost.

1.7 Methodology of Research

The research methodology includes the following:

1. Theoretical study criteria and sub criteria: Gathering indicators from previous research Studies and literature review for theoretical topics in the subject of criteria for sustainable materials used in construction projects.
2. Distribute the questionnaire to for experts in this field that can answer the questionnaire
3. Conduct a descriptive and quantitative analysis on the questionnaire answers using version 26 SPSS (Statistical Package for the Social Sciences) for statistical analysis method
4. Determine the most important criteria through the relative importance of the criteria , then ranging the criteria from high to low through the relative importance
5. By using the MATLAB program , analyzing data by work on fuzzy data according to the trigonometric method (converting numbers into fuzzy numbers)
6. Calculating the weights for each level (the weights of the criteria – sub criteria)
7. Arranging the sustainable alternatives for the selected materials by obtaining the total weight of the criteria throw (Determine the local weight and global weight of the criteria group and each of sub criteria) of the criteria as it is a measure of the relative importance of the alternatives. Where the decision-maker can obtain the best alternative of the materials according to the higher weight of the criteria
8. Conduct the case study

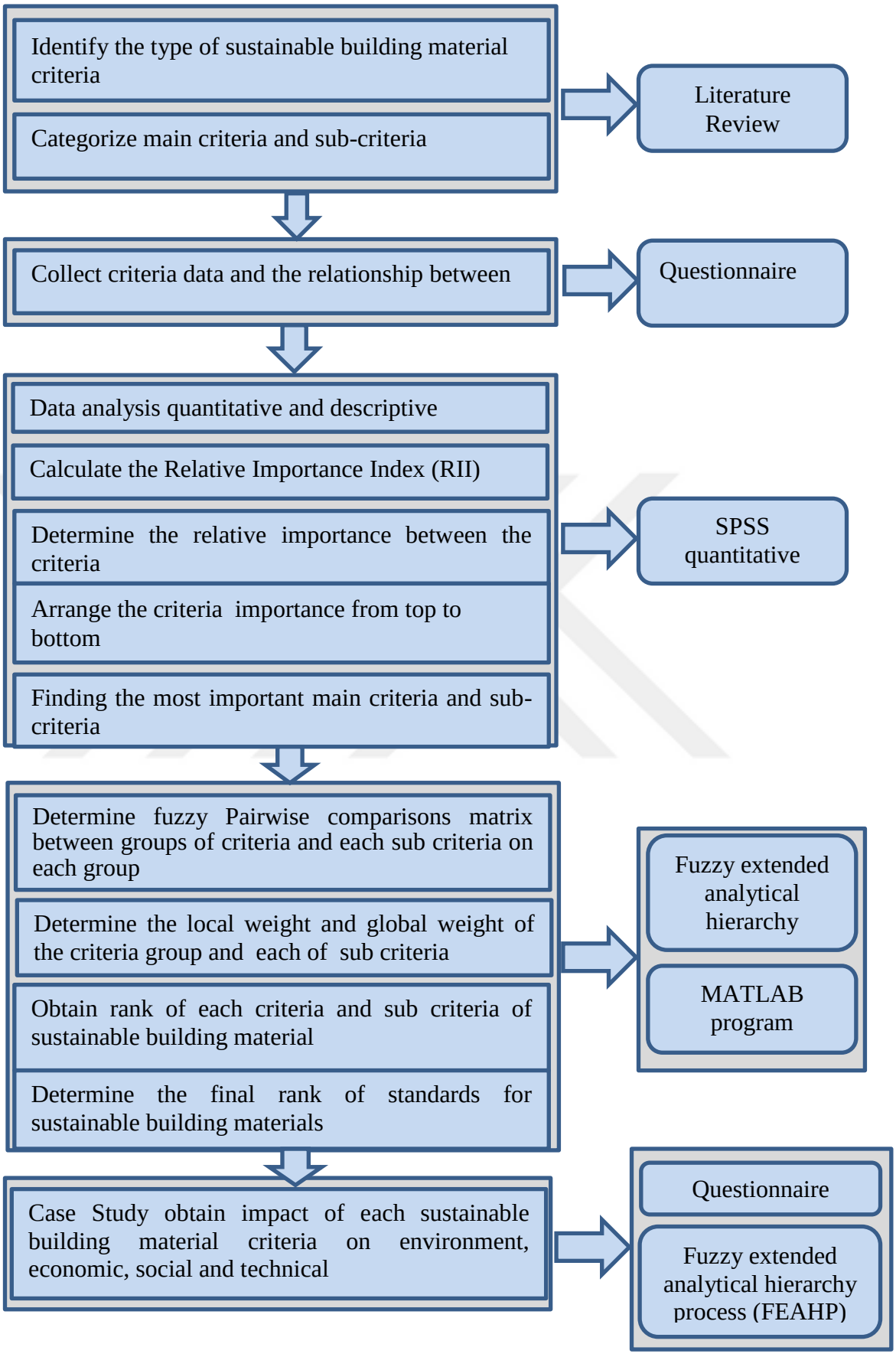


Figure 1.1: Thesis Methodology

2. LITERATURE REVIEW

2.1 Intruduction

In this chapter, sustainability in building projects in general and sustainability in the selection of building materials used in projects will be discussed

2.2 Sustainable (Green) Building Materials

A sustainable material is any material that can be used effectively in the present without compromising its potential for use before . future generations. These are mainly renewable materials that can be recycled and reused in the future [15].

Green materials are materials that perform more than other materials at the same time. The least, and be more in tune with the system's operations for the purpose of maintaining the environmental level, and helps . Optimal use of stocks of materials and energy, and contributes to , Achieving a global economy based on preserving services and the future of generations

It is likely that green building materials will be evaluated and promoted in the near future as they are considered the most environmentally friendly materials and the ecosystem . They can be produced with less energy, they may be recyclable, they emit fewer pollutants and harmful substances, they also make excellent use of local resources, and all these advantages can be obtained when using sustainable materials [16].

Construction materials classified as "green" have at least one favorable environmental characteristic . And the materials and products must have been grown or handled in a controlled environment that complies with sustainable usage requirements in order to be labeled or certified as "eco" or "green.", Consider the idea that manufacturing green building materials requires simple, secure, and safe inputs.

Identifies sustainable building materials as those that simultaneously do the most with the least effort. These materials help to decrease the usage of other materials and energy and fit most comfortably within ecological processes. Sustainable building materials helped to establish a service-based economy [17].

2.3 Sustainability

Is a broad and comprehensive concept for almost all areas of life, and it can be defined in a simplified way as providing the needs of current generations in the best way, provided that we do not affect the resources of future generations. Namely, how resilient and effective a system can be over time. For humans, sustainability is the capacity to uphold the high standard of living we currently enjoy over the long term, which in turn depends on resource conservation and wise use, and Sustainability can also be defined as maintaining the quality of life by preserving the environment and adapting to it using Natural resources that are available for the longest possible period of time and through which lead to the preservation of resources for life. In addition, the idea of sustainability includes a set of basic mechanisms and activities that provide livelihoods for all living species and the surrounding environment and help them preserve their generations Prosperity and forecasting growth over time

The most famous definition of sustainability is the definition .The widespread launch launched by (Brundtland, Prime Minister of Norway), at the United Nations In 1987:

A new approach to growth, sustainable development aims to satisfy current needs without jeopardizing the ability of future generations to satisfy their own. "Our Shared Future" was the title of the report [18][17].

The main objective of sustainability is to enable people of all levels from all the world's population to meet their basic needs and at the same time enjoy a better life, provided that it does not affect the lives of future generations, that is, the optimal use of materials at the same costs and without waste of resources [17]. Because of the negative effects on the environment, the scarcity of natural resources, and socioeconomic problems, making structures sustainable is a difficult task. The construction sector, one of the biggest consumers of energy, materials, and water, and the source of a significant portion of the pollution brought on by dangerous and

destructive emissions and wastes, lacks information regarding certain aspects of sustainability.[19]

The goals of sustainable development, which might include environmental, economic, and social overlap, are identical in all respects to the motivations behind its emergence and implementation. The term "sustainable architecture" refers to a movement in architectural design that is concerned with all things environmental. The real goal of sustainable building is to obtain our needs from the cosmos. This knowledge compels us to experiment with these resources' structure and benefit.[20]

The best and most effective use of the resources and aptitudes at hand is the definition of sustainability. physical, natural, or human. To assure sustainability without wasting the future, it is a concept of a balanced and urban environment. additionally, generational gains [21].

The idea of sustainability is the capacity to use resources efficiently while also managing human, material, and ecological capabilities in a balanced and urban manner without compromising the rights of future generations [17].

The effect of building materials varies according to their effects on the surrounding environment, such as pollution and the function of the material in them . As well as every stage of the production life cycle from cradle to grave for buildings and direct environmental impacts, which can range from the use of raw materials in their construction and renewal to their effects on the environment Consumption of natural resources, such as water and fuel, and emissions of harmful substances [22].

Green materials are considered low or non-existent Impact on humans and the environment and can reduce embodied energy. The main goal of sustainable construction is to reduce energy use. In addition to decreasing usage of natural resources and increasing. The possibility of recycling the intended waste is another important task that must be taken into consideration. In low energy buildings [23].

Every civilized society can be described as consisting of four dimensions: .Economic, social, environmental and institutional dimensions, and each of these dimensions is complex.

It consists of a dynamic entity and self-organization that is developed in itself, which makes it .The system is associated with one of the enormous complexities. For this

system to be an environment sustainable, each of the four sub-systems must be maintained on its ability to Survive and evolve [24].

A strategy known as sustainable development aims to permanently rectify an extreme parity scenario. For humanity, "in a complete systemic framework... it requires human, financial, and environmental concerns to work together to create an existence that never ends... Consequently, constructive

In order to prevent significant portions of the future population from losing their homes as a result of unforeseen weather events, the industry needs to alter and create more durable homes that can survive destructive forces like hurricanes and floods. Construction firms have embraced new technologies to prevent environmental catastrophes and boost sustainable growth [20].

2.4 Sustainable Strategy Development

The nine sustainable growth concepts are highly beneficial [25].

1. Respecting and caring for communal living
2. Improving the Quality of Human Life
3. Protecting Life and Diversity on Earth
4. Reducing the Consumption of Non-Renewable Resources
5. Maintaining the Earth's Bearing Capacity
6. Transforming Personal Habits and Conduct
7. Providing for showing respect to their environment by societies
8. the creation of a national framework that allows for integration of development and protection
9. Creating a Global Agreement Based on Sustainable Development Principles

The promotion of sustainability is done by raising awareness and supporting the rights of future generations. The issue of development currently has a crucial place in both the economy and the employment sector, placing sector-related enhancements at the forefront of efforts to devise sustainable improvement strategies. When using domains and resources, adhering to principles of equality and fairness is paramount.

On the other hand, respect for equitable distribution and equitable use of resources in the environment depends on equality and Exploitation prevention.[26]

The most widely used natural resources, followed by mines, are the materials used in building construction, such as cement and iron and aluminum, as well as water and natural gas, which are excellent for commercial use. Therefore, sustainable development must be developed in order to protect the environment and the economy, thus ensuring the sustainability of these resources for future generations[27]

2.5 General Sustainability Principles

The principle is energy and water conservation [28].

- Conserving both energy and water is the first rule. Careful planning, such as identifying the particular climate circumstances, constructing a strategy, and making the decision to preserve energy orientation
- The building life cycle is the second rule

The structure is divided into three phases , Which is called (the life cycle of the building), which are as follows:

1. The first stage, during which materials used in construction and long-life materials are included in the pre-construction stage
2. The second stage is the maintenance stage. It requires keeping up with the previous stage and using easy-to-maintain materials
3. The third stage includes the use of materials that can be reused as well as the reuse of existing infrastructure for buildings.

- The last principle is human design.

Preserving existing natural resources entails preserving topography, urban design, and site planning, and using strategies to reduce and meet energy and water needs. By maintaining health, humans can be comfortable. According to scientists, the benefits of global trade will quintuple until the year 2056. There may be a 50% increase in the world's population, and there may be a threefold increase in the use of resources. There may be at least three times more industrial activity [29].

2.6 Sustainability in the Construction of Buildings

Sustainability is critical to the health of our planet, the continued progress of society, and human progress .One of the most used building materials all over the world. It is the Portland cement industry and is a critical component, and results in the manufacture of one ton of Portland cement releases a lot of carbon dioxide estimated at about a ton, which is one of the greenhouse gases .It generates about one ton of greenhouse gases, and sustainable development will play a major role in addressing natural resource problems as well as environmental challenges related to greenhouse gases. and other issues [30].

Using non-renewable resources may exacerbate these side effects.

Lack of rural resources, destruction of forest areas, deterioration of natural diversity, destruction of green spaces, pollution of air, water and soil, and abnormal weather may lead to [31].

In recent years, the difficulty in building sustainable development, which is represented in the low social level, and environmental issues, how they affect nature and human well-being, and how sustainable building practices can achieve these goals, A key factor in the expansion of sustainable development is construction., just like the construction of buildings. A variety of contexts and perspectives are used to define sustainable development in a variety of fields, including architecture and construction. The architectural and construction concepts of sustainability, This is intertwined with the construction industry, right. The design, architecture and construction are environmentally friendly It was presented as the definition of sustainable building [32].

2.7 Sustainable Architecture

Sustainable engineering is defined as a set of practices that protect the environment while minimizing waste and using resources as effectively as possible. Contrary to a pattern that ignores the well-being of customers and removes cherished things unnecessarily harms people while still producing the same results [33].

Water accessibility and accessible content are key components in raising project value. Evidence of existence, water and technological means. For engineering

projects, feasibility is essential. Security in terms of time or resources. Gave decline in the use of non-renewable resources and construction [34].

The profession of sustainable architecture is often compared to the profession of juggling two teams – art and science – in a single endeavor. These are overlapping domains where practicing sustainable architecture is like playing two games on the same field. The integral goal is to score both goals simultaneously, and the play has a good feel to it in both games. Conflict over how to define architecture and sustainability is one factor in the difficulty of realizing the ambition of integration. The green elite fear that they will be co-opted, but if they do not participate in the aesthetic game, they will be excluded. Despite the queasy realization that the tech elite is intrinsically safe [35].

It is possible to improve the existing built environment by using multidisciplinary techniques to protect different resources, such as rationalizing the use of energy and resources, minimizing litter, and controlling emissions.

To manage the construction process and process resources to cause less harm to the environment [36].

The future of our planet, the progress of society, and human progress depend on sustainability. In the natural world is an extreme example of the idea of sustainability. It is the nutrition cycles in living organisms where they are considered a closed loop free of waste. Each living being assists the next through a system of birth, life, and death. On this, it is , the idea that “green building” refers to the same thing as “sustainable architecture,” “sustainable building,” “green building” etc [37].

2.8 Sustainable Implementation

Sustainability is important for the well-being of our planet, the continuous growth of society, and human development, especially in the field of construction. To maintain a sustainable environment

The required building materials must be chosen in terms of sustainability, which are locally-made materials as it reduces transportation expenses and outflows of carbon dioxide, and it can be composed of recycled materials, Wherever it is and has less environmental impact, is thermally insulated, and requires less energy than ordinary materials ,Therefore, it uses inexhaustible assets, that is, it is less in expenses, that is,

it is better in economic terms. The use of such materials is feasible in terms of transportation costs, carbon outflows, a lot of material costs, and it saves labor [38].

As a fundamental component of strategies and policies to achieve a sustainable future in the industrial production process The purpose of Sustainable Architecture, Design, and Housing is to examine the important ideas, approaches, uses, and takeaways of sustainable architecture, design, and housing. On different levels, innovative and modern architectural design is challenged by sustainable architecture as it sometimes contradicts the principles of sustainable development [35].

2.9 Resource Conservation

Sustainability includes the preservation of resources in a way that assures that future generations can benefit from them, and this idea has developed and become crucial in conversations about sustainable development.

We emphasized the importance of using products found in nature.

It is carefully managed to preserve the aspirations of future generations to evolve through replacement .By using less widespread or sustainable energy sources, society will uphold the rights of future generations. Economically, renewable energy initiatives should reduce energy use.

Prevent environmental degradation and use natural resources responsibly. Sources .Saving means getting more for less money. Humans manage natural resources to maximize benefits for present generations while maintaining the ability to meet the requirements of future generations.[39]

Conserving resources by linking social impact to behavior change.

The study revealed that social impact approaches were effective on resource conservation. The effectiveness was different for different social impact approaches and for different approaches

Security through changing social habits and awareness, which form the basis of the research An agenda to better understand the processes through which social impact approaches are encouraged resource conservation.[40].

2.10 Energy Conservation

Managing energy use is a must in any society that functions because it is one of the most significant environmental challenges. The biggest consumers of energy are buildings require energy and other resources at every step of a project, from design and construction through operation and eventual demolition[41].

The kind and quantity of energy used during a building material's life cycle, starting with production, Flow may be impacted by the post-life processing of building materials, for instance. Different methods and times are used to release greenhouse gases (GHGs) into the atmosphere. They efficiency gains can significantly cut consumption, which is a good strategy to cut greenhouse gas emissions and delay the depletion of non-renewable energy sources[28].

Both operational and embodied energy are considered when looking at energy use from a life cycle perspective. The energy needed to sustain the environment inside a building can be thought of as the facility's operational energy needs..[42]

By examining the building life cycle, it turns out that as a result of the use of heating, cooling, ventilation, and hot water, it may reach between 85% and 95% of the total energy consumed and carbon dioxide emitted from buildings during their occupation. This will include energy from electricity, gas and the combustion of fossil fuels such as coal or oil.[23]

All the energy required to extract, refine, and produce raw materials will be included in this indirect energy. It will also include all of the energy expended on transportation during this process, as well as the pertinent amounts of energy stored in the infrastructure of the facility, as well as the machinery utilized in building, manufacturing, and transportation. As a result, it is possible to conceptualize the energy life of a building as being composed of various operational and embodied energy inputs over the course of the building's lifetime.[43]

2.11 Materials Conservation

The extraction of public assets and their use as a building materials or as a new sources for the production of construction materials, as well as the production of materials themselves, when carrying out construction activity, directly affects natural

biological systems.It also affects diversity due to the degradation of land input activities. where enormous mineral resources are used in several places. Reduced use of non-renewable resources is therefore necessary in order to maximize these non-renewable mineral assets**.**[44]

Innovative manufacturing of construction waste, which is the first to produce useful materials from waste, which, if left unchanged, could cause a lot

Environmental, public and financial problems.

Residential construction waste can produce huge amounts of resources. and the growth of a body of scientific work primarily using tested resources decreasing and lowering waste is a key advantage that development designers have in the production of goods. The three waste design principles should be taken into account when planning technology as part of the mission sustainability plan: Reuse, recycling, and decreasing waste productionn[45].

That reduce, and improve internal waste: according to [46].

Using construction debris technology from the start and reducing its environmental impact are the only ways to reduce its impact. Since it provides financial benefits, the demand for reuse and recycling will decrease. The analysis showed that waste processing reduces waste production, greenhouse gas emissions, and consumption of raw resources either according to [47]. Recycling products reduces environmental impacts, especially resource use and waste introduction. The definitions of alternatives presented in the literature studies (which include recycling and reuse) reintroduce production materials and elements of the manufacturing chain. Structures materials can be recycled. The use of a deconstruction performance approach, which enables parts of the building to be recovered as additional bricks, to reduce structural waste and demolition during home renovation and demolition. In no case other than in traditional demolitions where components are reprocessed into raw materials [48]

As for the process of storing construction waste and the process of disposing of it: in the conditions in which the production takes place

It is unavoidable, you want to restore it and you want to store it properly and keep it under control. Construction debris and non-harmless construction trash are disposed of in municipal solid waste landfills or landfills that are best suited to handle construction waste. There are selections for the best trash types all across the

world.are totally determined by a site-specific hazard assessment in landfills. Licenses have been successful in keeping waste levels and patterns under control. The excessive loading cost for waste or additives is established in the case of dangerous waste.

Engineers want to take into account ideas on how to store and get rid of trash at the project's planning level.[46]

2.12 Water Conservation

Depletion of resources, particularly water resources, has become a global environmental issue due to the rapid growth of the global economy. According to the World Water Development Report (WWDR), the water we consume is becoming scarce and could be an environmental disaster due to the consumption and scarcity of fresh water[49]

Construction is the area where the effects on the environment are most obvious .the operations of the construction sector depend heavily on water from nature. And the use of water in cities causes, Significant decrease in the water level in the countryside and affects agriculture. Water used in buildings is a major problem in water consumption at the state level, and this is not the only form of water used at some point in building natural after consumption is also in the stage of material extraction, production, industrial, shipping, etc[50]

The study came to the conclusion that methods and regulations for water preservation are typically the most overlooked elements of the overall building planning process. However, the numerous water-making strategies that we employ in building are expanding and becoming more important, in part because of the greater credit of availability. water obtained by putting water-saving measures into practice[51].

2.13 Land Conservation

The construction sector relies heavily on land as a resource. Land use associated with urbanization has been noted as an important issue in both developed and developing countries. Although more land can be acquired for additional projects, large-scale use of land for industrial projects is not recommended as it may seriously harm

ecosystems. As a result of acid rain, groundwater pollution, soil erosion, and other industrial pollutants that harm plant communities. Landscape must be respected, and sustainable design must make more effort to understand how soil, plant, water, communities and associations, and habitats interact with each other and with human activities.[28]

The effects of the construction sector on the environment and the expansion of urban areas emphasize the significance of land as a crucial sustainability indicator, which has the potential to become a clear signal for truly sustainable building. By applying the policy of no urban expansion, the land can be conserved. This can be done without the need for new construction by appropriately reusing an existing structure. Spelling the built environment and housing agricultural and environmentally sensitive areas can be avoided by placing sustainable construction projects near public transportation, health care institutions, commercial centers and entertainment venues, These innovations will encourage better use of urban space through increased population density and improved infrastructure [52].

2.14 Cost Efficiency

Ensuring the long-term financial performance and expense of their structures is something construction clients demand. Also, the supply chain for construction projects, which consists of developers, suppliers, manufacturers, and design-build teams, is coming under increasing pressure from customers, to reduce the total cost of the project and take into account the cost of the building over its life cycle and how well it meets the requirements of the occupier. Buildings require a large and sustained expenditure of resources, financial and otherwise[53]

Sharply rising energy costs have highlighted the potential for overall savings over the life of a building that may be realized by initially investing in more energy efficient systems. Savings on other operational and maintenance expenses, such as the use of building finishes that don't require frequent re-painting, can also be taken into account. The financial performance of a building should be taken into account both during the construction phase. In terms of upkeep and preservation during the course of its useful life. To make sure that these objectives are achieved, the concept of life-cycle costing analysis (LCCA) will be crucial to the economics of a construction project. An economic assessment method known as life cycle cost analysis (LCCA)

may forecast a building's costs from construction to replacement and operation to end-of-life expenditures.[54] .

2.15 Design for Human Adaptation

Creating a safe and comfortable atmosphere for human activities is one of the key goals of a sustainable building. The structure must allow for the uses for which it was intended.

Give people enough area to work, live, learn, and process things, as well as the space and amenities to do those things. The structure must also offer a safe and welcoming inside environment for its occupants. The structure must be physically sound and fire-safe in addition to complying with these fundamental requirements, which include not endangering its occupants or the environment sustainable.

In order to comply with the development plan, a building cannot utilize excessive energy or pose a harm to the environment. encourage and improve human adaption [28].

An essential factor in assessing an occupant's quality of life is their well-being, including their health and comfort. People in contemporary culture spend more than 90% of their time indoors, with more than 70% of that time spent at home.[55].

2.16 Material Efficiency Standards

It includes the selection of green materials on the basis of the ability to recycle and that the materials are natural, renewable, saving raw materials, recyclable, low cost, non-toxic with a minimum number of toxic materials, moisture resistance, water conservation ability and energy efficiency; Minimum chemical emissions, moisture resistance, sanitary maintenance, systems or equipment. Other criteria include affordability, water conservation and energy efficiency.

The choice of materials for manufacturing enterprises is important. Inappropriate selection can affect productivity, profitability, and most importantly the negative reputation of an organization

The selection of materials The methodology requirements include not only technical and economic factors, but also environmental factors , as such It has been assumed

that the safety and health of the occupants is an important factor, and its importance may exceed the cost of materials, and the issue of public welfare is emphasized[56]

More sustainable products can be produced when life cycle, environmental impact, environmental efficiency, marketing aspects, cultural aspects, and fashion are evaluated. Guidelines for the development of sustainable products are presented with special attention to basic materials, design and the environment. Material selection and design models are then made on the basis of a sustainable society. , and the choice of sustainable construction, For products affected by specific factors, including economic impacts, to be safe to use, and low, Operation and maintenance, durable and more satisfactory to end users and customers, And achieves market requirements, environmental impacts of market demand [57].

Failure to use the technical aspect of materials leads to a great waste of materials and poor performance of construction projects. and final product quality and needs. The customer is the main concern of the customer. The factors related to the customer's requirements are identified and the designers and other professionals during the design stage determine the highest quality materials that can lead to customer satisfaction [57].

The choice of materials in architecture is not limited to choosing only the strongest or, The cheapest or most available material is the process of selecting materials, It is a complex process that is influenced and determined by many factors. Conditions, decisions, considerations, and selection of materials focus primarily on the technical aspects of materials for purpose

Make informed and justified material choices as architects. Need information on the full range of aspects considered during, Design and selection process. Building designers must be well aware of this material and its benefits as it is integral and pivotal to achieving sustainability. Although the factors to be taken into consideration while selecting materials depend on each of the scales Objectivity and subjectivity [58].

The selection of the Objectives Which is (Social criteria Technical criteria ، Environmental criteria ،Economic criteria) divided into criteria according to the importance and previous studies [5].

2.17 Selection of Sustainable Building Materials

Determining the selection of sustainable building materials can encounter some barriers as an important design strategy, from a building. Although sustainability is gaining importance, there is still great importance barriers to this 'new style ,Where appropriate importance should be given to the climatic conditions of the area when choosing building materials [59].

Mitigation of global warming is environmental strategies based on sustainable policies in developed countries aimed at reducing carbon emissions. for a purpose . Mitigation of global warming to reduce the impact on the environment due to reduced carbon dioxide emissions The construction process will improve when importance is given to the climate and the proposed site for the project in the selection of materials. So there will be Financial, economic, social and environmental benefits According to The [2] [59].

The construction industry has been revealed as the fastest growing and fastest growing industry worldwide This is due to the continuous increase in the population of urban cities. This rapid growth has affected the society for this .The economic and social movement is doing well, but at the same time it has caused more environmental pollution [60].

One of the main reasons for the high demand for sustainable buildings is due to the rapid depletion of natural resources, the large use of energy, the increase in emissions and the recent increase in awareness of the importance of the environment The integration of green building materials and their products into the construction and production process helps to conserve global non-renewable resources and therefore, the impact on the environment due to transportation, extraction, processing, manufacturing, recycling and disposal becomes less impactful [5].

The establishment and responsible management of sustainable construction are also considered. Environmental principles and resource efficiency are essential for a healthy constructed environment [61].

During construction, preparation and operation, as well as final demolition For buildings, the most important factors for their impact on the environment Directly (through high material consumption, energy consumption and pollution and waste generated from it) or indirectly (through pressures on infrastructure). There is a

growing consensus among organizations that commit to environmental performance targeting relevant techniques and measures required to make construction activities more sustainable, depending on the reaction to these charters [3].

The main important factors affecting the choice. Sustainable building materials for building are reducing greenhouse gases emissions from buildings, embodied energy cost, operating and maintenance cost, And the possibility of recycling [26].

Factors influencing sustainable building materials selection, The choice of building materials is not limited to choosing the strongest materials or materials ,The cheapest or most available materials, but the selection of these materials by engineers is a complex process and is determined by many conditions and considerations Where material selection can be described as a complex process. Affected by qualifications, judgments and broad ideas. Bearing in mind that there are many variables that must be taken into account in the quest to choose materials in the design and construction stages, not just choosing the strong and cheap and available materials [58].

Summary, here are some examples of the qualities of "green" building materials

1. Healthy for the indoor setting no issues with noxious fibers or toxic volatile organic compounds releasing into the interior environment , The people who work in the factories that make the goods are not affected in terms of their health.
2. Are safe for the environment outside-they don't raise the risk of smog, harm the ecosystem, deplete finite resources, create hazardous byproducts or excessive processing waste, or harm the health of those who mine the materials required to make the product
3. Possess low embodied energy and weren't created through energy-consuming manufacturing and material acquisition methods. (Materials with a high percentage of recycled material may meet this requirement if remanufacturing doesn't involve significant energy expenditure.)
4. Reduce the amount of energy used by a structure by minimizing heat gain or loss, using less electricity, and making maintenance easier.
5. Are long-lasting, reusable, recyclable, and/or biodegradable and won't need to be replaced rapidly or, worse, turn into "trash" or hazardous garbage.

2.18 Summary of Chapter (2)

In this chapter, sustainability in construction projects in general, the most important factors and goals that they achieve, sustainability in choosing building materials used in projects, and the benefits we get when applied in construction projects are discussed.

3. PREVIOUS STUDIES

3.1 Introduction

Most of the research papers in the previous literature focused mainly on the environment in the construction sector. Compared to them, significant contributions (economic, social, technical and environmental) have been used in this scientific research along with environmentally friendly formulations

Table (3.1) listed the most important previous studies. Which was summarized on this topic and we show the most important criteria used by researchers in the same subject on this research.

Table 3.1: Previous Studies on the Selection of Building Materials

	TITLE		**Criteria**	**Environmental criteria**	**Economic criteria**	**Social criteria**	**Technical criteria**
1	Developed Sustainable Scoring System for Structural Materials Evaluation[19]		Climate change [19]	✓			
			Pollution[19]	✓			
	YEAR	2012	Solid waste	✓			
			Resource use p [19]	✓			
			Life-cycle cost[19]		✓		
			Recyclability[19]		✓		
	Authors	E. S. Bakhoum and D. C. Brown	Local economic development p[19]			✓	
			Human health & safety[19]			✓	
			Human satisfaction p [19]			✓	
			Practicability[19]				✓

Table 3.1: (Cont.) Previous Studies on the Selection of Building Materials

	Title		Criteria	Environmental criteria	Economic criteria	Social criteria	Technical criteria
2	Multi-criteria evaluation model for the selection of sustainable materials for building projects[3]		: Potential for recycling and reuse [3]	✓			
	YEAR	2013	Availability of environmentally sound disposal options [3]	✓			
	Authors	Akadiri, Peter O., Paul O. Olomolaiye, and Ezekiel A. Chinyio	Impact of material on air quality [3]	✓			
			Ozone depletion potential [3]	✓			
			Environmental Impact during material harvest [[3]	✓			
			Zero or low toxicity [[3]	✓			
			E7: Environmental statutory compliance [3]	✓			
			Minimize pollution —e.g. air, land [19] [3]	✓			
			Amount of likely wastage in use of material [[3]	✓			
			Method of raw material extraction] [3]	✓			
			Embodied energy within material	✓			
			Disposal cost [3]		✓		
			Health and safety [3]		✓		
			Maintenance cost [3]		✓		
			Esthetics [3]		✓		
			Use of local material [3]		✓		
			Initial-acquisition cost [3]		✓		
			Labor availability [3]		✓		
			Maintainability [3]				✓
			Ease of Construction (build ability) [3]				✓
			Resistance to decay [3]				✓
			Fire resistance [3]				✓
			Life expectancy of material (e.g. strength, durability etc.)[3]				✓
			Energy saving and thermal insulation [3]				✓

Table 3.1: (Cont.) Previous Studies on the Selection of Building Materials

	TITLE		Criteria	Environmental criteria	Economic criteria	Social criteria	Technical criteria
3	Sustainable material selection for construction industry – A hybrid multi criteria decision making approach		Initial cost [31]		✓		
	YEAR	2015	Maintenance cost[31]		✓		
	Authors	K. Govindan, K. Madan Shankar, and D. Kannan	Disposal cost[31]		✓		
			Productivity[31]		✓		
			Revenue[31]		✓		
			Meeting user needs[31]		✓		
			Tax contribution[31]	✓			
			Energy saving[31]	✓			
			Potential for recycling and reuse[31]	✓			
			Raw material extraction[31]	✓			
			Land acquisition[31]				
			Usage of water[31]	✓			
			Waste management[31]	✓			
			CO2 emission[31]	✓			
			Soil consumption[31]	✓			
			Production and transportation[31]	✓			
			Fuel consumption[31]	✓			
			Resistance to decay [31]			✓	
			Fire resistance[31]			✓	
			Ease to construction ([31]			✓	
			Operational life[31]			✓	
			Esthetics[31]			✓	
			Use of local material[31]			✓	
			Health and safety[31]			✓	
			Labor availability[31]			✓	

Table 3.1: (Cont.) Previous Studies on the Selection of Building Materials

	TITLE		The criteria	Environmental criteria	Economic criteria	Social criteria	Technical criteria
4	Sustainable material selection for building enclosure through ANP method		Material & Construction Cost[62][62]		✓		
	YEAR	2018	Transportation Cost [62]		✓		
	Authors	S. Mahmoudkelaye, K. Taghizade Azari, M. Pourvaziri, and E. Asadian	Service & Maintenance Cost[62]		✓		
			Overhead Cost[62]		✓		
			Energy Cost (during operation)[62]		✓		
			Market value[62]		✓		
			Weigh[62]				✓
			Chemical Resistant[62]				✓
			Water Resistant[62]				✓
			Fire Resistance[62]				✓
			Strength[62]				✓
			Life Expectancy[62]				✓
			Consumption of Energy & Resources[62]	✓			
			Human Comfort & Health[62]	✓			
			Environmental Impacts	✓			
			Social, Religious And Cultural Identity[62]			✓	
			Aesthetics[62]			✓	
			Labor Availability[62]			✓	
			Designer's Knowledge[62]			✓	

Table 3.1: (Cont.) Previous Studies on the Selection of Building Materials

	TITLE		The criteria	Environmental criteria	Economic criteria	Social criteria	Technical criteria
5	A multi-criteria decision-making framework for selecting a suitable maintenance strategy for public buildings using sustainability criteria		Energy efficiency [63]	✓			
	YEAR	2019					
	Authors	D. E. Ighravwe and S. A. Oke	Waste reduction [63]	✓			
			Water usage reduction [63]	✓			
			Improved building value [63]	✓			
			Better rental returns [63]		✓		
			Reduced operational cost [63]		✓		
			Extended building life-span [63]		✓		
			Improved productivity [63]		✓		
			Occupants' health and safety [63]			✓	
			Human traffic [63]			✓	
			Occupants' satisfaction [63]			✓	
			Maintenance failure and downtime [63]			✓	
			Spare parts quality and materials[63]			✓	
			Staff expertise [63]			✓	
			Business operations [63]			✓	

Table 3.1: (Cont.) Previous Studies on the Selection of Building Materials

	TITLE		The criteria	Environmental criteria	Economic criteria	Social criteria	Technical criteria
6	Entropy-based fuzzy TOPSIS framework for selection of a sustainable building material		Global Warming Potential[64]	✓			
	YEAR	2019	Pollution and Emissions[64]	✓			
	Authors	A. S. Reddy, P. R. Kumar, and P. A. Raj	Construction and Demolition Waste[64]				
			Resource Consumption[64]		✓		
			Life Cycle Cost[64]		✓		
			Recyclability and Reusability[64]				
			Local Development[64]				✓
			Human Health &Safety[64]			✓	
			Human Satisfaction[64]			✓	
			Practicability & Flexibility[64]				✓
	TITLE		**The criteria**	**Environmental criteria**	**Economic criteria**	**Social criteria**	**Technical criteria**
7	Preference based multi-criteria framework for developing a Sustainable Material Performance Index (SMPI)		F1 Climate change	✓			
	YEAR	2019	Pollution and emissions	✓			
	Authors	A. S. Reddy, P. R. Kumar, and P. A. Raj	Construction and demolition waste	✓			
			Consumption of resource	✓			
			Cost		✓		
			Recyclability and Reusability		✓		
			Local development		✓		
			Human health and safety			✓	
			Practicability			✓	
			Human satisfaction				✓
			Recyclability and Reusability				✓

Table 3.1: (Cont.) Previous Studies on the Selection of Building Materials

	TITLE		The criteria	Environmental criteria	Economic criteria	Social criteria	Technical criteria
8	Sustainable Material Selection Criteria Framework for Environmental Building Enhancement		material impact on air quality (indoor & outdoor)	✓			
	YEAR	2022	recycling and reuse	✓			
	Authors	A. A. Alwafi	environmental form (eco-environmentally)	✓			
			healthy interior environment[65]	✓			
			land acquisition[65]	✓			
			water consumption [65]	✓			
			consumption of natural resources[65]	✓			
			production and transportation activities	✓			
			E9: waste management[65]	✓			
			embodied energy within material[65]	✓			
			operation and maintenance cost[65]		✓		
			meeting stakeholders needs[65]		✓		
			energy efficiency[65]		✓		
			investment cost[65]		✓		
			societal costs of construction materials		✓		
			tax contribution (e.g., imported materials		✓		
			financial and economic risks[65]		✓		
			use of local[65]			✓	
			ecological and social acceptability [65]			✓	
			social benefits and development[65]			✓	
			availability and adaptation[65]			✓	
			aesthetics[65]			✓	
			resistance against natural contamination and habitat disasters			✓	
			labour availability[65]			✓	
			ease of construction (build ability)			✓	
			ease and ability to integrate with other materials [65]			✓	
			isolation of noise pollution [65]			✓	
			health and safety [65]			✓	

3.2 Development of Sustainable Assessment Criteria

Sustainability assessment criteria have been devised to help in the choice of sustainable building materials for projects. A thorough review of the literature reveals that there is There isn't a complete list of sustainability-related evaluation

criteria made just for choosing materials. In order to help in the choice of evaluation criteria for the choices under consideration, the researchers have created a set of guidelines.[31][4][66][67].

1. Comprehensiveness

The criteria should cover the four areas of economic, environmental, social, and technological in order to ensure that progress toward sustainability goals is taken into account. According to these goals, the chosen criterion must be able to show either a shift towards or a move away from sustainability

2. Applicability

The selection criteria should be applicable to all of the options being thought about. This is necessary to ensure that the possibilities can be compared.

3. Transparency

To allow for stakeholder understanding, identification of the criteria being evaluated, and suggestion of any additional criteria that should be taken into account, the criteria should be determined in a transparent manner.

4. Practicability

The criteria should be realistic, taking into account the intended result of the choice, the tools to be used, and the amount of time and money available for research and evaluation. clearly,

This set of guidelines was taken into account in this study to help define evaluation criteria, for the purpose of trying to fill many gaps, including what the contracting sector suffers from, from the inability to choose sustainable materials in construction projects, to the lack of agreement between researchers on A comprehensive measure for the selection of building materials, especially in Iraq, and the main reason for this is the lack of a fixed framework that helps in the selection of materials.

In this study, we developed an integrated framework for selecting sustainable building materials for construction projects in Iraq in particular, and similar areas in general. There are very few previous studies on the selection of sustainable building materials in Iraq. There is also a clear weakness in the method of selecting building materials suitable for the Iraqi climate, due to the use of old methods that suffer from weakness, randomness, inaccuracy and lack of reliability in choosing sustainable materials.

We have chosen the main and secondary criteria accurately and according to previous studies and the great importance of these criteria.

The main criteria have been divided into four criteria. Which is (Social criteria , Technical criteria ، Environmental criteria ،Economic criteria) It is divided into sub-criteria according to importance and previous studies [5]

Table (3.2): In the following table are the main criteria and sub-criteria that were selected according to their importance, which are considered the most frequently used by experts and previous studies, which will be used for the purpose of evaluating and selecting sustainable building materials, that will be studied in this research

Table 3.2: Criteria, Sub-Criteria and to Select Sustainable Construction Material

	Chosen Criteria and sub-criteria select in the research			
	Social criteria	**Technical criteria**	**Environmental criteria**	**Economic**
1-	Human health and safety[30] [65] [3] [19] [63] [31] [62]	Maintainability[3]	Climate change [30] [19]	operation and maintenance cost[65][68] [3] [12][69]
2-	Use of local material [65] [31] [3]	Practicability[19]	mount of likely wastage in use of material [65] [30] [3] [19] [63] [31]	meeting stakeholders needs[65][31] [12]
3-	Labor Availability[62] [65] [31] [3]	Fire Resistance[62] [3]	Minimize Pollution and emissions [19] [30] [3]	energy efficiency[65][70] [31]
4-	aesthetics[65] [3] [62] [31]	Staff expertise [63]	Consumption of resource [30] [65] [19] [62]	investment cost[65][68]
5-	isolation of noise pollution [65]	Chemical Resistant[62]	recycling and reuse [65] [3] [31]	societal costs of construction materials[31] [65]
6-	social benefits and development[65] [19]	Time-appropriate handling[71][16]	material impact on air quality (indoor & outdoor) [3] [65] [31]	financial and economic risks[65]
7-	ease of construction (buildability) [65] [31]	Repair and reconstruction method[72][73]	production and transportation activities[65] [31]	Disposal cost[3][67][74]
8-	Operational life[31]		embodied energy within material[65] [3]	
9-			land acquisition[65] [31]	

The following is a definition of each of the main and sub-criteria

3.3 Social Criteria

Social sustainability can relate to the impact, management and impact of a business, both positive and negative, on people. The quality and quality of relationships between the company and engagement with stakeholders is critical.

Social sustainability, which is the most vital goal for the purpose of sustainable improvement, is that ,It focuses on the rights and freedoms associated with being a human being. The maximum in each of the basic rights, freedoms and duties should be equality and that ,The balance between generations. And the resources must be shared with other people for the next era in order to. They maintain their way of life well and preserve their wealth.[75]

Social standards of sustainability and help to provide the basic requirements of social life which include work and home as well as conditions of physical fitness, education and cultural activities for all in the long term (strategic), and raising the quality of life. It includes the reintegration of the disabled into society at the same time . They will be protected in proportion to the age of the future technology[75]

"Social sustainability occurs when official and informal processes, regulations, structures, and relationships effectively enhance the capacity of present and future generations to develop healthy and living communities," claims the Australian Council for Social Services (ACOSS). Socially sustainable communities offer a high standard of living and are just, varied, linked, and democratic. (From The Institute for Sustainable Futures) [76].

These days, social sustainability has been commonly used to prevent incorrect changes that potential generations don't want to see. And to ensure fair distribution of wealth. In this, Context Much of sustainable development derives mainly from the importance of man and his social needs[77]

And in this research the social standard has been divided into sub-criteria according to previous studies Which is :-

3.3.1 Human health and safety

It is concerned with all environmental elements, whether natural or established, that affect human health and safety. Other terms that mean or refer to environmental health include environmental and public health, and environmental prevention.

Environmental health can be considered closely related to environmental sciences and public health, as it deals with the factors that affect human health[30] [65] [3] [19] [63] [31] [62].

3.3.2 Use of local material

The use of local materials is one of the important indicators in the sustainability process, as it is difficult to imagine the use of materials that were manufactured in remote areas and transported using transportation that consumes additional energy, presents pollutants and costs materially. Therefore, it is important to achieve long-term sustainability for a healthy indoor environment using locally manufactured materials [65] [31] [3].

3.3.4 Labor Availability

The provision of decent work for people, especially local employment, for the purpose of eradicating poverty and achieving sustainable development contributes to global growth, and that productive societies can keep pace with the significant increase in the world's population for the purpose of providing needs, Societies must be inclusive and fair for all. To provide decent work opportunities for all, to aim for equality, and to eradicate poverty. Actually, the use of local labor reduces transportation expenditures and other costs, As well as to ensure the production of accurate and systematic work that meets quality requirements , which contributes to sustainable development[78] [65] [31] [3]

3.3.5 Aesthetics

The benefits of a sustainable building must be clear, as its purpose is to protect the environment. However, this does not prevent the building from being beautiful and keeping pace with urban development. Sustainable design differs from traditional design, as it must take into account the aesthetic form, as well as adaptability to the surrounding environment, usability for long periods, and the possibility of benefiting from it for many years, i.e. shape must be taken into account as well as adaptability in design **:** [65] [3] [62] [31].

3.3.6 Isolation of noise pollution

Noise pollution is one of the types of environmental pollution in the past and the present, and noise: it is noise and loud sounds that hurt hearing. Nerves get tired, disturb the mind, disturb comfort, prevent sleep, and negatively affect human life, especially patients and children who need rest and calmness greatly [65].

3.3.7 Social benefits and development

The first goal of sustainable development is to improve the living conditions of every individual in society, through increasing and developing production means and methods, and managing them in correct and scientific ways so that they do not lead to the depletion of the earth's natural resources, so that we do not burden the planet beyond its capacity and that the creation of sustainable buildings will result in improving the standard of living the individual [65] [19].

3.3.8 Ease of construction (build ability)

It refers to ease of use, elegant application, suitable for green building application, ease of use and renewal [14] [17][65] [31].

3.3.9 Operational life

It can be defined as the service life which is the actual time of using the service. The service life of materials and building components is essential for effective use, as well as the cost of materials. For this reason, it is important that methods are available to reliably predict service life. In Techniques for Material Selection Methods[31]

3.4 Technical Criteria

The process of neglecting the technical side in various regions of the world in the last century led to serious problems due to the patterns and technologies that are considered unsustainable [57].

It is considered one of the important criteria in selecting sustainable building materials, and despite that, most researchers combine it with merging it directly or indirectly in economic or environmental criteria. This has influenced the

consideration of technical aspects as a separate entity in the material selection process[79].

Technology and technical assistance are crucial for implementing the sustainability process in all industrial activities in both developing and developed nations. In fact, these two factors are seen as the backbone of the majority of industrial endeavors and are necessary for overcoming harmful environmental factors. To achieve sustainable development, the construction industry must respond swiftly to the rapid changes in technology, the environment, and knowledge [27]

It is important to consider environmental factors even though the business approach usually deals only with technical and environmental factors[56].

And in this research , The technical standard has been divided into criteria s according to previous studies Which is:

3.4.1 Maintainability

The term maintainability is used in engineering sciences to express how easy it is to maintain a product in order to know faults and their causes and repair them, as well as the possibility of discovering new ways to facilitate the maintenance process and adapt to new work environments ,Sometimes it can be defined as a process of continuous improvement of a system or a product. This is done by learning from previous experiences and mistakes so that maintenance is facilitated and reliability is improved [3]

3.4.2 Practicability

Practical, which is that the materials are implementable, so it is easy for people to implement them, and it means that they are useful and realistic in terms of idea, feasibility, appropriateness, and comfort [5].

3.4.3 Fire resistance

The materials that resist fire or fire can be defined as those materials that have the ability to not melt and burn for a period, that is, they can withstand the heat, so that the residents of the building can leave the building safely and can be called fire-resistant materials. It is one of the important factors in sustainable construction, as it

is very important to pay attention to fire safety, especially in the construction industry [62] [3].

3.4.4 Staff expertise

The main goal of human resources is to ensure sufficient and qualified workers to meet the strategic goals and operational plans of employers and to provide the right people with the right skills at the right time. To keep pace with the social and economic trends, and obtaining an employee who combines experience and loyalty has become very difficult, and if he is found, he will be attracted from other companies depending on the competitive advantages offered by those companies. Among these features is the advantage of training and developing employees for labor market developments, health insurance benefits, and others [63].

3.4.5 Chemical resistant

Chemical resistance is meant to measure the ability of material surfaces to resist the impact of chemicals, upon exposure for a specific period of time. With the advent of modern chemistry; Many new chemicals have been invented; Which plays a huge role in the modern construction industry. Building materials that are resistant to chemicals or construction chemicals are an important part of the chemical industry and with its great progress, the basics of the construction industry have changed radically as these chemicals are used to improve the quality and efficiency of building materials in construction projects to make the project sustainable, durable and economical. [62]

3.4.6 Time-appropriate handling

Dealing with the appropriate procedure at the right time, i.e. dealing with time management to waste less time and avoid more disturbances and problems, as well as taking the necessary precautions in a timely manner. As well as the speed of implementation and maintenance:[71][16].

3.4.7 Repair and reconstruction method

The method of repair and reconstruction, which means trying to rebuild and reform in a better and more innovative way, i.e. striving for recovery and building in a manner that is more environmentally friendly and more resilient, and addressing

discrepancies in design and implementation in ways that can benefit from social, environmental and health services to reach sustainable development [31][32].

3.5 Environmental Criteria

It is a term describing how ecosystems remain vibrant and productive over time. And environmental sustainability is the ability to maintain the life we live in the long term and this depends on the conservation of the natural world through the responsible use of nature. Environmental sustainability refers to the ability of the environment to continue operating while trying to reach the lowest percentage from the deterioration of the surrounding environment. The concept of sustainability will be realized .When planning the development process, not to harm the natural capital as a Minimal environmental damage[51]. The following are among the most prominent goals that environmental sustainability seeks to achieve[80]

And in our research, the Environmental criteria has been divided into criteria according to previous studies Which is:

3.5.1 Climate change

Denotes long-term changes in weather and temperature. These changes could be organic and take place, for instance, through variations in the solar cycle. But,

The use of fossil fuels, such as coal, oil, and gas, has become the primary driver of climate change in recent years, and this can be attributed in large part to human activity. Also, the use of certain products and the construction sector are taken into account.

With their blanket-like effect, greenhouse gas emissions trap the sun's heat and cause global temperatures to rise [14] [16].

3.5.2 Mount of likely wastage in use of material

Large amounts of valuable resources are lost during waste management and due to inefficient and incorrect waste collection as well as consumer behavior. Much of the responsibility for the vast amount of waste lies with the construction industry. Due to the continuing high costs of landfills and building materials, any developer or owner A smart drug will appreciate the need for a solid waste management strategy. for sustainable construction [65] [30] [3].

The good thing is, a sustainable construction waste management method is not only a recommended standard. But it will also save you money and time. Reducing resource losses is essential to ensuring our well-being and strengthening the economy [19] [63] [31]**.**

3.5.3 Minimize pollution and emissions

When we try to find ways to reduce air pollution, we might think of using electric cars, riding a bike to work or using public transportation to reduce the number of cars used. While these measures will help improve our air quality, the fact is that it is commercial buildings that can make a significant difference in reducing carbon dioxide emissions. 40% of annual carbon dioxide emissions come from commercial buildings. And 11% of pollutants come from new construction and 28% from building operations And the process of controlling air pollutants caused by buildings will make a big difference [19] [30] [3].

3.5.4 Consumption of resource

The construction industry accounts for a large proportion of resource and energy consumption in urban areas. In the concept of sustainable development, we must pay attention to the problem of resources, consumption and environmental pressure of the urban construction industry .The construction industry is one of the factors that cause. Pressure on the environment due to resource consumption [30] [65] [19] [62][81].

3.5.5 Recycling and reuse

Using recycling and reuse effectively can help avoid the wastage of important resources in landfills and help EU Member States move toward the 70% recovery goal set by the European Commission's Waste Framework Regulation by 2020. By creating rules But, this is no longer the main obstacle to increasing resource efficiency in building. Tax recovery is a low-cost alternative for disposal, as well as for enhancing quality and broadening uses for recovered resources. Building practices still generate a lot of trash in the UK throughout both the design and construction phases, and preventing waste is the least expensive choice. Recycling waste is also a more resource-efficient option [65] [3] [31][82].

3.5.6 Material impact on air quality (indoor & outdoor)

Across the world, there is a growing realization that building health is important to the well-being of housing. A healthier and more luxurious building can improve productivity and talent retention, and can attract tenants and investment. The materials and pollutants in the air in buildings come from natural sources such as mold and animal dander, but there are external sources, especially through design such as doors, windows, ventilation systems Direction of sunlight and air movement inside the building, which leads to concentrations of pollutants. Or implementation through the materials used in the construction of the building, that is, some pollutants come to the interior through the foundations of the building [3] [65] [31].

3.5.7 Production and transportation activities

A great deal of energy is consumed during material extraction, processing and transportation as well as during unnecessary travel or transportation over long shipping distances and imprecision in selecting transportation of materials between production sites. The main and are activities resulting from the production of raw materials, and emissions during, Transported from suppliers to construction sites, As well as energy derived from non-renewable sources for transporting materials, assembling them and building them. The process of transporting some building materials leads to an increase in carbon emissions, and transportation consumes fuel at all stages, i.e. an additional cost [65] [31]

3.5.8 Embodied energy within material

Embodied energy is the amount of energy to produce any good or service. . And that the embodied energy is an arithmetic method whose aim is to calculate the total energy, the sum of the energy needed for a complete life cycle, and that the life cycle energy assessment is the sum of the energy that was required in extracting, manufacturing and assembling raw materials

The construction of buildings uses a wide range of building materials, and the manufacture of each building material consumes energy and emits carbon dioxide, and the accumulation of any part of the building material waste magnifies the energy involved and emissions of carbon dioxide to a large extent[83]

3.5.9 Land acquisition

According to research, if a huge project is not effectively planned and managed, the number of persons displaced as a result usually increases. There are increasingly more international standards “such as the World Bank's environmental and social standards, the International Finance Corporation's performance standards, the Equivalence Principles, and the United Nations Guiding Principles on Business and Human Rights”, and these standards and good practices must be followed when developing investment projects.[65] [31]

Any state's federal or state government has the authority to take private lands and make them publicly accessible while compensating the original owners and other parties harmed by the purchase. These lands may then be used for projects. Large-scale land acquisition and resettlement projects connected to significant development initiatives (such as mines, hydroelectric power, highways, industrial parks, electricity transmission corridors, and agricultural developments), where research on the resettling of people following significant projects typically demonstrates that they can suffer worsening. Concerns regarding breaches of human rights are another issue. [84]

3.6 Economic Criteria

Economic sustainability can be defined as the ability to improve the living conditions of all human beings and all generations and natural organisms without increasing the use and consumption of resources in a manner that ensures that resource consumption does not exceed the planet's ability to control resources. We work in the modern and contemporary critical optimization paradigm: there is a supposed long way to go. For that economic identity, which will flourish within the market by increasing the purchase of people . electricity and increase the gross national product. It can also be understood from its definition that this optimization version is dependent

Control and balance between continuous production and consumption. Note that the previous version required the existing resources to be used as if they were unlimited. However, sources that may satisfy people's simple needs are still out of reach due to excessive consumption of resources. These assets grew to be reduced every day

without replenishing those resources due to overuse. On the other hand, the opportunity exists to control resources by applying the principles of sustainable development[24]

In short, monetary sustainability is the possibility of a systematic balance of public and private investments with green use and resource management; and an assessment of overall economic performance taking into account social criteria rather than organizational profitability[20]

And in this research, the economic criteria has been divided into criteria according to previous studies Which is;

3.6.1 Operation and maintenance cost

Building maintenance is fundamental to keeping buildings looking and performing well. And we need to maintain the performance of the building in order to extend its value and life cycle of the building. We still lack good management of the cost of building operation and maintenance. It was found that the cost of housing maintenance is relatively high due to poor and incorrect maintenance practices[85] [65][68]

Operational costs are costs associated with running a company, a machine, a piece of equipment, or a building. Perhaps the maintenance costs or the resources needed by the business to continue operating are to blame. In other words, maintenance costs are what the business spends on routine maintenance to keep an asset in good working order [3] [12][69].

3.6.2 Meeting stakeholders needs

The participation of stakeholders in making decisions in projects, especially in construction projects, is a major driver of performance. However, sustainability is a complex concept in projects that will come from diverse stakeholders. It appears that failing to include them in decision-making procedures results in a failure to solve sustainability challenges [86] [12].

There is a need for a structured way of engaging with stakeholders regarding sustainability. In the new global economy, stakeholder participation has become an integral part of the practice of construction projects in order to achieve the required results. A well-involved project stakeholder engagement process has helped

decision-making stakeholders work together to increase comfort and quality of life while minimizing negative environmental impacts and increasing sustainability economics of the project. Therefore, stakeholder participation should be taken as an essential component of any 'sustainable development' plan [65][31].

Regarding the identification of stakeholders, there is a pluralistic view of their identity. We can think of them as those who have interests and investments in an organization that go beyond the current traditional concept of shareholders to include employees, suppliers, customers, trade unions, and societies, and that different stakeholders have different levels and types of investments. and interests in building projects, as well as being considered one or more clients of the project they are working on.[87]

3.6.3 Energy efficiency

Buildings can be considered a major consumer of energy throughout their life. The generation of consumed energy depends mainly on traditional sources, which can be considered the main cause of environmental pollution. The aim of improving the environmental performance of the building should be by switching to the choice of low embodiment energy materials. Precise control, at every stage of a building's development, is critical in the process of improving energy efficiency [65][70] [31]

The selection of materials in terms of energy efficiencies for building materials depends on several criteria, such as choosing natural materials that have positive properties from manufactured materials. . In addition, the materials must be local[70] [31]

Because the energy consumed to transfer it is large in addition to that. The coefficient of thermal conductivity is important. Since construction spends a portion of its energy consumption during, their life cycles, in the use phase, in the process, for, Reducing energy consumption for construction as well, Availability of heat preservation, and for this it is necessary to choose, Materials with low thermal conductivity.[88].

4.6.4 Investment cost

Investment costs include all expenses incurred up until the project's termination date, including construction, operation, development, and other costs. These are the costs

of investments, goods, and services that will pay off throughout the course of the project. [68].

In order to increase the efficiency of investors, developers, customers, and contractors as well as the individuals directly involved in the implementation of investment and building projects, modern investment requires a system to regulate costs. By controlling the elements that contribute to increased construction costs as well as the problems associated with rising costs because of rising building material prices [65].

3.6.5 Societal costs of construction materials

The execution of construction projects in residential areas has a number of repercussions that may directly improve the regional economy and peoples' quality of life. Building projects, particularly those in metropolitan settings, can cause significant environmental problems for the nearby population as well as unforeseen detrimental consequences on the environment. The negative effects on the neighborhood's residents are referred to as the socio-economic costs to the community's welfare, and the social costs are the total of all external causes and any private expenses associated with the activity. The community is responsible for paying the construction costs, which are not covered by the construction offer. borne by individuals, such as overpopulations [31] [65].

An official method of assessing the potential effects of suggested development projects on the environment and its population is the environmental impact calculation. These effects might include potential modifications to the biophysical environment that the planned development might bring about, as well as the cultural effects of the proposed development on the nearby community [89][90].

3.6.6 Financial and economic risks

Due to recent intensive study, risk management is a critical area in the construction business that has grown in importance globally. But for this relatively new field to be productive, more attention is needed. Many risks affecting project elements including time, cost and quality exist in the construction industry[91].

More effort needs to be done to manage the most important risks in order to reduce or eliminate their impact on the project. Effectively scheduling activities and

coordinating them well throughout the implementation phase is critical because it may enable project managers to focus on key areas to improve project management [65]

3.6.7 Disposal cost

Unwanted materials are produced on construction and demolition sites as a result of the activities involved. Construction and demolition waste is the term most people use to describe these products. Waste in general and construction site waste in particular has the potential to harm the environment by causing air, water and land pollution [74][92].

To obtain the desired result, the structure can be demolished traditionally or eclectically. Unlike conventional demolition, selective demolition should theoretically allow for the recovery of a large amount of recyclable and reusable materials. Therefore, it is reasonable to weigh the expenses of the two building demolition proposals against their potential impacts on the environment taken into account for the EIA [3][67].

3.7 Summary

In this chapter the most important previous studies are listed. Which are summarized in this topic as well as an explanation of the most important criteria used by researchers in the same subject in this research, and a brief definition of the criteria and sub-criteria that were chosen for the purpose of the study in this research.

4 METHODS AND PROGRMS

4.1 Introduction

This chapter presents the method of collecting and analyzing data by creating a questionnaire and the method of analyzing the data extracted from this questionnaire and the programs used to do this . The method and conditions of the questionnaire will be explained.

Then the fuzzy hierarchical analysis method will be explained. Fuzzy AHP that will be used for data analysis

Where some literature has been studied, and it was mentioned in the second and third chapters of this study. The questionnaire was conducted and involved 105 professionals in this field, including university professors, experts, heads of departments and project managers from various specializations in Iraq. By sending the online questionnaire by e-mail. And other means of communication. The answers were collected, studied, analyzed and discussed in the fifth chapter of this thesis

4.2 Design of a Questionnaire

A questionnaire is a list of questions that a researcher creates in order to gather details about a particular issue or topic. It is sent, delivered, or received by the individuals who have been selected as the study's subject and asks them to write down their responses and return them to the researcher

It is a common scientific approach to collecting information and data on a specific topic by asking people according to people's circumstances, tendencies, or attitudes. The researcher formulates inquiries to obtain primary information relevant to the group being examined [93].

It is easiest to conduct a questionnaire survey of a large number of people. This information can be used to guide an analytical research study on this topic.

Creating well-designed questionnaires requires gathering accurate information

The following points must be taken into consideration [80] [94].

1. When resources and financial support are limited;
2. When it comes to survey administration and implementation, the questionnaire may be one of the least expensive methods of data collection [80].
3. When Preserving the privacy of survey participants , is important ;
4. As it is necessary to inform the respondents in the questionnaire that their privacy and personal information during , Answers will be protected. And no one was notified of anything .For personal information or answers.[94].
5. When it intended to conduct a documentary , study of individual results :
6. There may be results from previous studies and another study aims to verify these results. Here, the questionnaire is considered one of the correct and good options for this purpose, Because it is fast and inexpensive [80].

4.3 Identify the Questionnaire's Objectives

There must be a clear objective of the questionnaire because if there is no clear and specific objective of the questionnaire, the required results will not be obtained in reality. The more ambiguous the goal or purpose, the more wasted the participants' time and the resources of the survey creator.

In the event that there is a problem with writing the questionnaire, it must be taken into account that the questionnaire did not take enough time to define its objectives.[95].

4.4 Questionnaire Types

After we have identified the main objective of the questionnaire, it is now time to write it.

The theme of the questionnaire design is very essential as it will influence the user response and the extent of interaction by the respondents. The survey questions are divided into: [80] [96].

1. The Open formula

2. The closed formula.

4.5 Positive and Negative Aspects of the Questionnaire

The questionnaire has positive and negative aspects that can be summarized as follows :

1- Its positive

a. Answers shall be provided via email or any other channel in a complete, clear and un moderated manner.

b. Although some formulas may change depending on who is asking them, some inquiries are the same for everyone.

c. The structure of the questionnaire and the unit of questions facilitate the collection and understanding of information and drawing the correct conclusions.

d. You have the option to respond whenever you want.

e. The multiple-choice test format allows the researcher to speak with a large number of participants at once.

f. Reducing costs such as printing and transportation costs,[97]

2- Its negative

a. It is important to follow up on each answer in case the response is not appropriate. Or the response is inaccurate or some people do not respond, which causes the questionnaire to be inaccurate

b. The person who sets the questions is responsible for collecting and analyzing the answers. This illustrates the need to give the questions in the questionnaires more thought while formulating the inquiries.

c. Too many questions in a survey can make respondents feel bored and overwhelmed.[98].

4.6 Questionnaire Design Steps

The questionnaire design steps is:

1. Deciding the questionnaire's goals and the topics it will cover
2. Decide what topics the questionnaire will cover in terms of fields (axes).
3. Creating inquiries that center on the objectives.
4. Carrying out a first analysis of the questionnaire.
5. Distributing the questionnaire to the professionals (arbitration)
6. Use statistical approaches to evaluate the questionnaire's validity and dependability. [98][80]

4.7 Questionnaire Distribution

Distribution by Ordinary Mail He is given a return envelope, an address to which he will answer and, if possible, a postage if he is to be posted by post to many remote places. The fact that questionnaires sent to the researcher are not returned is one of the problems with this procedure. But suppose it is intended for distribution to certain establishments or in the neighborhood. In this case, it is preferable to submit it by the researcher or with the help of his colleagues.

One of its advantages is that the percentage of responses can be higher and more honest . Another way to distribute questionnaires is to publish them in newspapers magazine pages, TV or radio. It happens on issues that matter country and people. The last, easiest, fastest, and most widespread trend is to distribute it through computer networks or E-mail.

4.8 Analyzing the Questionnaire Results

Using SPSS was the initial stage in the data analysis process. This is a program that examines the information gathered from the survey. In many scientific fields, the statistical analysis tool SPSS is employed. Additionally, survey firms, educational researchers, marketing organizations, market researchers, health researchers, data miners, and survey corporations use it [99].

Then the method was used fuzzy analytical hierarchy process (Fuzzy AHP).

4.9 Fuzzy Analytical Hierarchy Process (Fuzzy AHP)

The Analytical Hierarchy Process (AHP) method, which can be used to help address unstructured problems in a variety of social, management, and economic sciences, has been promoted by Saaty since 1980. AHP has been used to a variety of challenges, from the simple task of choosing a school or workplace to more challenging issues like forecasting potential outcomes for developing nations, assessing political candidates, allocating different energy resources, and so forth. Along with the capacity to methodically evaluate a large number of quantitative and qualitative features in a multi-criteria environment with conflicting criteria and structure a complicated problem in the form of a direct hierarchy [100].

As a multi-step analytical judgment process that develops a systematic hierarchical structure from a complex arrangement, describe the AHP technique. It makes it possible to compare a collection of challenging issues that have an effect on a wide audience. When making multi-objective, multi-criteria, and multi-actor decisions—exactly the decision-making scenario met with material selection—it is meant to deal with the intuitive, the rational, and the irrational. Also, it is straightforward for decision-makers who must make the decision to understand and put into practice [4].

This approach considers a variety of choices in reaching a conclusion that result from multicriteria decision making , Because this method allows to describe the problem as hierarchical believed in a combination of quantitative, qualitative and analytical standards .The hierarchical process is one of the most comprehensive systems of making judgments by different standards [101].

The AHP consists of four steps: [101].

1. Identify the decision, options , and the criteria.
2. Do pairwise comparisons
3. Calculate the important weight for each of the criteria.
4. Determine the best option by calculating the highest important weight of the sum of the important weight of the criteria

Fig (4.1) Complete Resolution. The organization of data is done in a tree-like structure in a hierarchical database model. Records that are linked to one another serve as storage units for the data. A hierarchical data structure is a tree.

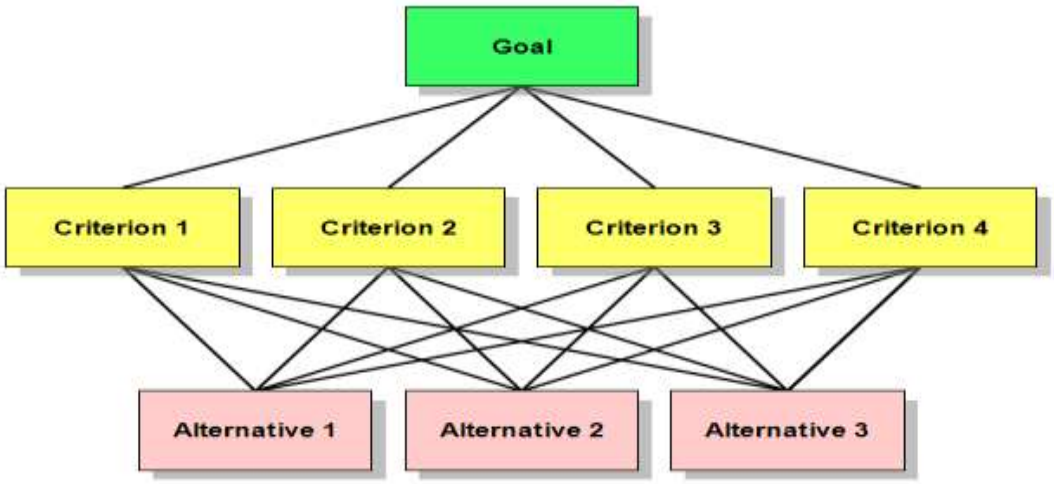


Figure 4.1: An Example of a Hierarchical Tree

Source: (Adamczyk, 2017)

AHP employs a traditional preference scale of 1 to 9, which runs from "equal significance" to "great importance," but it may also occasionally use other rating scales, such as the Likert scale, which spans from 1 to 5. The value 1 represents equal importance, the value 1/9 denotes that one element is noticeably less important than the other, and the number 9 in the pairwise comparison matrix denotes that one component is much more important than the other. The reciprocal importance of the second factor in regard to the first is therefore indicated if the importance of one component is mentioned in relation to another. Using a ratio scale and verbal comparisons, quantifiable and non-quantifiable elements are weighted [10].

The AHP is a powerful and flexible multi-criteria decision-making method when dealing with complex issues where both qualitative and quantitative elements must be taken into account. The AHP helps analysts establish a hierarchy, or family tree-like structure, for the crucial elements of a problem [11].

Items are compared at a given level using a nine-point numeric scale to determine how important one thing is over another, in order to make pairwise comparisons and produce a judgment matrix. If A and B are the items being compared, "1" indicates that there is a weak relationship in importance between the two, while "9" indicates that A is significantly more important. Each pairwise comparison is provided in each pairwise comparison. Given in an array of sentences. Next comes finding the local weights , and consistency of comparisons . Reach the goal that takes the highest weight

4.10 Fuzzy Analytical Hierarchy Process (Fuzzy AHP)

Despite the many benefits of a discrete scale in terms of usability and simplicity, it is not sufficient to take into account the uncertainty involved in one's perception of a number or in assessing the uncertainty of human feelings.

Because of the ambiguity of the requirements, it is not feasible to portray them in exact number terms. Giving judgments about periods rather than continuous values can inspire greater confidence in us. To designate a priority one decision variable over the other in this situation, linguistic variables and trigonometric fuzzy numbers can be used. Analyzing structural range [61].

based on the so-called Fuzzy AHP and triangle fuzziness numbers, used to establish final priority weights (Fuzzy AHP)[102].

The Fuzzy AHP approach analysis method, which employs fuzzy triangular numbers to represent the comparison judgments of decision makers and fuzzy triangular numbers to determine the final priority of various decision criteria, is used to enhance the AHP method and streamline the global supplier selection process. Fuzzy set theory makes inferences based on approximations and uncertainty, much like human reasoning. It gives systematic approaches to cope with the uncertainty prevalent in many problems and has the advantages of mathematical representation and ambiguity. The suggested Fuzzy AHP evaluates the relative weights of multiple selection criteria and sub-criteria by using trigonometric fuzzy numbers as a pairwise comparison scale [61].

Some of the decision data can be accurately assessed in the majority of real-world scenarios, but others cannot. While humans are rather ineffective at generating quantitative forecasts, they are relatively good at qualitative predicting [103].

Essentially, the uncertainty in preference judgements, which also results in confusion in the ranking of alternatives, is what makes it difficult to determine the consistency of preferences. Fuzzy AHP is an advanced analytical method. It is an improvement on the basic AHP software. AHP Multi-criteria Decision-making presents straightforward issues when using both quantitative and qualitative factors. Decision makers estimate that there is a lot of ambiguity and uncertainty in the world today. Decision-making difficulties may lead to inaccurate appraisals of a decision. Makers in the core curriculum of the AHP course [104].

Fig (4.3) , the Steps use in the fuzzy analytic hierarchy process (AHP) algorithm [105].

A complex issue is broken down into a hierarchy using the method's central strategy, which places the goal (or criterion) at top, followed by the criteria and sub-criteria at levels and sub-levels , and the decision possibilities at bottom. Elements at specific hierarchy levels are examined in pairs to discover their relative criterion in respect to each element at the level above. The method computes and aggregates the eigenvectors of each option until the final composite vector of weight coefficients for alternatives is obtained. The entries in the final weight coefficients vector depict how important (valuable) each option is in respect to the overall objective [9].

Figure 4.2: Steps in the Fuzzy Analytic Hierarchy Process (AHP) Algorithm

Source: (Weck et all., 1997)

So, many researchers[106][107][8][108] who studied fuzzy AHP, an extension of Saaty's theory, have provided evidence that fuzzy AHP more accurately describes these kinds of decision-making processes than do conventional AHP methods.

Human experiences and opinions are reflected in complex systems by linguistic and ill-defined patterns. Consequently, a far more accurate depiction of these. Linguistics can be developed as quantitative data, which is then improved using fuzzy set theory's evaluation techniques. Contrarily, the AHP approach , is mostly employed in applications requiring nearly crisp (non-fuzzy) decision making and produces and

manages an extremely imbalanced scale of judgment. Because of this, the AHP technique disregards the mapping's inherent uncertainty.[100]

In hazy, imprecise, and unclear conditions, it has been shown that using approximation information and ambiguity to draw conclusions is useful. This approach resembles human reasoning. They offer straightforward strategies for dealing with the ambiguity prevalent in many decision-making scenarios and were created specifically to depict uncertainty. The fuzzy variant of AHP is the Fuzzy AHP, which effectively manages the fuzziness of the data involved in material selection while taking sustainability into account.

It is simpler to understand and can manage both qualitative and quantitative data in situations with several decision-making factors. In this method, triangular fuzzy numbers are employed to select one criterion over another. The extent analysis approach is then used to ascertain the results. Calculated is the pairwise comparison's synthetic extent value. Using this method, the weight vectors are selected and normalized, producing the normalized weight vectors. The final priority weights of the alternative sustainable material are thus determined using the varying weights of the various criteria and sub-criteria. The most weight would be assigned to the substance that weighs the most sustainably.[109]

4.11 Establishment of Triangular Fuzzy Numbers

proposed the fuzzy set theory to address uncertainty resulting from ambiguity and imprecision. The ability of fuzzy set to express ambiguous data was a significant contribution. The theory also made it possible to use programming and mathematical operators in the fuzzy domain. A class of objects with a range of membership grades is referred to as a fuzzy set. A membership function that awards each object a membership grade ranging from 0 to 1 defines such a set. To describe a range of numerical values in this collection, broad phrases like "big," "medium," and "small" will each be used. [100][103]

Fig. 1 depicts M, a triangular fuzzy number (TFN). The TFN is simply referred to as (l, m, u). The parameters l, m, and u stand for the lowest, most promising, and largest potential values, respectively, that can be used to characterize a fuzzy event.

By convention, m=u=1 is the non-fuzzy number , Each of TFN has a linear representations on its left and right sides, allowing for the definition of its membership function as [110]:

$$\mu M(x) = \begin{cases} 0, x < 1 \\ (x - I)/(m - I), L \leq x \leq m, \\ (u - x)/(u - m), m \leq x \leq u \\ 0, x \geq u \end{cases} \quad \textbf{(1)}$$

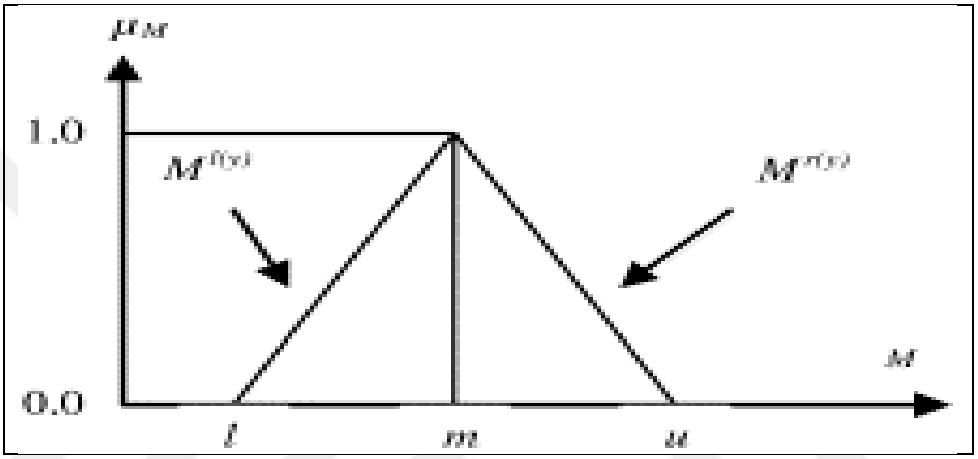


Figure 4.3: A Triangular Fuzzy Number, M

Source: (Nieto-Morote and Vila, 2012)

For the decision maker, fuzzy numbers are intuitively simple to communicate qualitative evaluations. The mysterious number can always. The left and right representations, which correspond to each level of membership, provide them.[111]

$$M = (M^{1(y)}, M^{r(y)} = 1 + (m - 1)y, (m - u)y), y \in [0,1] \quad \textbf{(2)}$$

where l(y) and r(y) stand for a fuzzy number's left side representation and right side representation, respectively. TFNs M 1, M 3, M 5, M (7), and M (9) are used to represent the pairwise algebraic operations with fuzzy numbers. TFNs M (2), M (4), M 6 and M (8) stand for the intermediate preference values between "Equal" and "Extremely favored" in a comparison of decision variables. Figure 2 displays the membership capabilities of . the TFNs, $M_i = (m_{i1}, m_{i2}, m_{i3})$, where i= 1, 2,…, 9 and $m_{i1}, m_{i2}, m_{i3}$are

the lower , the middle and the upper values of fuzzy number M_i respectively. Higher the value of $(m_{i3}–m_{i1})$ or $(m_{i1}–m_{i3})$ the signifies of greater fuzziness of the judgment.

4.12 Calculation of the Priority Weights At Different Level of Hierarchy

A unique scale consisting of a scale of one to nine used to assess fragile AHP. Where in the AHP method it is unclear which decision variable should come first. Variables are used in fuzzy language or numbers. Actually, the solution Inconspicuous shapes that are triangular or trapezoidal are usually preferred by makers.

Fuzzy AHP uses fuzzy numbers, so solutions vary depending on how fragile the AHP is. The pro-range analysis method is the most widely used method for solving confusing AHP application problems. It is the method that has been suggested before Chang's [112]

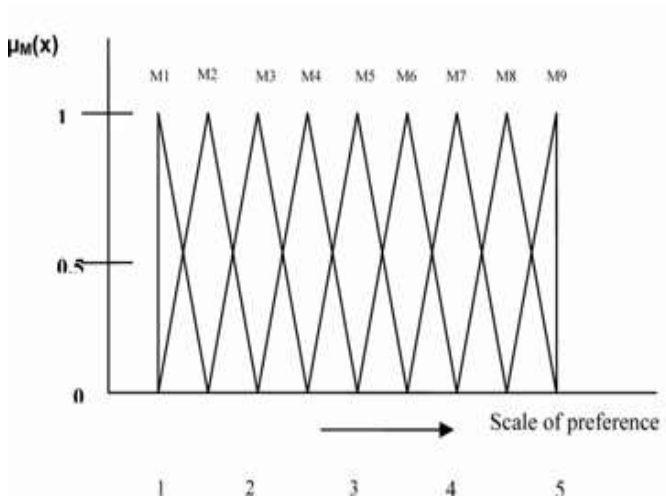
The extent analysis approach is used to consider the extent of an object that must be fulfilled for the purpose, or the extent that has been fulfilled. Range is calculated using a fuzzy number in the approach. A synthetic fuzzy score value can be generated using fuzzy values to analyze the extent of each object, and has the following definition

Let p=p1, p2,..., pn represent the components of the choices in a materials selection issue as an object set, and allow, Establishing objectives for the criteria for the material selection (Q = q1, q2,..., qm). In accordance with Chang's theory[112]

Each item is taken into consideration for the extent analysis, which is then carried out separately for each aim, Oi. As a result, each object's m extent analysis results can be retrieved, with the indications listed below;

M_{oi}^{1} , M_{oi}^{2} , M_{oi}^{3},…. M_{oi}^{m} where i=1,2,3,…,n **(3)**

where all the $\boldsymbol{M_{oi}^{j}}$ (j=1, 2,..... m) are triangular fuzzy numbers.



Scale of preference between two elements

Membership Function	Preference
M_1	Equally
M_3	Moderately
M_5	Strongly
M_7	Very Strongly
M_9	Extremely

Figure 4.4: The Membership Functions of the Triangular Fuzzy Numbers

Source: (Chang, 1996)

The following equations can be used to order the steps of Chang's range analysis: According to the itch object, the fuzzy synthetic range value can be defined as [113] [110]

$$F1 = \sum_{j=1}^{m} M_{oi}^{j} \otimes \left[\sum_{i=1}^{n}.\sum_{j=1}^{m}. \quad M_{oi}^{j}\right]_{.}^{-1} \qquad \textbf{(4)}$$

The value $\sum_{j}^{m} = 1\, M_{oi}^{J}$ m extent analysis values from a specific matrix can be discovered by using the fuzzy addition operation, such that:

$$\sum_{j=1}^{m} M_{oi}^{j} = \left(\sum_{i=1}^{m} {}_{j,}^{I} \sum_{j=1}^{m} {}_{j}^{m}, \sum_{j=1}^{m} {}_{j}^{u}\right) \qquad \textbf{(5)}$$

and the value of $\sum \left[\sum_{i=1}^{n}.\sum_{j=1}^{m}. \quad M_{oi}^{j}\right]_{.}^{-1}$ can be acquired by carrying out Moi j's fuzzy addition operation (j= 1, 2,..., m), such that

$$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{oi=}^{j} \left(\sum_{i=1}^{n} {}_{i}^{I}, \sum_{j=1}^{n} {}_{i}^{m}, \sum_{j=1}^{n} {}_{i}^{u}\right) \qquad \textbf{(6)}$$

and then compute the inverse of the vector in equation above Eq. (6) such that

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{oi}^{j}\right]_{.}^{-1} = \frac{1}{\sum_{i=1}^{n} u_i} \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} I_i} \qquad \textbf{(7)}$$

1. What likelihood there is of $M_{2_1} = (I_2 , m_2 , Iu_2) \geq M_1 = (I_1 , m_1 , u_1)$ is defined , as:

$$V(M_2 \geq M_1) = \sup_{x \geq y} \left[\min(\mu_{M_1}(x), \mu_{M_2}(y))\right] \quad \textbf{(8)}$$

when the pair (x ,y) , exists such that $x \geq y$ and $\mu_{M_1}(x) = \mu_{M_2}(y) = 1$

then . we have $V(M_1 \geq M_2) = 1$, Since M_{1_1} and M_{2_1} are convex fuzzy numbers , so:

$V(M_{1_1} \geq M_{2_1}) = 1$ if $m_{11} \geq m_{21}$ and

$$V(M_2 \geq M_1) = \text{hug } V(M_1 \cap M_2) = \mu_{M_2}(d) \quad \textbf{(9)}$$

where d , is the ordinate of highest intersection points D between μ_{M_1} and μ_{M_2}

(Fig. 3) , the intersection between, M_1 and M_2 . To compare M_1 and M_2 , we need both values of $V(M_1 \geq M_2)$ and $V(M_2 \geq M_1)$

2. The degree of the possibility for the fuzzy number to be greater than k convex , fuzzy numbers M_i (i= 1, 2,…, k) can be defined :

$V(M \geq M_1 ; M_2 ; \ldots, M_k) = V(M_1 \geq M_1)$ and $V(M \geq M_{2_1})$ and …..and $V(M_1 \geq M_k)$

$$= \min V(M \geq M_i) , i= 1,2,\ldots., k \quad \textbf{(10)}$$

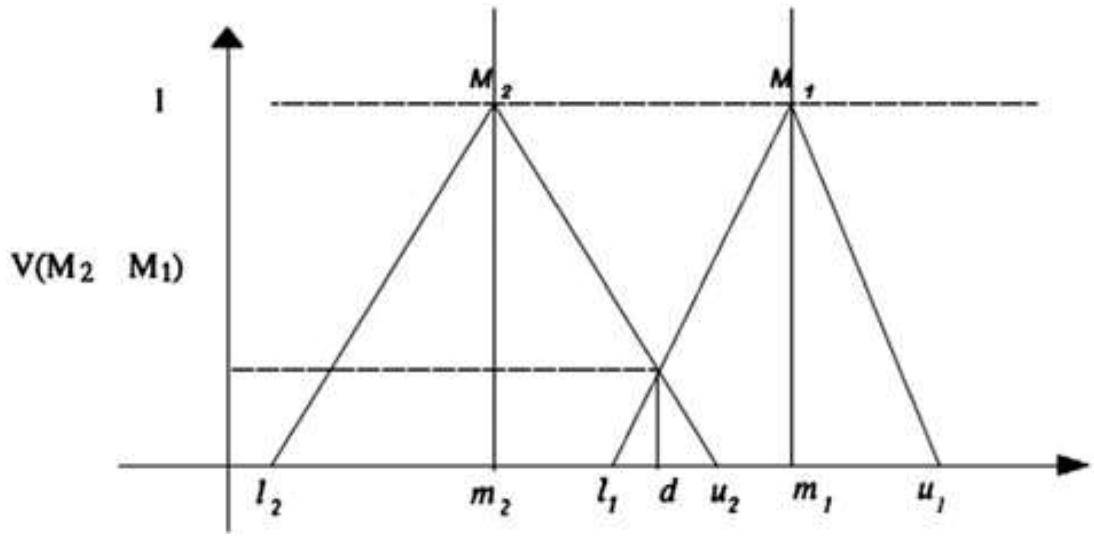


Figure 4.5: The Intersection Between, $M1$ and M_2

Source: (Kwong and Bai, 2003)

If

$$m(P_i) = \min V(F_i \geq F_k) \quad \textbf{(11)}$$

for k=1, 2,....., n; k ≠i, then the weight vector is given by

$$W_p = (m(P_1), (m(P_1), \ldots (m(P_n))^T, \quad \textbf{(12)}$$

where Pi(i=1, 2,..... n) are n elements

3. After normalizing W_p , we get the normalized weight vectors as

$$W = (w(P_1), (w(P_1), \ldots (w(P_n))^T \quad \textbf{(13)}$$

where W is a non-fuzzy number and this gives the priority weights of one alternative over the other

4.13 MATLAB

MATLAB program was used for the purpose of data analysis using the extended fuzzy AHP approach using fuzzy triangular numbers to determine the final priority of different decision criteria to determine the relative importance of different selection criteria and sub-criteria It is an important programming platform specially designed for engineers and scientists for the purpose of analyzing and designing systems and products that change our world.

Additionally, MATLAB, a matrix-based programming language, enables the most natural expression of mathematical and computational problems..

Deep learning, machine learning, signal processing, communications, image and video processing, control systems, test and measurement, computational finance, and computational biology are just a few of the many applications it is used for in both industry and academia. Mat lab is used by millions of engineers and scientists worldwide.

Math Works has created the multi-paradigm programming language and computer environment known as MATLAB (matrix laboratory). It was created to manipulate matrices, visualize functions and data, perform algorithms, create user interfaces, and communicate with other programming languages [114].

4.14 Statistical Product and Service Solutions (SPSS)

For data management, sophisticated analytics, multivariate analysis, corporate intelligence, and criminal investigation, IBM created the statistical software suite SPSS Statistics. It was long manufactured by SPSS Inc. before being purchased by IBM in 2009. The brand of the most recent iterations is: Statistics using IBM SPSS

SPSS. Also, market researchers, health researchers, survey firms, the government, researchers in the field of education, marketing organizations, and data miners use it. Because it made it possible for regular researchers to conduct their own statistical analysis, the original SPSS manual has been referred to as one of "sociology's most influential publications."[115].

5. ANALYSIS AND DISCUSSION

5.1 Introduction

In this chapter presents the method to analyze the data extracted from previous survey,

After examining the responses, the researcher excluded results that contained deficiencies or were not completed by the participants in the questionnaire

Then the results were collected and analyzed using the SPSS. statistical program, by conducting a descriptive and quantitative analysis on the answer alternatives. Each question was discussed separately first, and then a file discussed. The result of the questionnaire was discussed

Then the fuzzy hierarchical analysis method was used. In conducting Fuzzy AHP for the purpose of selecting an appropriate alternative to sustainable building materials.

5.2 Analysis Steps

It can be divided into a stage of

Preparation and distribution of the questionnaire

1. Establish the major criteria and the sub-criteria for construction projects' utilization of building materials.
2. Distribute the questionnaire to for experts in this field that can answer the questionnaire
3. Conduct a descriptive and quantitative analysis on the questionnaire answers\

- Data analysis include

1. Determine the most important criteria through the relative importance of the criteria
2. Ranging the criteria from high to low through the relative importance

3. Scale change from Likert scale to Saaty's scale
4. By using the MATLAB program ,Work on fuzzy data according to the trigonometric method (converting numbers into fuzzy numbers))
5. Calculating the weights for each level (weights of the criteria and the sub criteria)
6. Find the priority weights for each primary criterion, sub-criteria, and alternative
7. Case study application

5.3 Establish the Criteria of Sustainable Building Materials

Through previous studies, Table (3.2): Criteria, and the sub criteria and to select sustainable construction material.

the main criteria and the sub criteria have been identified, which will be studied in this study, that we have explained in detail in chapter (3), and they are summarized.

the study criteria divided into (4) main criteria, (social, technical, environmental and economic criteria), where the social sub criteria included (8)sub criteria, the technical criteria included(7)sub criteria and the environmental criteria .(9)sub criteria, and the economy consists of (7)sub criteria,

5.4 The Descriptive Analysis of the Data

A questionnaire was prepared to find out (the importance of the criteria of this study) and distributed to a sample of 105 experts in construction projects field, to find the priorities and weights of the main criteria. and sub-criteria

Step 1 - Analyze the results of the questionnaire

After the results were collected , It analyzed using The (SPSS) Version 26. The statistical program, by conducting a descriptive and quantitative analysis on the answer alternatives. Each question was discussed separately first, . The results of the questionnaire were discussed as follows :

5.5 General Information

This part attempts to determine the academic qualifications of the research sample. place of work (city) Occupation, department in which they were employed, number of years .Professional experience, academic degree specialization, and types. Projects that contributed to the implementation. The Information about the respondent

5.5.1 Place of work

According to the place of work, the most of the respondents work in the capital, Baghdad, with a rate that may reach 57%, with a number of about 60 respondents, followed by Basra, with a rate of 9.5%, with a number of about 10 respondents, followed by other regions of Iraq, as in the as in Figure (5.1) , and Figure (5.2)

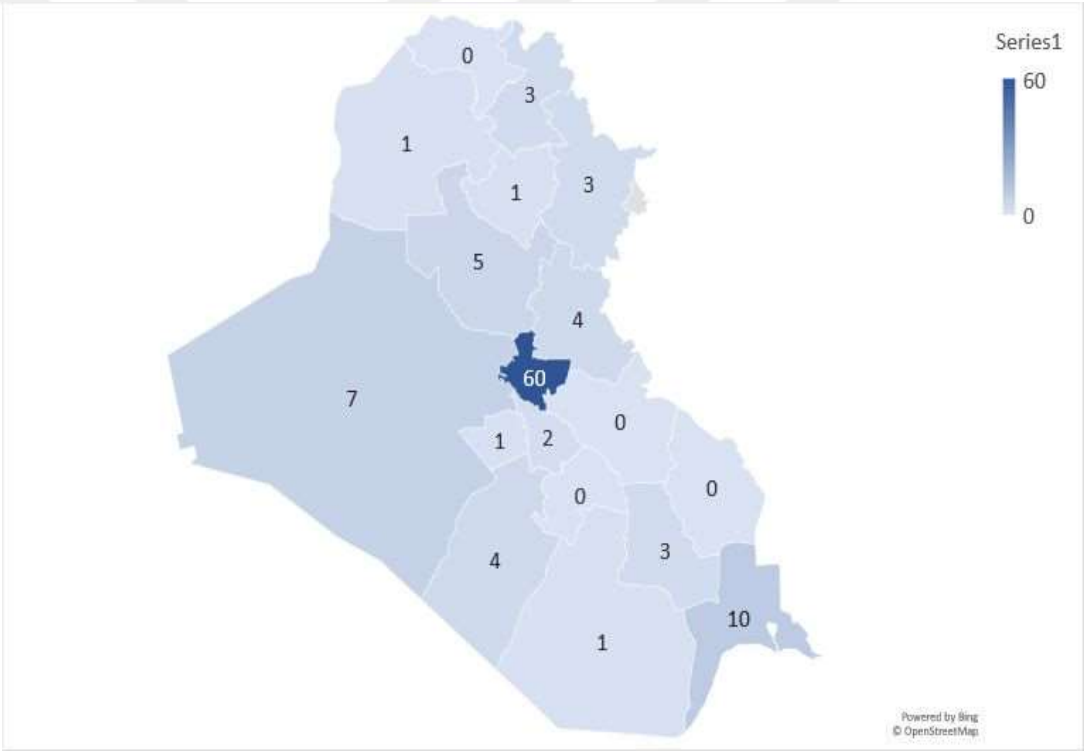


Figure 5.1: Frequency of Workplace

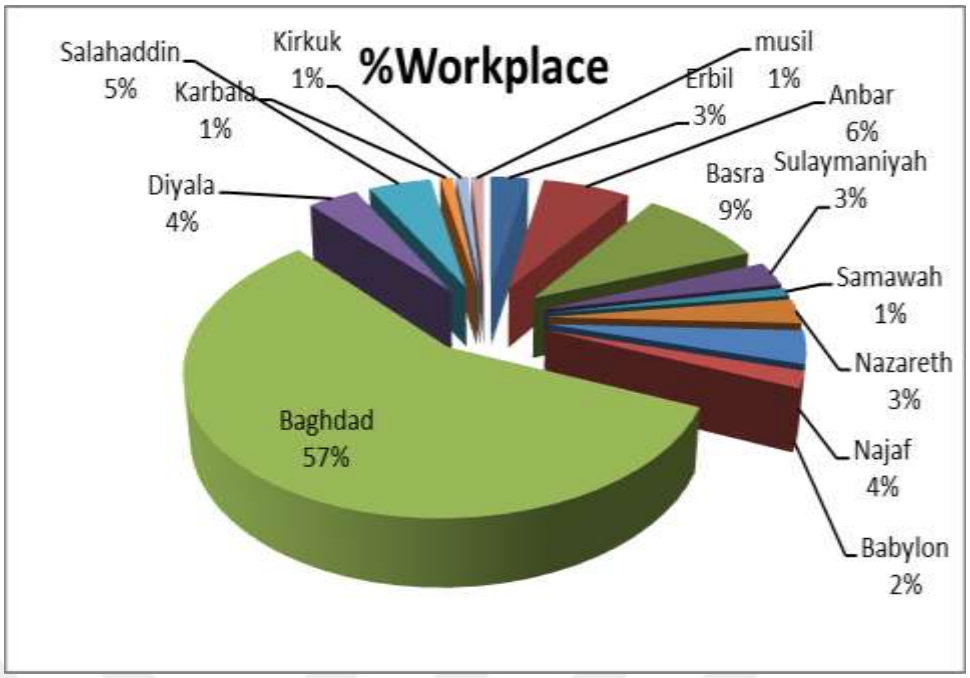


Figure 5.2: Percentage of Workplace

5.5.2 Employment class

Regarding the question about the job grade, it was found that most of the respondents are engineers with experience, and some of them have the rank of expert, their number is 20, and a number of them are with the rank of manager, their number is 15, and most of them work in construction projects as in the fig. (5.3)

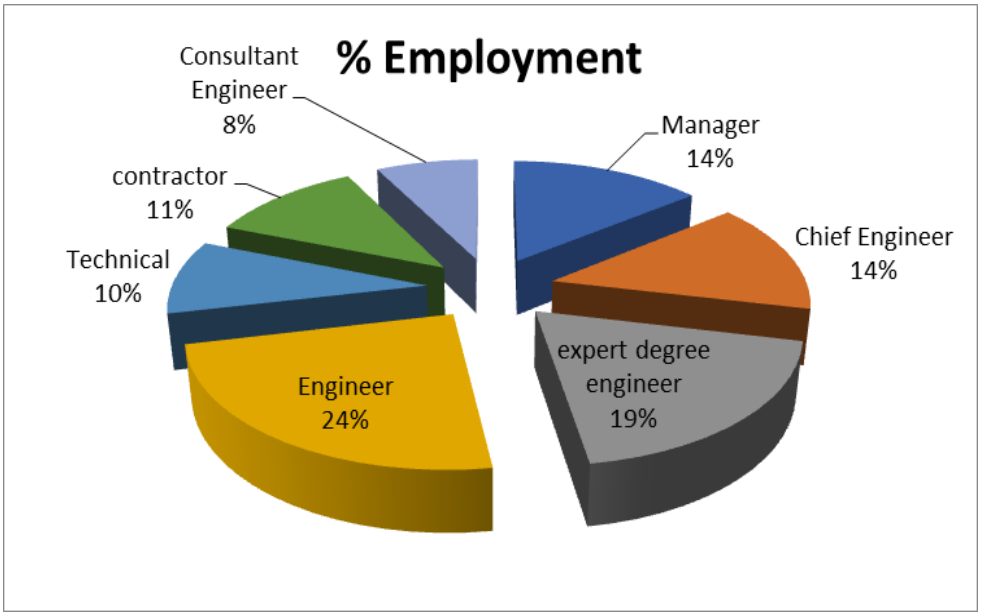


Figure 5.3: Percentage of Employment

5.5.3 The department worked on

By asking the respondents about the department in which they work, it was found that most of them work in the field of construction and buildings, at a rate of 29%, followed other departments as in the Fig (5.4)

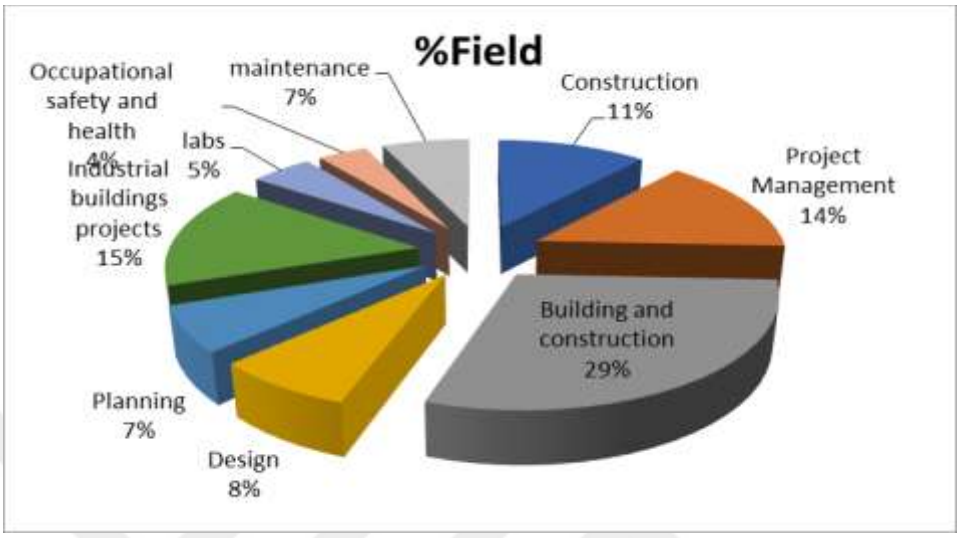


Figure 5.4: The Percentage of Department Work

5.5.4 Years of professional experience

By asking about thy years of experience, the largest percentage was between From 15 years to 20 and by percentage of 38 % , Followed by those with experience Less than 15 years old by percentage of 28 % , also have a percentage of 7% have more than 30 years of experience as in the Fig (5.5)(

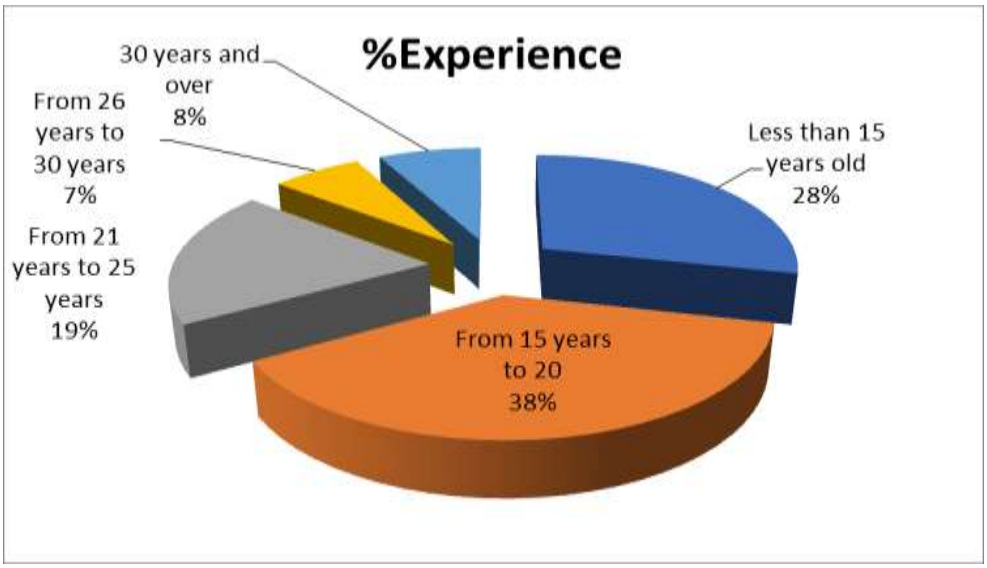


Figure 5.5: The Percentage Of Experience

5.5.5 Academic certification

By asking about the academic certificate of the respondents, it was found that 6% of PhD , and the percentage of Approximately 19 % of Master's and degrees as in the Fig (5.6)

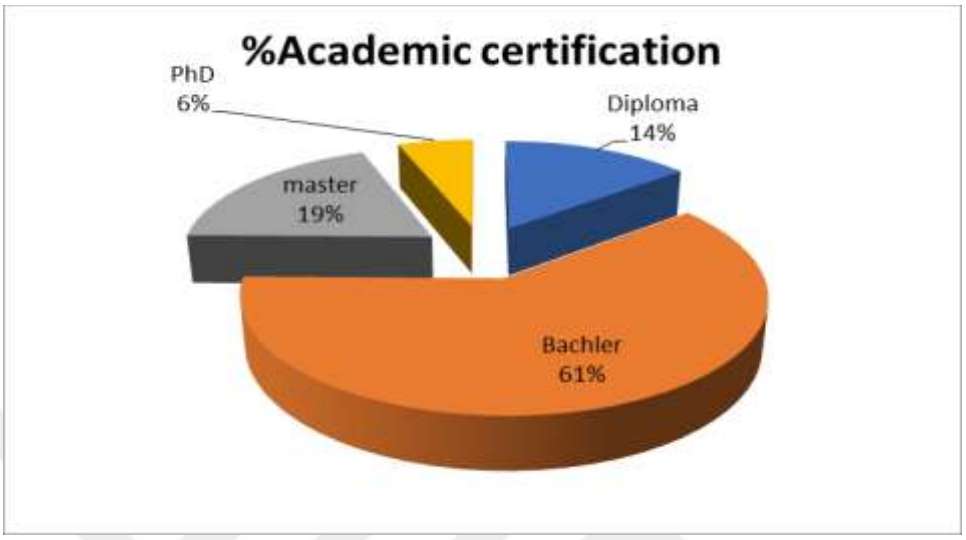


Figure 5.6: The Percentage of Academic Certification

5.5.6 The projects type

By asking about the type of projects that the respondents contributed to implement, representing approximately 38%, are working on projects of Residential construction projects, representing approximately 19%, answered that they are working on projects of Infrastructure projects as in the table Fig (5.7)

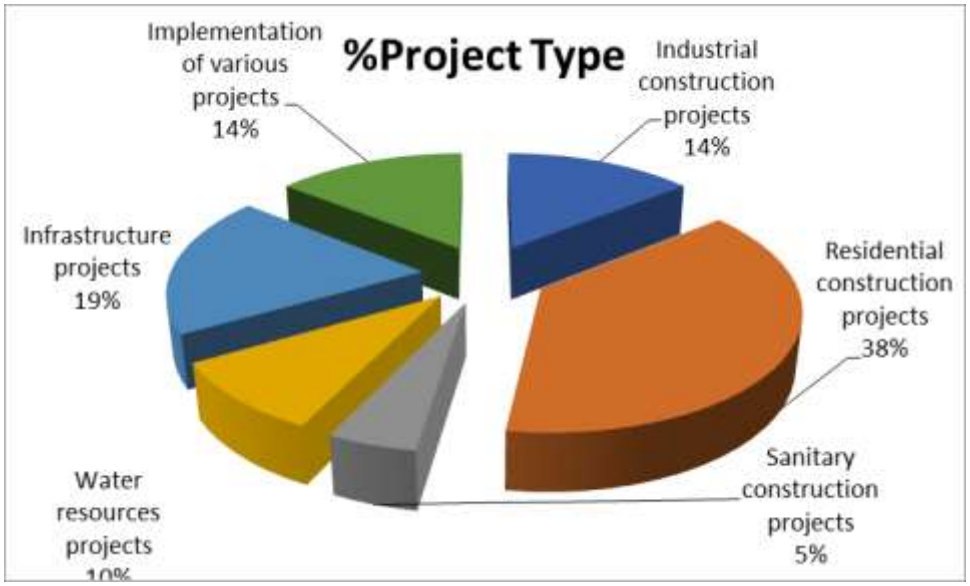


Figure 5.7: The Percentage of Project Type

5.6 The distribution of importance

Table.(5.1)) , by using the Likert scale 1–5 , the answers of the study sample were measured according to a Likert scale from 1 to 5, as the encoding of the answers (very low importance=1 , low importance=2 , medium importance=3 , high importance=4 , Very high importance =5) according to the [116]

Table 5.1: The Distribution Of Importance

Likert scale	1	2	3	4	5
Importance level	Very low importance	Low importance	Medium importance	High importance	Very high importance
Importance	1-1.8	1.8-2.6	2.6-3.4	3.4-4.2	4.2-5

5.7 Relative Importance Index (RII)

Is used to determine the relative importance of the quality factors involved. The respondent's weighting of each piece is W, and this is equivalent to the used likert scale points. The Relative Importance Index was calculated using the formula shown below[116].

RII= $\sum W/A * N$

Where the :

W: Weighting given to each sub criteria , by the respondent

A: the research's highest weight

N: total number of the respondents

In order to rank the sub criteria according to their relative importance, relative index analysis was chosen for this study.

In addition to calculating the level of importance for each criteria , as it was divided according to the relative importance into (a high level if the relative importance was greater than 0.8, a high-medium level if the relative importance was confined between 0.6-0.8, and a medium level if the relative importance was confined between 0.4 -0.6, and a medium-low level if the relative importance is between 0.2-0.4, and a low level if the relative importance is less than 0.2. according to the Table.(5.2)

Table 5.2: The Level of Importance

Values	Importance	Importance
0.8 ≤ RII ≤ 1	High	H
0.6 ≤ RII ≤ 0.8	Medium - High	M - H
0.4 ≤ RII ≤ 0.6	Medium	M
0.2 ≤ RII ≤ 0.4	Low - Medium	L - M
0 ≤ RII ≤ 0.2	Low	L

Table. (5.3), the level of importance of the criteria and their order from top to bottom. according the answer alternatives

Table 5.3: Criteria Importance

Criteria	**Valid percentage of score of (%)**					**RII**		**Ranking by category**	**Overall ranking**	**Importance level**
	1	2	3	4	5					
Social criteria										
Operational life	1	4.8	12.4	38.1	43.8	0.8381	0.7262(H-M)	1	1	H
Human health and safety	2.9	2.9	11.4	43.8	39	0.8267		2	2	H
Ease of construction (buildability)	1	5.7	14.3	52.4	26.7	0.7962		3	6	M-H
Aesthetics	4.8	2.9	21	52.4	19	0.7562		4	9	M-H
Isolation of noise pollution	2.9	10.5	26.7	46.7	13.3	0.7143		5	18	M-H
Social benefits and development	2.9	7.6	54.3	24.8	10.5	0.6648		6	22	M-H
Labor availability	4.8	14.3	36.2	37.1	7.6	0.6571		7	23	M-H
Use of local material	13.3	20	46.7	15.2	4.8	0.5562		8	31	M
Technical criteria										
Practicability	1	3.8	16.2	49.5	29.5	0.8057	0.7358(H-M)	1	4	H
Time-appropriate handling	0	8.6	17.1	44.8	29.5	0.7905		2	7	M-H
Fire resistance	1	5.7	25.7	52.4	15.2	0.7505		3	10	M-H
Maintainability	1.9	3.8	36.2	46.7	11.4	0.7238		4	14	M-H
Staff expertise	0	4.8	45.7	35.2	14.3	0.7181		5	16	M-H
Repair and reconstruction method	0	8.6	37.1	41.9	12.4	0.7162		6	17	M-H
Chemical resistant	1	14.3	50.5	29.5	4.8	0.6457		7	26	M-H
Environmental criteria										
Mount of likely wastage in use of material	1.9	5.7	30.5	51.4	10.5	0.7257	0.6445(	1	13	M-H

Table 5.3: (Cont.) Criteria Importance

Criteria	Valid percentage of score of (%)					RII		Ranking by category	Overall ranking	Importance level
	1	2	3	4	5					
Minimize Pollution and emissions	1.9	7.6	41.9	34.3	14.3	0.7029	0.6445(H-M)	2	20	M-H
Climate change	3.8	9.5	39	37.1	10.5	0.6819		3	21	M-H
Consumption of resource	3.8	11.4	46.7	29.5	8.6	0.6552		4	24	M-H
Material impact on air quality (indoor & outdoor(	2.9	16.2	41.9	29.5	9.5	0.6533		5	25	M-H
Production and transportation activities	4.8	19	51.4	18.1	6.7	0.6057		6	27	M-H
Recycling and reuse	10.5	14.3	45.7	22.9	6.7	0.6019		7	28	M-H
١ Embodied energy within material[	5.7	18.1	53.3	20	2.9	0.5924		8	29	M
Land acquisition	9.5	18.1	48.6	20	3.8	0.5810		9	30	M
Economic criteria										
Investment cost	1.9	4.8	14.3	43.8	35.2	0.8114	0.7586(H-M)	1	3	H
Meeting stakeholders needs	1	3.8	20	45.7	29.5	0.7981		2	5	M-H
Financial and economic risks	0	6.7	18.1	55.2	20	0.7771		3	8	M-H
Societal costs of construction materials	1.9	4.8	28.6	45.7	19	0.7505		4	11	M-H
Operation and maintenance cost	1	6.7	28.6	45.7	18.1	0.7467		5	12	M-H
Energy efficiency	1.9	8.6	31.4	42.9	15.2	0.7219		6	15	M-H
Disposal cost	2.9	10.5	32.4	40	14.3	0.7048		7	19	M-H

Table. (5.3), Through these alternatives, the percentages and the relative importance index for each sub criteria were calculated, in addition to arranging these responses from the highest to the lowest within the same criterion, as well as arranging them according to all criteria, as we note from Table No. (7) that the sub criteria (operational life) within the social criterion was It is the highest in terms of relative importance index , as it reached (0.8381) with the high level of importance. At the level of all sub criteria, it ranked (1). As for the technical criterion, the sub criteria that had the highest relative importance was (the process (the possibility of using it easily)) as it reached (0.8057) with a high level of importance, but at the level of all sub criteria, it was ranked (4), and with regard to the environmental criterion, the sub

criteria (potential waste in the use of materials) was the highest possessing a relative importance index, as it reached (0.7257) with a high-medium level of importance. All sub criteria were ranked (31), and as for the economic criterion, the sub criteria (cost of investment (prices)) was the highest, reaching (0.8114) with a high level of importance. As for the level of all sub criteria, it was ranked (3).

As for the main criteria, we note that the economic criterion has a highest relative importance through the answers of the experts according to the questionnaire that was distributed to them, as the relative importance of this criterion reached (0.7586) with the high-medium level of importance, followed by the technical criterion, as its relative importance reached (0.7358). With a high-medium level of importance, followed by the social criterion, as its relative importance reached (0.7262) at a high medium level of importance, followed by the environmental criterion, as its relative importance amounted to (0.6445) at a high medium level of importance.

5.8 Convert the Likert Scale Value to an Saaty's Scale

For a given response,. In this study, we use Saaty's scale. A Likert scale must be converted into a saaty scale, by weights of criteria for the purpose of comparing two alternative evaluations, and by relative classification of ratios. Saaty's relative importance is adopted.[30]

Table (5. 4), the conversion of the five Likert scale to the Saaty's scale which contain five levels (Equal importance=1, Moderate importance=3, Strong importance=5, Very strong=7, Extreme importance= 9) , as the data was converted in order to apply the AHP [30][3].

The relative importance of one choice variable to another has been established via trigonometric fuzzy number identification. based on ambiguous triangular numbers. The AHP. [1][2]

Table 5.4: The Linguistic Variables and Their Associated Fuzzy Numbers

Importance level	Value adopted	The fuzzy number	The membership function
Equal - importance	1	~ 1	(1 ,1 ,2)
Moderate - importance	3	~ 3	(2 , 3 ,4)
Strong - importance	5	~ 5	(4 , 5 , 6)
Very - strong	7	~ 7	(6 , 7 , 8)
Extreme importance	9	~ 9	(8 , 9 , 10)

5.9 Calculate the Relative Weights of Alternatives

Using .pairwise comparison (Saaty ’s scale , decision matrix) , for the main criteria

Table (5.5),the decision matrix was calculated in order to obtain the initial weights for each of main criteria , noted that the social criterion has obtained the highest relative importance as it reached (0.29), while the technical criterion came in second place as its relative importance was (0.28), and the environmental criterion came in the third rank, as its relative importance reached (0.23), while the economic criterion came in the fourth rank, as it reached (0.20) [3]

Table 5.5: Fuzzy Evaluation of the Main Criteria

Main criteria	Social criteria	Technical criteria	Environmental criteria	Economic criteria	W_0
Social criteria	1,1,1	1,1,2	4,5,6	2,3,4	0.29
Technical criteria	1,1, 0.5	1,1,1	6,7,8	2,3,4	0.28
Environmental criteria	0.25,0.2, 0.17	0.17,0.14, 0.125	1,1,1	8,9,10	0.23
Economic criteria	0.5,0.33, 0.25	0.5,0.33, 0.25	0.13,0.11, 0.1	1,1,1	0.20
Summation					1

5.10 Normalize the Matrix to the Sub-Criteria

With this process repeated for each of the criteria

1-Social criteria

Table (5.6) , the decision matrix was calculated in order to obtain the initial weights for each of the sub criteria of social criteria, where we note that the operational life and Human health and safety criterion has obtained the highest relative importance as it reached (0.15), while the ease of construction criterion came in second place as its relative importance was (0.14), and the Aesthetics criterion came in the third rank, as its relative importance reached (0.13), while the isolation of noise pollution criterion came in the fourth rank, as it reached (0.12), and the (social benefits and development) and (Labor Availability) criterion relative importance reached to (0.11), The use of local material has importance reached to (0.09).

Table 5.6: Fuzzy Evaluation of Sub-Criteria (Social Criteria)

Social criteria	Operational life	Human health and safety	Ease of construction (build ability)	Aesthetics	Isolation of noise pollution	Social benefits and development	Labor Availability	Use of local material	W_0
Operational life	1,1,1	1,1,2	1,1,2	2,3,4	4,5,6	6,7,8	6,7,8	8,9,10	0.15
Human health and safety	1,1,0.5	1,1,1	1	2,3,4	4,5,6	6,7,8	6,7,8	8,9,10	0.15
Ease of construction (build ability)	1,1,0.5	1,1,0.5	1,1,1	1,1,2	2,3,4	4,5,6	4,5,6	8,9,10	0.14
Aesthetics	0.50,0.33,0.25	0.50,0.33,0.25	1,1,0.5	1,1,1	1,1,2	2,3,4	2,3,4	8,9,10	0.13
Isolation of noise pollution	0.25,0.20,0.17	0.25,0.20,0.17	0.25,0.33,0.25	1,1,0.5	1,1,1	1,1,2	2,3,4	6,7,8	0.12
Social benefits and development	0.17,0.14,0.13	0.17,0.14,0.13	0.17,0.20,0.17	0.5,0.33,0.25	1,1,0.5	1,1,1	1,1,2	4,5,6	0.11
Labor availability	0.17,0.14,.013	0.17,0.14,0.13	0.17,0.20,0.17	0.5,0.33,0.25	0.5,0.33,0.25	1,1,0.5	1,1,1	4,5,6	0.11
Use of the local material	0.13,0.11,0.10	0.13,0.11,0.10	0.13,0.11,0.10	0.13,0.14,0.10	0.17,0.14,0.13	0.25,0.20,0.17	0.25,0.20,0.17	1,1,1	0.09
Summation									1

Table 5.7: Fuzzy Evaluation of Sub-Criteria (Technical Criteria)

Technical criteria	Practicability	Time-appropriate handling	Fire Resistance	Maintainability	Staff expertise	Repair and reconstruction	Chemical Resistant	W_0
Practicability	1,1,1	1,1,2	2,3,4	4,5,6	4,5,6	4,5,6	8,9,10	0.17
Time-appropriate handling	1,1,0.5	1,1,1	2,3,4	4,5,6	4,5,6	4,5,6	6,7,8	0.17
Fire Resistance	0.5,0.33,0.25	0.5,0.33,0.25	1,1,1	3.00	2,3,4	2,3,4	6,7,8	0.15
Maintainability	0.25,0.20,0.17	0.25,0.20, 0.17	0.5,0.33,0.17	1,1,1	1,1,2	1,1,2	4,5,6	0.13
Staff expertise	0.25,0.20,0.17	0.25,0.20, 0.17	0.5,0.33,0.17	1,1,0.5	1,1,1	1,1,2	4,5,6	0.13
Repair and reconstruction	0.25,0.20,0.17	0.25,0.20, 0.17	0.5,0.33,0.17	1,1,0.5	1,1,0.5	1,1,1	4,5,6	0.13
Chemical Resistant	0.13,0.11,0.10	0.17,0.14,0.13	0.17,0.14,0.13	0.25,0.20, 0.17	0.25,0.20,0.17	0.25,0.20,0.17	1,1,1	0.13
Summation								1

2- Technical criteria

Table (5.7) , the decision matrix was calculated in order to obtain the initial weights for each of the sub criteria of Technical criteria, where we note that the Practicability and Time-appropriate handling criterion has obtained the highest relative importance as it reached (0.17), while the Fire resistance criterion came in second place as its relative importance was (0.15), and the (Maintainability, Staff expertise, Repair and reconstruction and chemical resistant) criterion came in the third rank, as its relative importance reached (0.13).

3- Environmental criteria

Table (5.8), the decision matrix was calculated in order to obtain the initial weights for each of the sub criteria of environmental criteria, noted that the(mount of likely wastage) in use of material criterion has obtained the highest relative importance as it reached (0.14), while the minimize pollution and emissions criterion came in second place as its relative importance was (0.13), and the climate change criterion came in the third rank, as its relative importance reached (0.12), while the (Consumption of resource and material impact on air quality (indoor & outdoor)) criterion came in the fourth rank, as it reached (0.11), and the (production and transportation activities) and (recycling and reuse) criterion relative importance reached to (0.10), The (embodied energy within material and land acquisition) has importance reached to (0.09).

4- Economic criteria

Table (5.9) , the decision matrix was calculated in order to obtain the initial weights for each of the sub criteria of Economic criteria, noted that the investment cost criterion has obtained the highest relative importance as it reached (0.18), while the meeting stakeholders needs criterion came in second place as its relative importance was (0.17), and the financial and economic risks criterion came in the third rank, as its relative importance reached (0.15), while the societal costs of construction materials criterion came in the fourth rank, as it reached (0.14), and the operation and maintenance cost criterion relative importance reached to (0.13), The energy efficiency has importance reached to (0.12), and the last one is disposal cost reached to (0.11)

Table 5.8: Fuzzy Evaluation of Sub-Criteria (Environmental Criteria)

Environmental criteria	mount of likely wastage in use of material	Minimize Pollution and emissions	Climate change	Consumption of resource	material impact on air quality (indoor & outdoor)	production and transportation activities	recycling and reuse	embodied energy within material	land acquisition	W_0
Mount of likely wastage in use of material	1,1,1	1,1,2	2,3,4	4,5,6	4,5,6	8,9,10	8,9,10	8,9,10	8,9,10	0.14
Minimize Pollution and emissions	1,1,0.5	1,1,1	1,1,2	2,3,4	2,3,4	4,5,6	6,7,8	6,7,8	8,9,10	0.13
Climate change	0.5,0.33,0.25	1,1,0.5	1,1,1	1,1,2	1,1,2	4,5,6	4,5,6	4,5,6	6,7,8	0.12
Consumption of resource	0.25,0.20,0.17	0.5,0.33,0.25	1,1,0.5	1,1,1	1,1,2	2,3,4	2,3,4	2,3,4	4,5,6	0.11
Material impact on air quality (indoor & outdoor)	0.13,0.20,0.17	0.5,0.33,0.25	1,1,0.5	1,1,0.5	1,1,1	2,3,4	2,3,4	2,3,4	4,5,6	0.11
Production and transportation activities	0.13,0.11,0.10	0.25,0.20,0.17	0.25,0.20,0.17	0.5,0.33,0.25	1,1,0.5	1,1,1	1,1,2	1,1,2	1,1,2	0.10
Recycling and reuse	0.13,0.11,0.10	0.17,0.14,0.13	0.25,0.20,0.17	0.5,0.33,0.25	1,1,0.5	1,1,0.5	1,1,1	1,1,2	1,1,2	0.10
Embodied energy within material	0.13,0.11,0.10	0.13,0.14,0.13	0.25,0.20,0.17	0.5,0.33,0.25	1,1,0.5	1,1,0.5	1,1,0.5	1,1,1	1,1,2	0.09
Land acquisition	0.13,0.11,0.10	0.13,0.11,0.10	0.17,0.14,0.13	0.25,0.20,0.17	1,1,0.5	1,1,0.5	1,1,0.5	1,1,0.5	1,1,1	0.09
Summation										1

Table 5.9: Fuzzy Evaluation of Sub-Criteria (Economic Criteria)

Economic criteria	investment cost	meeting stakeholders needs	financial and economic risks	societal costs of construction materials	operation and maintenance cost	energy efficiency	Disposal cost	W_0
Investment cost	1,1,1	1,1,2	2,3,4	6,7,8	6,7,8	8,9,10	8,9,10	0.18
Meeting stakeholders needs	1,1,0.5	1,1,1	2,3,4	4,5,6	6,7,8	8,9,10	8,9,10	0.17
Financial and economic risks	0.5,0.33,0.25	0.5,0.33,0.25	1,1,1	2,3,4	2,3,4	6,7,8	8,9,10	0.15
Societal costs of construction materials	0.17,0.14,0.13	0.25,0.20,0.17	0.5,0.33,0.25	1,1,1	1,1,2	2,3,4	4,5,6	0.14
Operation and maintenance cost	0.17,0.14,0.13	0.17,0.14,0.13	0.5,0.33,0.25	1,1,0.5	1,1,1	2,3,4	4,5,6	0.13
Energy efficiency	0.13,0.11,0.10	0.13,0.11,0.10	0.17,0.14,0.13	0.5,0.33,0.25	0.5,0.33,0.25	1,1,1	1,1,2	0.12
Disposal cost	0.13,0.11,0.10	0.13,0.11,0.10	0.13,0.11,0.10	0.25,0.20,0.17	0.25,0.20,0.17	1,1,0.5	1,1,1	0.11
Summation								1

5.11 Computation of Fuzzy Evaluation Matrices for Decision Alternatives

Table (5.10), Each main criterion, sub-criteria, and alternative's priority weights are listed. It is decided how each alternative will be weighted locally in relation to the relevant sub-criteria for the fuzzy evaluation matrices of choice alternatives. The weights per material multiplied by the weights of the relevant criteria are added to get the priority weights of materials with regard to each criterion.

Local weight (1) - The local weight is found from the judgment matrix in relation to the weights of the main criteria

Local weight (2) - The local weight is found from the judgment matrix with respect to the weights of the sub-criteria

Global weight (3) This entry is obtained as follows . The global weight (3) of the sub-criterion is obtained by multiplying the local weight (1) by the Local weight (2) weight of the sub -criterion

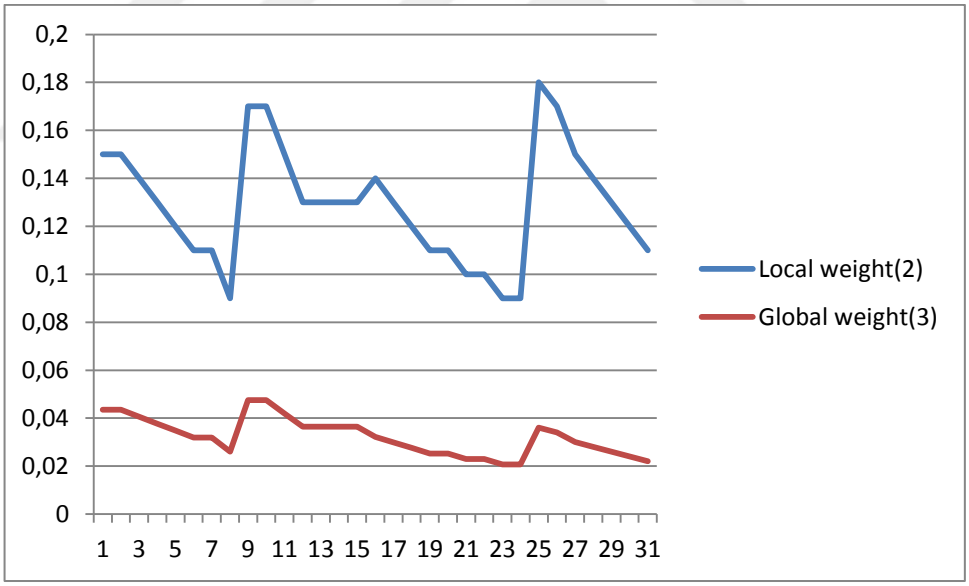


Figure 5.8: Priority Weights for Criteria and Sub Criteria Used

Table 5.10: Priority Weights for Criteria and Sub Criteria Used

Main Criteria	Local Weight(1)	Sub Criteria	Local Weight(2)	Global Weight(3)
Social criteria	**0.29**	Operational life	0.15	0.0435
		Human health and safety	0.15	0.0435
		ease of construction (build ability)	0.14	0.0406
		Aesthetics	0.13	0.0377
		isolation of noise pollution	0.12	0.0348
		social benefits and development	0.11	0.0319
		Labor Availability	0.11	0.0319
		Use of local material	0.09	0.0261
Technical criteria	**0.28**	Practicability	0.17	0.0476
		Time-appropriate handling	0.17	0.0476
		Fire Resistance	0.15	0.042
		Maintainability	0.13	0.0364
		Staff expertise	0.13	0.0364
		Repair and reconstruction	0.13	0.0364
		Chemical Resistant	0.13	0.0364
Environmental criteria	**0.23**	mount of likely wastage in use of material	0.14	0.0322
		Minimize Pollution and emissions	0.13	0.0299
		Climate change	0.12	0.0276
		Consumption of resource	0.11	0.0253
		material impact on air quality (indoor & outdoor)	0.11	0.0253
		production and transportation activities	0.1	0.023
		recycling and reuse	0.1	0.023
		embodied energy within material	0.09	0.0207
		land acquisition	0.09	0.0207
Economic criteria	**0.2**	investment cost	0.18	0.036
		meeting stakeholders needs	0.17	0.034
		financial and economic risks	0.15	0.03
		societal costs of construction materials	0.14	0.028
		operation and maintenance cost	0.13	0.026
		energy efficiency	0.12	0.024
		Disposal cost	0.11	0.022
Sumiton	1		4	1

5.12 Hierarchy of the Decision Problem

Figure (5.9). A practical example to illustrate the application of the framework, to a material selection problem. In case to use Fuzzy AHP multi-criteria decision making.

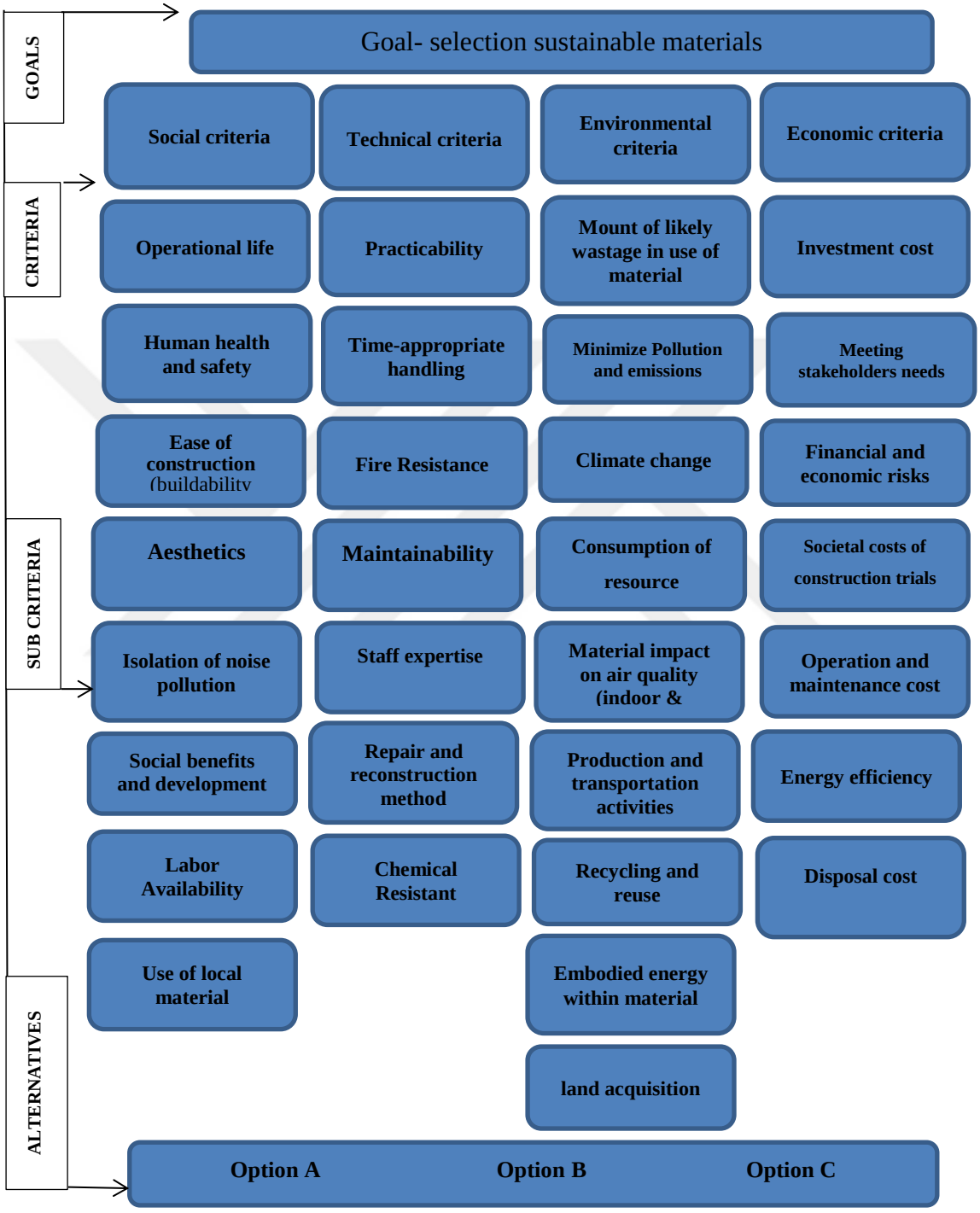


Figure 5.9: Hierarchy of the Decision Problem

5.13 Case Studies

For the purpose of applying this framework (a framework for the sustainable selection of building materials used in construction projects in Iraq), a case study was conducted for the purpose of making multi-criteria decisions using the AHP fuzzy method to solve the problem of selecting sustainable materials. The case study includes the selection of three types of bricks used in construction in Iraq red bricks (red) Fig (5.10), yellow bricks (yellow) Fig (5.11) , and solid yellow bricks (yellow s) Fig (5.12) and applying the framework that was proposed in this study for selecting the most sustainable types of bricks

The same criteria and sub-criteria used in this research were used and applied to alternative materials.

Figure 5.10: Red Bricks (Red)

Figure 5.11: Yellow Bricks (Yellow)

Figure 5.12: Solid Yellow Bricks (Yellow S)

5.14 The Framework Application (Case Studies)

For the purpose of applying the same steps that were proposed in this framework, which include:

1. A questionnaire was prepared, that included (36) experts in the field of construction in Iraq with more than (15) years of experience in this field. through the answers of the experts according to the questionnaire that was distributed to them ,then Analyze the results of the questionnaire using The (SPSS) program

Table 5.11: Frequency of Experience (Case Studies)

Experience	Frequency	%
More than 15 years	36	100
Total	36	100.00

Figure 5.13: The Educational Qualification of the Respondents Is

2. Examine the questionnaire's consistency

To check the compatibility of the questionnaire, SPSS version 26 was used , according to the Cranach's alpha values(Cranach's alpha) is a measure of the internal consistency , that demonstrates how closely a group of items are related to one another . Table (5.12) shows the credibility (measure of scale reliability) statistics of the case study for each indicator, shows all Cranach's Alpha of yellow, yellow s and red is great than 70%, and that refer to good consistency of responses.

Table 5.12: Shows Reliability Statistics of (Case Studies)

Criteria	Cranach's Alpha of yellow	Cranach's Alpha of yellow s	Cranach's Alpha of red	No of Items
Social	0.711	0.701	0.744	8
Technical	0.706	0.736	0.740	7
Environmental	0.857	0.820	0.799	9
Economic	0.719	0.751	0.710	7
ALL	0.907	0.900	0.921	31

3. Determine the Relative Importance Index (RII) of the quality factors involved For the purpose of calculating the level of importance for each criterion

A. Yellow bricks

Table (5.13) The percentages of the answer alternatives and the importance show the percentage and order of the criteria in addition to the level of importance of Yellow

From Table (5.13) through these alternatives For (Yellow) , the percentages and the relative importance index for each criteria and the sub criteria were calculated, in addition to arranging these responses from the highest to the lowest within the same criterion, as well as arranging them according to all criteria, as noted from Table No. (5.13) that the sub criteria (operational life) within the social criterion was It is the highest in terms of the relative importance index, as it reached (93.89) with a high level of importance. At the level of all sub criteria, it ranked (2). As for the technical criterion, the sub criteria that had the highest relative importance was (Fire Resistance) as it reached (95.00) with a high level of importance, but at the level of all sub criteria, it was ranked (1), and with regard to the environmental criterion, the sub criteria (Climate change) was the highest possessing the relative importance index, as it reached (84.44) with a high level of importance. All sub criteria were ranked (13), and as for the economic criterion, the sub criteria (meeting stakeholders needs) was the highest, reaching (92.22) with a high level of importance. As for the level of all sub criteria, it was ranked (3).

As for the main criteria, noted that the economic criterion has the highest relative importance, as the relative importance of this criterion reached (87.22) with a high level of importance, followed by the technical criterion, as its relative importance reached (86.11). With the high level of importance, followed by the social criterion, as its relative importance reached (85.83) at the high level of importance, followed by the environmental criterion, as its relative importance amounted to (79.19) at a high-medium level of importance.

Table 5.13: Level of Importance of Yellow

Criteria	Sub criteria	Valid percentage of score of (%)					RII		Ranking by category	Overall ranking	Importance level
		1	2	3	4	5					
Social criteria	Operational life	0	0	0	30.6	69.4	93.89	85.83 (H)	1	2	H
	Isolation of noise pollution	0	0	0	58.3	41.7	88.33		2	8	H
	Ease of construction (build ability)	0	0	0	58.3	41.7	88.33		3	9	H
	Aesthetics	0	0	5.6	52.8	41.7	87.22		4	10	H
	Human health and safety	0	0	11.1	58.3	30.6	83.89		5	14	H
	Labor availability	0	0	11.1	63.9	25	82.78		6	17	H
	Use of local materials	0	2.8	22.2	41.7	33.3	81.11		7	22	H
	Social benefits and development	0	0	22.2	50	27.8	81.11		8	23	H
Technical criteria	Fire resistant	0	0	2.8	19.4	77.8	95.00	86.11 (H)	1	1	H
	Practical	0	0	2.8	44.4	52.8	90.00		2	5	H
	Time-appropriate handling	0	0	2.8	66.7	30.6	85.56		3	11	H
	Chemical resistance	0	0	11.1	52.8	36.1	85.00		4	12	H
	Staff experience	0	0	8.3	63.9	27.8	83.89		5	15	H
	Repair and reconstruction method	0	0	11.1	66.7	22.2	82.22		6	19	H
	Maintainability	0	0	11.1	72.2	16.7	81.11		7	24	H
Environmental criteria	Climate change	0	0	8.3	61.1	30.6	84.44	79.19 (H-M)	1	13	H
	Mount of likely wastage in use of material	0	0	11.1	69.4	19.4	81.67		2	20	H
	Material impact on air quality (indoor & outdoor)	0	0	5.6	80.6	13.9	81.67		3	21	H
	Minimize Pollution and emissions	0	0	16.7	66.7	16.7	80.00		4	26	H
	Production and transportation activities	0	0	16.7	66.7	16.7	80.00		5	27	H
	Embodied energy within material]	0	0	19.4	69.4	11.1	78.29		6	28	M-H
	Consumption of resource	0	0	33.3	55.6	11.1	75.56		7	29	M-H
	Recycling and reuse	0	0	38.9	44.4	16.7	75.56		8	30	M-H
	Land acquisition	0	0	33.3	55.6	11.1	75.56		9	31	M-H
Economic criteria	Meeting stakeholders needs	0	0	0	38.9	61.1	92.22	87.22 (H)	1	3	H
	Societal costs of construction materials	0	0	0	38.9	61.1	92.22		2	4	H
	Investment cost	0	0	2.8	44.4	52.8	90.00		3	6	H
	Operation and maintenance cost	0	0	2.8	50.0	47.2	88.89		4	7	H
	Financial and economic risks	0	0	0	80.6	19.4	83.89		5	16	H
	Disposal cost	0	0	13.9	58.3	27.8	82.78		6	18	H
	Energy efficiency	0	0	11.1	75.0	13.9	80.56		7	25	H

B. Yellow Solid Bricks(Yellow s)

Table (5.14) show The percentages of the answer alternatives and the importance show the percentage and order of the criteria in addition to the level of importance of Yellow s

From Table (5.14) through these alternatives For (Yellow s) , the percentages and the relative importance index for each paragraph were calculated, in addition to arranging these responses from the highest to the lowest within the same criterion, as well as arranging them according to all criteria, as noted that the paragraph (easy of construction (build ability) within the social criterion was It is the highest in terms of the relative importance index, as it reached (75.00) with a high-medium level of importance. At the level of all paragraphs, it ranked (4). As for the technical criterion, the paragraph that had the highest relative importance was (Fire Resistance) as it reached (80) with a high level of importance, but at the level of all paragraphs, it was ranked (1), and with regard to the environmental criterion, the paragraph (Climate change) was the highest possessing the relative importance index, as it reached (71.11) with a high level of importance. All paragraphs were ranked (12), and as for the economic criterion, the paragraph (investment cost) was the highest, reaching (79.44) with a high level of importance. As for the level of all paragraphs, it was ranked (2).

As for the main criteria, we note that the economic criterion has the highest relative importance through the answers of the experts according to the questionnaire that was distributed to them, as the relative importance of this criterion reached (71.67) with a high-medium level of importance, followed by the social criterion, as its relative importance reached (70.90), with a high-medium level of importance, followed by the technical criterion, as its relative importance reached (70.64) at a high-medium level of importance, followed by the environmental criterion, as its relative importance amounted to (64.38) at a high-medium level of importance.

Table 5.14: The Level of Importance of (Yellow s)

	Criteria	Valid percentage of score of (%)					RII		Ranking by category	Overall ranking	Importance level
		1	2	3	4	5					
Social criteria	Ease of construction (buildability)	0	0	38.9	47.2	13.9	75.00	70.90 (H-M)	1	**4**	M-H
	Isolation of noise pollution	0	2.8	36.1	52.8	8.3	73.33		2	**6**	M-H
	Labor availability	0	0	44.4	47.2	8.3	72.78		3	**7**	M-H
	Use of local materials	0	0	47.2	47.2	5.6	71.67		4	**9**	M-H
	Operational life	0	0	52.8	38.9	8.3	71.11		5	**10**	M-H
	Aesthetics	0	5.6	50.0	38.9	5.6	68.89		6	**16**	M-H
	Human health and safety	0	5.6	52.8	38.9	2.8	67.78		7	**18**	M-H
	Social benefits and development	0	0	69.4	27.8	2.8	66.67		8	**22**	M-H
Technical criteria	Fire resistant	0	0	13.9	72.2	13.9	80.00	70.64 (H-M)	1	**1**	H
	Time-appropriate handling	0	2.8	41.7	47.2	8.3	72.22		2	**8**	M-H
	Practical	0	5.6	44.4	38.9	11.1	71.11		3	**11**	M-H
	Repair and reconstruction method	0	5.6	44.4	41.7	8.3	70.56		4	**13**	M-H
	Staff experience	0	0	52.8	44.4	2.8	70.00		5	**15**	M-H
	Chemical resistance	0	5.6	55.6	33.3	5.6	67.78		6	**19**	M-H
	Maintainability	0	8.3	69.4	22.2	0	62.78		7	**26**	M-H
Environmental criteria	Climate change	0	0	50.0	44.4	5.6	71.11	64.38 (H-M)	1	**12**	M-H
	Land acquisition	0	2.8	58.3	38.9	0	67.22		2	**21**	M-H
	Production and transportation activities	0	0	5.6	61.1	33.3	65.56		3	**23**	M-H
	Embodied energy within material	0	5.6	66.7	25.0	2.8	65.00		4	**25**	M-H
	Mount of likely wastage in use of material	0	11.1	63.9	25.0	0	62.78		5	**27**	M-H
	Recycle and reuse	0	16.7	58.3	22.2	2.8	62.22		6	**28**	M-H
	(Material impact on air quality (indoor & outdoor)	0	13.9	63.9	19.4	2.8	62.22		7	**29**	M-H
	Minimize Pollution and emissions	0	13.9	66.7	16.7	2.8	61.67		8	**30**	M-H
	Consumption of resource	0	11.1	72.2	13.9	2.8	61.67		9	**31**	M-H
Economic criteria	Investment cost	0	0	13.9	75.0	11.1	79.44	71.67 (H-M)	1	**2**	M-H
	Societal costs of construction materials	0	0	27.8	63.9	8.3	76.11		2	**3**	M-H
	Operation and maintenance cost	0	0	36.1	58.3	5.6	73.89		3	**5**	M-H
	Meeting stakeholders needs	0	2.8	52.8	33.3	11.1	70.56		4	**14**	M-H
	Energy efficiency	0	0	2.8	52.8	44.4	68.33		5	**17**	M-H
	Financial and economic risks	0	2.8	61.1	30.6	5.6	67.78		6	**20**	M-H
	Disposal cost	0	2.8	66.7	30.6	0	65.56		7	**24**	M-H

C. Red bricks (red)

Table (5.15) show The percentages of the answer alternatives and the importance show the percentage and order of the criteria in addition to the level of importance of red

From Table (5.15) through these alternatives for (Red), the percentages and the relative importance index for each paragraph were calculated, in addition to arranging these responses from the highest to the lowest within the same criterion, as well as arranging them according to all criteria, as we noted that the paragraph (easy of construction (build ability)) within the social criterion was it is the highest in terms of the relative importance index, as it reached (94.44) with a high level of importance. At the level of all paragraphs, it ranked (4). As for the technical criterion, the paragraph that had the highest relative importance was (Practicability) as it reached (95) with a high level of importance, but at the level of all paragraphs, it was ranked (3), and with regard to the environmental criterion, the paragraph (mount of likely wastage in use of material) was the highest possessing the relative importance index, as it reached (96.11) with a high level of importance. All paragraphs were ranked (1), and as for the economic criterion, the paragraph (meeting stakeholders needs) was the highest, reaching (95.56) with a high level of importance. As for the level of all paragraphs, it was ranked (3).

As for the main criteria, we note that the social criterion has the highest relative importance through the answers of the experts according to the questionnaire that was distributed to them, as the relative importance of this criterion reached (90.83) with a high level of importance, followed by the technical criterion, as its relative importance reached (90.16), with a high level of importance, followed by the economic criterion, as its relative importance reached (89.37) at a high level of importance, followed by the environmental criterion, as its relative importance amounted to (88.12) at a high level of importance.

Table 5.15: The Level of Importance of Red

	Criteria	Valid percentage of score of (%)					RII		Ranking by category	Overall ranking	Importance level
		1	2	3	4	5					
Social criteria	Ease of construction (buildability)	0	0	0	27.8	72.2	94.44	90.83 (H)	1	**4**	H
	Operational life	0	0	0	30.6	69.4	93.89		2	**5**	H
	Human health and safety	0	0	5.6	25.0	69.4	92.78		3	**7**	H
	Aesthetics	0	0	5.6	33.3	61.1	91.11		4	**10**	H
	Isolation of noise pollution	0	0	0	44.4	55.6	91.11		5	**11**	H
	Use of local materials	0	0	11.1	30.6	58.3	89.44		6	**17**	H
	Labor availability	0	0	8.3	47.2	44.4	87.22		7	**21**	H
	Social benefits and development	0	0	5.6	55.6	38.9	86.67		8	**23**	H
Technical criteria	Practical	0	0	0	25.0	75.0	95.00	90.16 (H)	1	**3**	H
	Fire resistant	0	0	2.8	30.6	66.7	92.78		2	**8**	H
	Time-appropriate handling	0	0	0	44.4	55.6	91.11		3	**12**	H
	Chemical resistance	0	0	0	50.0	50.0	90.00		4	**14**	H
	Repair and reconstruction method	0	0	2.8	44.4	52.8	90.00		5	**15**	H
	Maintainability	0	0	5.6	52.8	41.7	87.22		6	**22**	H
	Staff experience	0	0	5.6	63.9	30.6	85.00		7	**29**	H
Environmental criteria	Mount of likely wastage in use of material	0	0	0	19.4	80.6	96.11	88.12 (H)	1	**1**	H
	Minimize Pollution and emissions	0	0	5.6	22.2	72.2	93.33		2	**6**	H
	Consumption of resource	0	0	0	38.9	61.1	92.57		3	**9**	H
	Production and transportation activities	0	0	5.6	50.0	44.4	87.78		4	**19**	H
	Recycle and reuse	0	0	8.3	52.8	38.9	86.11		5	**26**	H
	Material impact on air quality (indoor & outdoor)	0	0	5.6	58.3	36.1	86.11		6	**27**	H
	Climate change	0	0	0	72.2	27.8	85.56		7	**28**	H
	Embodied energy within material]	0	0	11.1	61.1	27.8	83.33		8	**30**	H
	Land tenure	0	0	13.9	61.1	25.0	82.22		9	**31**	H
Economic criteria	Meeting stakeholders needs	0	0	0	22.2	77.8	95.56	89.37 (H)	1	**2**	H
	Societal costs of construction materials	0	0	2.8	41.7	55.6	90.56		2	**13**	H
	Financial and economic risks	0	0	0	50.0	50.0	90.00		3	**16**	H
	Operation and maintenance cost	0	0	0	58.3	41.7	88.33		4	**18**	H
	Disposal cost	0	0	2.8	55.6	41.7	87.78		5	**20**	H
	Energy efficiency	0	0	0	66.7	33.3	86.67		6	**24**	H
	Investment cost	0	0	5.6	55.6	38.9	86.67		7	**25**	H

1. Calculate relative weights of the alternatives , using the pairwise comparison (Saaty's scale Decision matrix), for criteria, and sub-criteria

Table(5.16) , To convert data collected from case study to Saaty's scale, we use relative importance of criteria to construct the Saaty's scale and we set the (50 to 59) equal 1, (60 to 69) equal 3, (70 to 79) equal 5, (80 to 89) equal 7 and (90 to 100) equal 9. Then the numbers were converted to fuzzy numbers so that the number 1 equals (1,1,2) , the number 3 equals (2,3,4) , the number 5 equals(4,5,6) , the number 7 equals(6,7,8) , the number 9 equals(8,9,10)

Table 5.16: Scale conversion from Likert scale to Saaty's scale in case study.

RII%	Saaty's scale	Fuzzy numbers
50 to 59	1	(1,1,2)
60 to 69	3	(2,3,4)
70 to 79	5	(4,5,6)
80 to 89	7	(6,7,8)
90 to 100	9	(8,9,10)

2. Table (5.17) calculate the priority, the sustainability , criteria and sub criteria used in the case study

Overall rating of the three material by using , Fuzzy AHP technique that aimed to find the best material, from results of we see that the importance of (red) about 44.8342% which is the highest with rank (1), the second importance is 40.1242% for (yellow) with rank(2) and the third importance is 15.09159% for (yellow s) with rank(3).

Table 5.17: Overall Rating of Three (Types of Bricks)

Main criteria	Local weight(1)	Sub criteria	Local Weight (2)	Global Weight (3)	Local weight(3)			Global weight(4)		
					Yellow	Red	Yellow s	Yellow	Red	Yellow s
Social criteria	0.29	Operational life	0.15	0.0435	0.44	0.44	0.11	0.019333	0.019333	0.0048333
		Human health and safety	0.15	0.0435	0.44	0.47	0.09	0.019131	0.020497	0.0038717
		Ease of construction (buildability)	0.14	0.0406	0.25	0.50	0.25	0.01015	0.0203	0.01015
		Aesthetics	0.13	0.0377	0.44	0.47	0.09	0.01658	0.017764	0.0033555
		Isolation of noise pollution	0.12	0.0348	0.29	0.45	0.27	0.009943	0.015624	0.0092327
		Social benefits and development	0.11	0.0319	0.44	0.44	0.11	0.014178	0.014178	0.0035444
		Labor availability	0.11	0.0319	0.40	0.40	0.20	0.01276	0.01276	0.00638
		Use of local material	0.09	0.0261	0.40	0.40	0.20	0.01044	0.01044	0.00522
Technical criteria	0.28	Practicability	0.17	0.0476	0.44444	0.444444	0.11111	0.021156	0.021156	0.0052889
		Time-appropriate handling	0.17	0.0476	0.28571	0.44898	0.26531	0.0136	0.021371	0.0126286
		Fire resistance	0.15	0.0420	0.4	0.4	0.2	0.0168	0.0168	0.0084
		Maintainability	0.13	0.0364	0.44444	0.444444	0.11111	0.016178	0.016178	0.0040444
		Staff expertise	0.13	0.0364	0.4	0.4	0.2	0.01456	0.01456	0.00728
		Repair and reconstruction	0.13	0.0364	0.28571	0.44898	0.26531	0.0104	0.016343	0.0096571
		Chemical resistant	0.13	0.0364	0.43979	0.471204	0.08901	0.016008	0.017152	0.0032398

Table 5.17: (Cont.) Overall Rating of Three (Types of Bricks)

Main criteria	Local weight(1)	Sub criteria	Local Weight (2)	Global Weight (3)	Local weight(3)			Global weight(4)		
					Yellow	Red	Yellow s	Yellow	Red	Yellow s
Environmental criteria	0.23	Mount of likely wastage in use of material	0.14	0.0322	0.43979	0.471204	0.08901	0.014161	0.015173	0.002866
		Minimize Pollution and emissions	0.13	0.0299	0.43979	0.471204	0.08901	0.01315	0.014089	0.0026613
		Climate change	0.12	0.0276	0.4	0.4	0.2	0.01104	0.01104	0.00552
		Consumption of resource	0.11	0.0253	0.23214	0.642857	0.125	0.005873	0.016264	0.0031625
		Material impact on air quality (indoor & outdoor)	0.11	0.0253	0.44444	0.444444	0.11111	0.011244	0.011244	0.0028111
		Production and transportation activities	0.1	0.0230	0.44444	0.444444	0.11111	0.010222	0.010222	0.0025556
		Recycling and reuse	0.1	0.0230	0.28571	0.571429	0.14286	0.006571	0.013143	0.0032857
		Embodied energy within material	0.09	0.0207	0.28571	0.571429	0.14286	0.005914	0.011829	0.0029571
		Land acquisition	0.09	0.0207	0.28571	0.571429	0.14286	0.005914	0.011829	0.0029571
Economic criteria	0.2	Investment cost	0.18	0.0360	0.57143	0.285714	0.14286	0.020571	0.010286	0.0051429
		Meeting stakeholders needs	0.17	0.0340	0.44444	0.444444	0.11111	0.015111	0.015111	0.0037778
		Financial and economic risks	0.15	0.0300	0.56545	0.34555	0.08901	0.016963	0.010366	0.0026702
		Societal costs of construction materials	0.14	0.0280	0.44444	0.444444	0.11111	0.012444	0.012444	0.0031111
		Operation and maintenance cost	0.13	0.0260	0.4	0.4	0.2	0.0104	0.0104	0.0052
		Energy efficiency	0.12	0.0240	0.44444	0.444444	0.11111	0.010667	0.010667	0.0026667
		Disposal cost	0.11	0.0220	0.44444	0.444444	0.11111	0.009778	0.009778	0.0024444
	Sum			1.000	Sum			0.401242	0.448342	0.1509159
					Rank			2	1	3

Fig (5.14) Overall rating of the three (Types of bricks) material using (Fuzzy AHP)

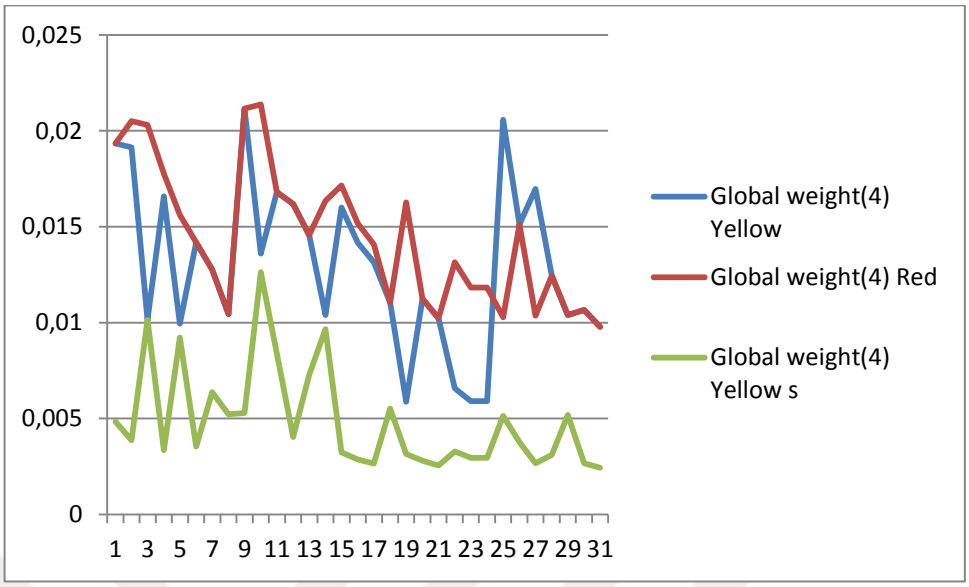


Figure 5.14: Overall Rating of the Three (Types of Bricks)

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

In this chapter, a discussion of the most important conclusions and recommendations obtained through this research that help in choosing sustainable building materials

6.2 Conclusion

The use of green resources is a unique and essential tactic to meet the demands of a rapidly growing population. This is because urbanization and population expansion have increased the demand for new housing and infrastructure. The aim of the research is to find a decision-making framework for selecting sustainable materials for construction projects in Iraq, the choice of building materials plays a vital role in achieving sustainable construction as well

This research proposes an approach that focuses on collecting criteria that affect sustainability material selection .It was found that, there are a number of the criteria and the sub-criteria significantly affect the sustainability of the materials used in construction projects and collected through a comprehensive survey of previous research and theoretical literature in this field. The criteria have been divided into (4) main criteria (social criteria , technical criteria , environmental criteria , economic criteria) and (31) sub - criteria .

SPSS method was used to analyze the data obtained through a questionnaire of experts in this field

And also due to the fact that the selection of sustainable materials as well as the selection of the appropriate materials is considered a state of uncertainty because the selection of materials is one type of multicriteria decision-making method (MCDM), which is an effective way to deal with the challenges of selecting sustainable building materials.

In this study, relative measurement weights were calculated using the Fuzzy Hierarchical Analytical Process approach (Fuzzy AHP) to evaluate the data in order to determine the significance of these selection criteria. In order to achieve this goal of allowing the analyst to concentrate on only two aspects at once, Fuzzy AHP uses pairwise comparisons to establish weights and ratings. Using this method, decision-makers can define and resolve confusing challenges involving several criteria and complexity in the selection of alternate building materials.

All 31 criteria were identified as important in selection of the sustainable building materials, as through the results of the questionnaire, they obtained a relative importance index (RII) ranging from medium to high, none of which were obtained. Low significance was obtained . The strategy outlined in this study can support evaluation. For a wide range of options, particularly given the opposing goals. It may also support important decisions made by stakeholders. by selecting sustainable material substitutes.

A case study was conducted for the purpose of applying the framework "a framework for the sustainable selection of building materials used in construction projects in Iraq" , for the purpose of making multi - criteria decisions using the fuzzy AHP method to solve the problem of selecting sustainable materials . Where the case study included the selection of the brick material by selecting three types of bricks used in construction in Iraq, which are red bricks (red), yellow bricks (yellow), and solid yellow bricks (yellow s). And when applying the framework that was proposed in this study for the purpose of selecting the most sustainable types of bricks. The same criteria and the sub-criteria used in this research were used and applied to the types of bricks to choose the best alternative material. It appeared from the general evaluation of the three materials using the Fuzzy AHP technique, which aims to find the best materials, and it was found that the importance of red bricks is the highest rank (1), the second importance of perforated yellow bricks (yellow) is the rank (2), and the third importance of solid yellow bricks (yellow s) with a degree (3).

This framework can be used as a reference for construction professionals seeking to promote sustainable construction through sustainable building materials.

6.3 Recommendations

This research work can provide the framework that helps engineers and experts choose the most appropriate materials under the sustainability constraints of Iraqi construction projects. The following are the most important recommendations

- It is important for engineers and managers to familiarize themselves with these forms, Which may help in choosing building materials in choosing the building materials to be used in projects eliminate weaknesses by taking action measures at an early stage in order to obtain a building with a high standard of sustainability

Continue to conduct related research in order to establish a framework for choosing building materials that can be applied to solving material selection issues and in order to give construction professionals who want to improve the sustainability of construction projects a useful resource.

6.4 Suggest Future Studies

The study being conducted now is just an initial step in this direction.

More research is possible to enhance the selection of more sustainable building materials in the future. To increase and enhance green building technologies, this research can be adapted and developed. Results and ratings may also be valuable

Since Fuzzy AHP requires more numerical calculations than the traditional method using ordinary numbers for the purpose of evaluating complex priorities, as the use of fuzzy numbers requires a great deal of effort for the purpose of analyzing many criteria for selecting materials for sustainable construction. It is therefore advised to use MCDM methodologies including “Analytical Network Practical Techniques” (ANP), the “Technique for Order Preference by Similarity to an Ideal Solution” , (TOPSIS) , “Elimination and Choice Expressing Reality”(ELECTRE) , and “Data Envelopment Analysis” (DEA)

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APPENDIX

Appendix -A: Questionnaire Form

1- Questionnaire form in English

Good greeting:

The researcher is preparing a master's thesis in / Engineering management department)

The title of the thesis is (A framework for selecting sustainable materials in Iraqi construction projects).

The research aims to find criteria for selecting sustainable materials in construction projects in Iraq

Based on the theoretical review, there are Objectives and criteria that significantly affect the selection of sustainable materials in construction projects in Iraq. The questionnaire aims to find out the relative importance of Objectives and criteria that affect the success of choosing sustainable materials in construction projects in Iraq.

Through which the importance of the criteria is determined through the numbers shown opposite each of the criteria in this questionnaire, where the criteria of high relative importance are chosen to find their weights. Due to your experience in your field of specialization, you have been chosen to answer this questionnaire, hoping for your cooperation with your observations and answers that would enrich the research and give it scientific strength.

We appreciate that the questionnaire will take a part of your precious time, but without your answers, the desired benefit of the research will not be achieved. In the end, I thank you for your kindness and valuable attention, for the answer.

Part One Specific to identifying information for the honorable respondent

1- Profession……

2- The department you work for……

3- Number of years of professional experience.

4 - Academic certificate ……

5- Specialization……

6- Type of projects that you contributed to the implementation of ……

1- Place of work (Country/city) ……

The second part

The axes below represent the Objectives and criteria that affect the performance of the construction project: It is required to criteria the relative importance of each indicator or factor in the axes and according to your experience..

Note:

- The answer is in digital form and as shown below

The number(1) represents the choice of ..... Very low relative importance

The number (2) represents the choice of ..... Low relative importance

The number (3) represents the choice of …… Medium relative importance

The number (4) represents the choice of ..... of high relative importance

The number (5) represents the choice of ..... very high relative importance

The following are criteria for selecting sustainable materials in construction projects in Iraq. Please indicate the relative importance of each criterion, as you see fit

Objectives - criteria	**Importance**				
Social criteria	1	2	3	4	5
Human health and safety					
Use of local material					
Labor availability					
Aesthetics					
Isolation of noise pollution					
Social benefits and development					

Ease of construction (buildability					
Operational life					
Technical criteria	1	2	3	4	5
Maintainability					
Practicability					
Fire resistance					
Staff expertise					
Chemical resistant					
Time-appropriate handling					
Repair and reconstruction method					
Environmental criteria	1	2	3	4	5
Climate change					
Mount of likely wastage in use of material					
Minimize Pollution and emissions					
Consumption of resource					
Recycling and reuse					
Material impact on air quality (indoor & outdoor)					
Production and transportation activities					
Embodied energy within material					
Land acquisition					
Economic criteria	1	2	3	4	5
Operation and maintenance cost					
Meeting stakeholders needs					
Energy efficiency					
Investment cost					
Societal costs of construction materials					
Financial and economic risks					
Disposal cost					

2- Questionnaire form in Arabic

استمارة الاستبيان

تحية طيبة:

ايها السيدات والسادة الكرام ... يعد الباحث رسالة ماجستير في اختصاص قسم ادارة المشاريع الهندسية . يهدف البحث الى ايجاد معايير لاختيار المواد المستدامة في مشاريع البناء في العراق

عنوان الأطروحة (إطار لاختيار المواد المستدامة في مشاريع البناء العراقية). بناءً على المراجعة النظرية ، هناك أهداف ومعايير تؤثر بشكل كبير على اختيار المواد المستدامة في مشاريع البناء في العراق . يتم من خلالها تحديد أهمية المعايير من خلال الأرقام الموضحة مقابل كل معيار من المعايير في هذا الاستبيان

نظرًا لخبرتك في مجال تخصصك ، فقد تم اختيارك للإجابة على هذا الاستبيان على أمل تعاونك ، مع ملاحظاتك وإجاباتك التي من شأنها إثراء البحث وتعطيه قوة علمية. نحن نقدر أن الاستبيان سيأخذ جزءًا من وقتك ، ولكن بدون إجاباتك ، لن تتحقق الفائدة المرجوة من البحث. في النهاية ، أشكركم على لطفكم واهتمامكم القيم على الإجابة.

الجزء الأول

الخاص بتحديد المعلومات الخاصة بالمستجيب المحترم

1- المهنة .....

2- القسم الذي تعمل به .....

3- عدد سنوات الخبرة المهنية.....

4- الشهادة الأكاديمية .....

5- التخصص .....

6- نوع المشاريع التي ساهمت بها في تنفيذ .....

7- مكان العمل (المدينة) .....

الجزء الثاني

تمثل المحاور أدناه العوامل والمؤشرات التي تؤثر على أداء مشروع البناء: مطلوب الإشارة إلى الأهمية النسبية لكل معيار في المحاور ووفقًا لتجربتك .. مع مراعاة أن المعايير محددة وقابلة للقياس.

ملحوظة:

- الجواب في شكل رقمي وكما هو مبين أدناه

يمثل الرقم (1) اختيار ..... أهمية نسبية منخفضة جدًا

يمثل الرقم (2) اختيار ..... أهمية نسبية منخفضة

يمثل الرقم (3) اختيار ..... الأهمية النسبية المتوسطة

يمثل الرقم (4) اختيار ..... ذو الأهمية النسبية العالية

يمثل الرقم (5) اختيار ..... أهمية عالية جدا نسبي

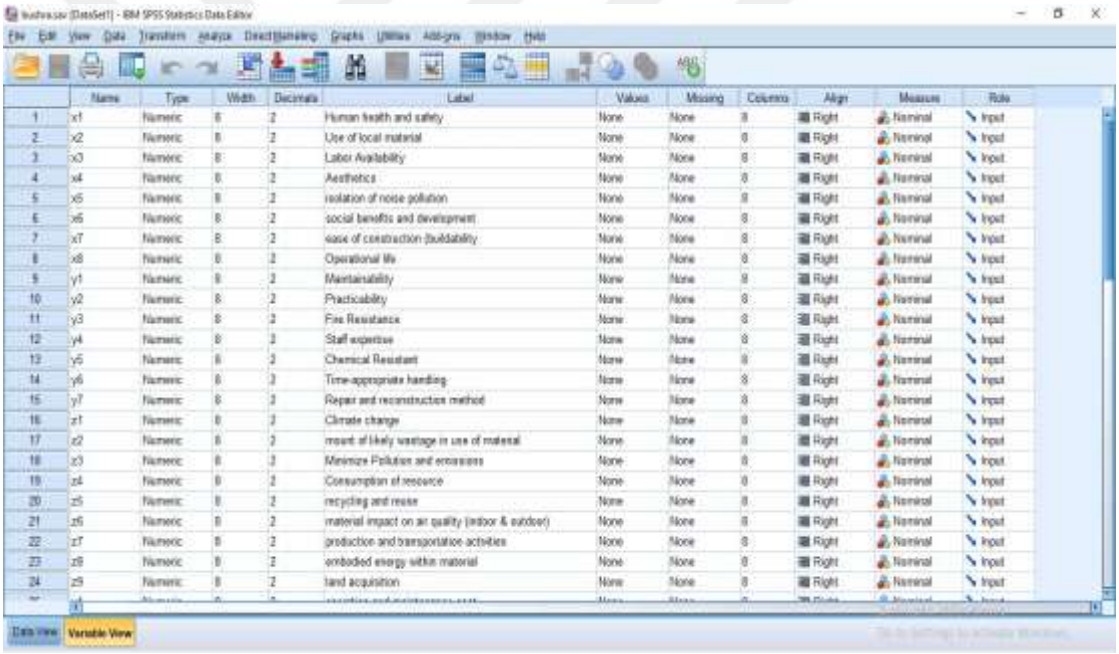
فيما يلي معايير لاختيار المواد المستدامة في مشاريع البناء في العراق يرجى تأشير الأهمية النسبية لكل معيار وحسب ما ترونه مناسبا

أهمية					الأهداف ـ المعايير
5 أهمية عالية جدا نسبيًا	4 الأهمية النسبية العالية	3 الأهمية النسبية المتوسطة	2 أهمية نسبية منخفضة	1 أهمية نسبية منخفضة جدًا	**المعايير الاجتماعية**
					صحة الإنسان وسلامته
					استخدام المواد المحلية
					توفر العمالة
					جماليات
					عزل التلوث الضوضائي
					الفوائد الاجتماعية والتنمية
					سهولة البناء (قابلية البناء(
					الحياة التشغيلية
5	4	3	2	1	**المعايير الفنية**
					قابلية الصيانة
					العملي
					مقاوم النار
					خبرة الموظفين
					مقاومة كيميائية
					التعامل مع الوقت المناسب
					طريقة الإصلاح وإعادة البناء
5	4	3	2	1	**المعايير البيئية**
					تغير المناخ
					الهدر المحتمل في استخدام المواد
					تقليل التلوث والانبعاثات
					استهلاك الموارد
					إعادة التدوير وإعادة الاستخدام
					التأثير المادي على جودة الهواء (داخليًا وخارجيًا)
					أنشطة الإنتاج والنقل
					الطاقة المتجسدة داخل المادة

حيازة الأرض					
المعايير الاقتصادية	1	2	3	4	5
تكلفة التشغيل والصيانة					
تلبية احتياجات أصحاب المصلحة					
كفاءة الطاقة					
ثمن الاستثمار					
التكاليف المجتمعية لمواد البناء					
المخاطر المالية والاقتصادية					
تكلفة التخلص					

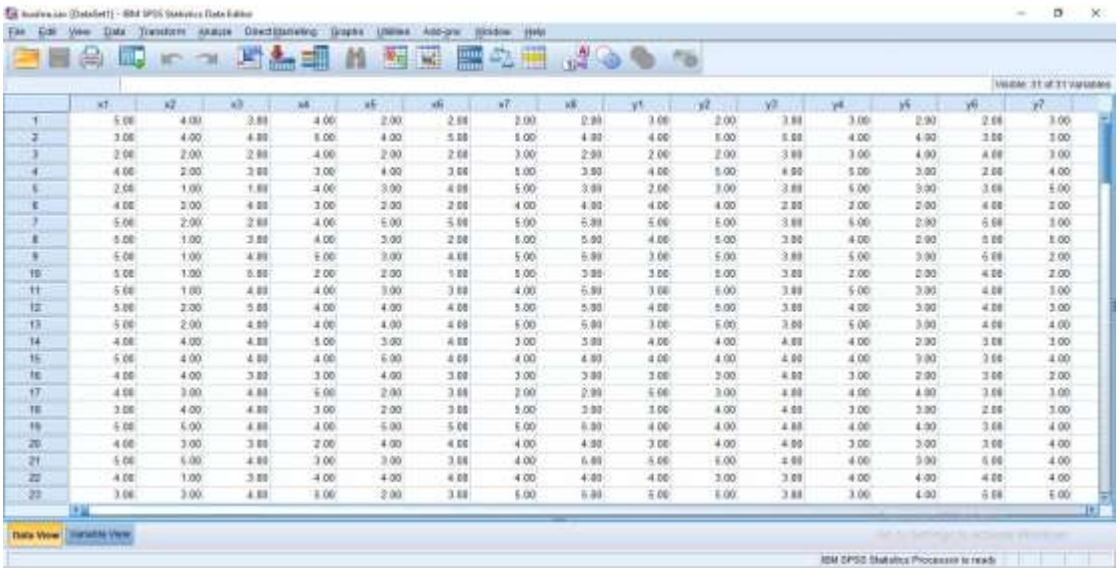
1- Data entry into the SPSS26 program

The figure below represents the coding of the variables included in the analysis, in addition to giving a name to each coding of the first study questionnaire related to the answers of the study sample.



	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure	Role
1	x1	Numeric	8	2	Human health and safety	None	None	8	Right	Nominal	Input
2	x2	Numeric	8	2	Use of local material	None	None	8	Right	Nominal	Input
3	x3	Numeric	8	2	Labor Availability	None	None	8	Right	Nominal	Input
4	x4	Numeric	8	2	Aesthetics	None	None	8	Right	Nominal	Input
5	x5	Numeric	8	2	isolation of noise pollution	None	None	8	Right	Nominal	Input
6	x6	Numeric	8	2	social benefits and development	None	None	8	Right	Nominal	Input
7	x7	Numeric	8	2	ease of construction (buildability	None	None	8	Right	Nominal	Input
8	x8	Numeric	8	2	Operational life	None	None	8	Right	Nominal	Input
9	y1	Numeric	8	2	Maintainability	None	None	8	Right	Nominal	Input
10	y2	Numeric	8	2	Practicability	None	None	8	Right	Nominal	Input
11	y3	Numeric	8	2	Fire Resistance	None	None	8	Right	Nominal	Input
12	y4	Numeric	8	2	Staff expertise	None	None	8	Right	Nominal	Input
13	y5	Numeric	8	2	Chemical Resistant	None	None	8	Right	Nominal	Input
14	y6	Numeric	8	2	Time-appropriate handling	None	None	8	Right	Nominal	Input
15	y7	Numeric	8	2	Repair and reconstruction method	None	None	8	Right	Nominal	Input
16	z1	Numeric	8	2	Climate change	None	None	8	Right	Nominal	Input
17	z2	Numeric	8	2	mount of likely wastage in use of material	None	None	8	Right	Nominal	Input
18	z3	Numeric	8	2	Minimize Pollution and emissions	None	None	8	Right	Nominal	Input
19	z4	Numeric	8	2	Consumption of resource	None	None	8	Right	Nominal	Input
20	z5	Numeric	8	2	recycling and reuse	None	None	8	Right	Nominal	Input
21	z6	Numeric	8	2	material impact on air quality (indoor & outdoor)	None	None	8	Right	Nominal	Input
22	z7	Numeric	8	2	production and transportation activities	None	None	8	Right	Nominal	Input
23	z8	Numeric	8	2	embodied energy within material	None	None	8	Right	Nominal	Input
24	z9	Numeric	8	2	land acquisition	None	None	8	Right	Nominal	Input

The figure above represents the entry of data for SPSS26, where we note that the data has been coded from 1 to 5 in order of importance.



Appendix –B: Questionnaire Form (Case Study)

Questionnaire for (case study)

Good greeting:

The researcher is preparing a master's thesis in the Engineering Management Department. The title of the thesis is (A framework for selecting sustainable materials in Iraq)

The research aims to find criteria for selecting sustainable materials in construction projects in Iraq. In this questionnaire, this framework will be applied to selecting types of bricks in Iraq according to the sustainable criteria used in this research. Where three types of bricks used in Iraq will be selected. This framework will be applied to them in order to choose the most sustainable types.

Where based on the theoretical review, there are goals and criteria that greatly affect the selection of sustainable materials in construction projects in Iraq. The questionnaire aims to know the relative importance of the objectives and criteria that affect the success of the selection of materials. Sustainable types of (bricks) will be selected in construction projects in Iraq.

Through which the importance of the criteria is determined through the numbers shown against each of the criteria in this questionnaire, as the criteria with high relative importance are chosen to find their weights. Due to your experience in your field of specialization, you have been chosen to answer this questionnaire, hoping for your cooperation with us as your answer would enrich the research and give it scientific strength ... With thanks.

Part One Specific to identifying information for the honorable respondent

1- Profession……

2- The department you work for……

3- Number of years of professional experience.

4 - Academic certificate ……

5- Specialization……

6- Type of projects that you contributed to the implementation of ……

7- Place of work (Country/city) ……

The second part

The axes below represent the objectives and criteria that affect the selection of building materials (bricks): Criteria for the relative importance of each indicator or factor in the axes are required, according to your experience..

Note:

The answer is in digital form and as shown below

The number(1) represents the choice of ..... Very low relative importance

The number (2) represents the choice of ..... Low relative importance

The number (3) represents the choice of …… Medium relative importance

The number (4) represents the choice of ..... of high relative importance

The number (5) represents the choice of ..... very high relative importance

Three types of bricks used in Iraq have been selected. The most sustainable types will be chosen according to importance. Please indicate the relative importance of each criterion, as you see fit

1- Perforated yellow bricks

Objectives - criteria	**Importance**				
Social criteria	1	2	3	4	5
Human health and safety					
Use of local material					
Labor Availability					
Aesthetics					
isolation of noise pollution					
social benefits and development					
ease of construction (buildability					
Operational life					
Technical criteria	1	2	3	4	5
Maintainability					
Practicability					
Fire Resistance					
Staff expertise					
Chemical Resistant					
Time-appropriate handling					
Repair and reconstruction method					

Environmental criteria	1	2	3	4	5
Climate change					
mount of likely wastage in use of material					
Minimize Pollution and emissions					
Consumption of resource					
recycling and reuse					
material impact on air quality (indoor & outdoor)					
production and transportation activities					
embodied energy within material					
land acquisition					
Economic criteria	1	2	3	4	5
operation and maintenance cost					
meeting stakeholders needs					
energy efficiency					
investment cost					
societal costs of construction materials					
financial and economic risks					
Disposal cost					

2- red bricks

Objectives - criteria	Importance				
Social criteria	1	2	3	4	5
Human health and safety					
Use of local material					
Labor Availability					
Aesthetics					
isolation of noise pollution					
social benefits and development					
ease of construction (buildability					
Operational life					
Technical criteria	1	2	3	4	5
Maintainability					
Practicability					
Fire Resistance					
Staff expertise					
Chemical Resistant					
Time-appropriate handling					

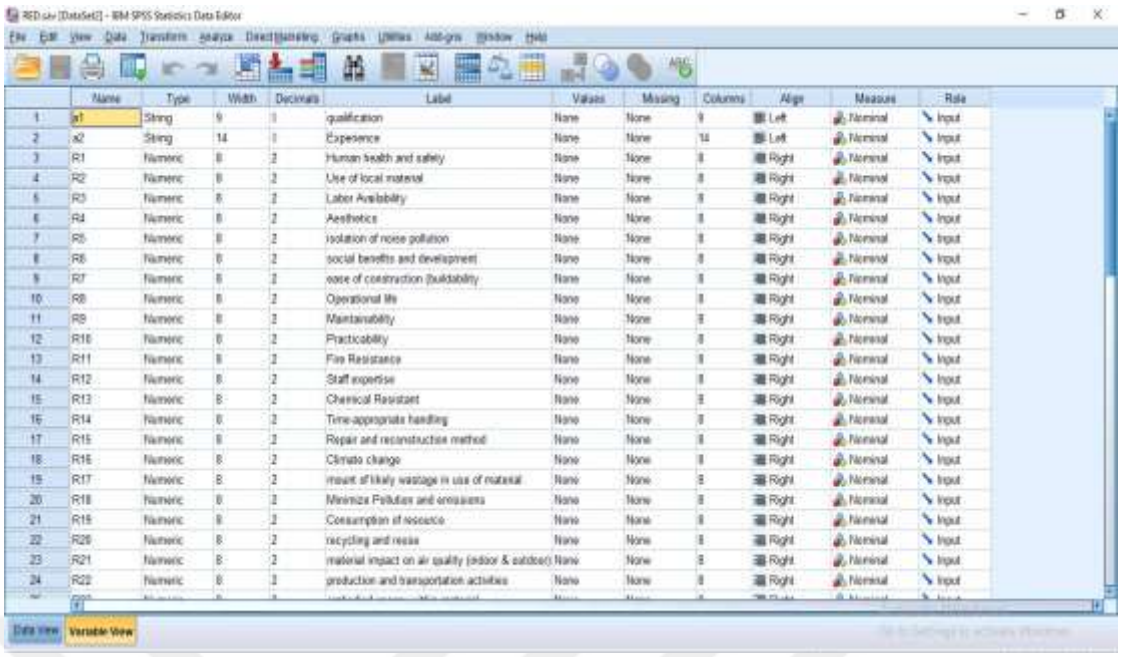
Repair and reconstruction method					
Environmental criteria	1	2	3	4	5
Climate change					
mount of likely wastage in use of material					
Minimize Pollution and emissions					
Consumption of resource					
recycling and reuse					
material impact on air quality (indoor & outdoor)					
production and transportation activities					
embodied energy within material					
land acquisition					
Economic criteria	1	2	3	4	5
operation and maintenance cost					
meeting stakeholders needs					
energy efficiency					
investment cost					
societal costs of construction materials					
financial and economic risks					
Disposal cost					

3- Solid yellow brick

Objectives - criteria	**Importance**				
Social criteria	1	2	3	4	5
Human health and safety					
Use of local material					
Labor Availability					
Aesthetics					
isolation of noise pollution					
social benefits and development					
ease of construction (buildability					
Operational life					
Technical criteria	1	2	3	4	5
Maintainability					
Practicability					
Fire Resistance					
Staff expertise					

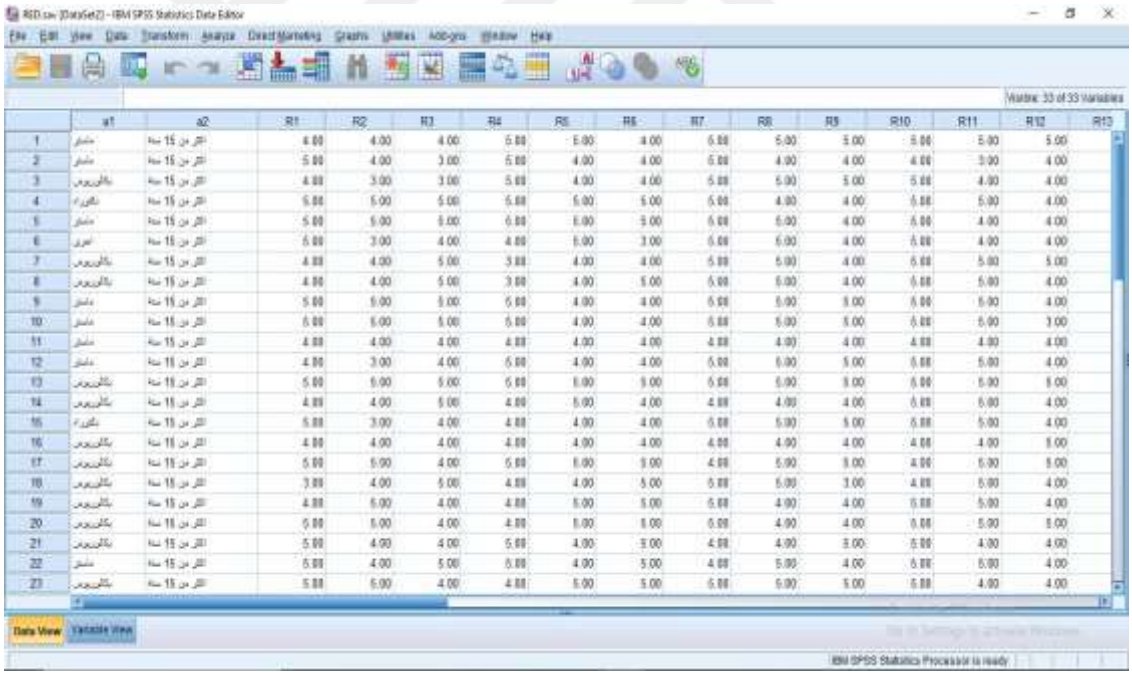
Chemical Resistant					
Time-appropriate handling					
Repair and reconstruction method					
Environmental criteria	1	2	3	4	5
Climate change					
mount of likely wastage in use of material					
Minimize Pollution and emissions					
Consumption of resource					
recycling and reuse					
material impact on air quality (indoor & outdoor)					
production and transportation activities					
embodied energy within material					
land acquisition					
Economic criteria	1	2	3	4	5
operation and maintenance cost					
meeting stakeholders needs					
energy efficiency					
investment cost					
societal costs of construction materials					
financial and economic risks					
Disposal cost					

1- The figure below represents the coding of the variables included in the analysis, in addition to giving a name to each coding of the case study questionnaire related to the answers of the study sample of experts on the red bricks.

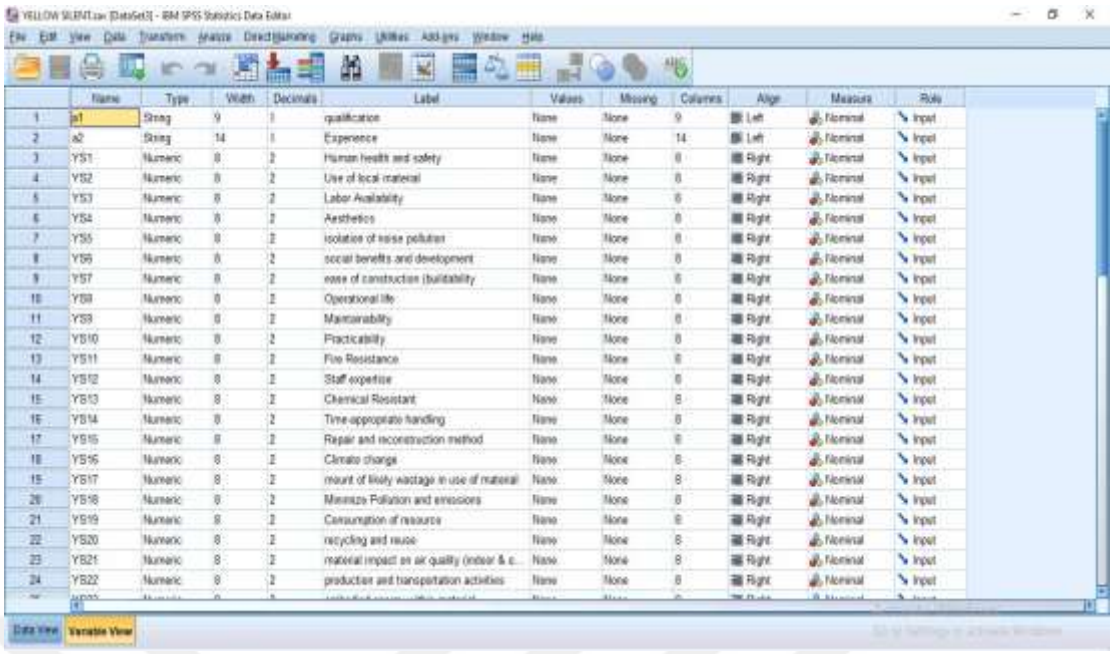


	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure	Role
1	a1	String	9	1	qualification	None	None	9	Left	Nominal	Input
2	a2	String	14	1	Expesence	None	None	14	Left	Nominal	Input
3	R1	Numeric	8	2	Human health and safety	None	None	8	Right	Nominal	Input
4	R2	Numeric	8	2	Use of local material	None	None	8	Right	Nominal	Input
5	R3	Numeric	8	2	Labor Availability	None	None	8	Right	Nominal	Input
6	R4	Numeric	8	2	Aesthetics	None	None	8	Right	Nominal	Input
7	R5	Numeric	8	2	isolation of noise pollution	None	None	8	Right	Nominal	Input
8	R6	Numeric	8	2	social benefits and development	None	None	8	Right	Nominal	Input
9	R7	Numeric	8	2	ease of construction (buildability	None	None	8	Right	Nominal	Input
10	R8	Numeric	8	2	Operational life	None	None	8	Right	Nominal	Input
11	R9	Numeric	8	2	Maintainability	None	None	8	Right	Nominal	Input
12	R10	Numeric	8	2	Practicability	None	None	8	Right	Nominal	Input
13	R11	Numeric	8	2	Fire Resistance	None	None	8	Right	Nominal	Input
14	R12	Numeric	8	2	Staff expertise	None	None	8	Right	Nominal	Input
15	R13	Numeric	8	2	Chemical Resistant	None	None	8	Right	Nominal	Input
16	R14	Numeric	8	2	Time-appropriate handling	None	None	8	Right	Nominal	Input
17	R15	Numeric	8	2	Repair and reconstruction method	None	None	8	Right	Nominal	Input
18	R16	Numeric	8	2	Climate change	None	None	8	Right	Nominal	Input
19	R17	Numeric	8	2	mount of likely wastage in use of material	None	None	8	Right	Nominal	Input
20	R18	Numeric	8	2	Minimize Pollution and emissions	None	None	8	Right	Nominal	Input
21	R19	Numeric	8	2	Consumption of resource	None	None	8	Right	Nominal	Input
22	R20	Numeric	8	2	recycling and reuse	None	None	8	Right	Nominal	Input
23	R21	Numeric	8	2	material impact on air quality (indoor & outdoor)	None	None	8	Right	Nominal	Input
24	R22	Numeric	8	2	production and transportation activities	None	None	8	Right	Nominal	Input

2- The above figure represents the entry of data for SPSS26 program, where we note that the data has been coded from 1 to 5 according to importance



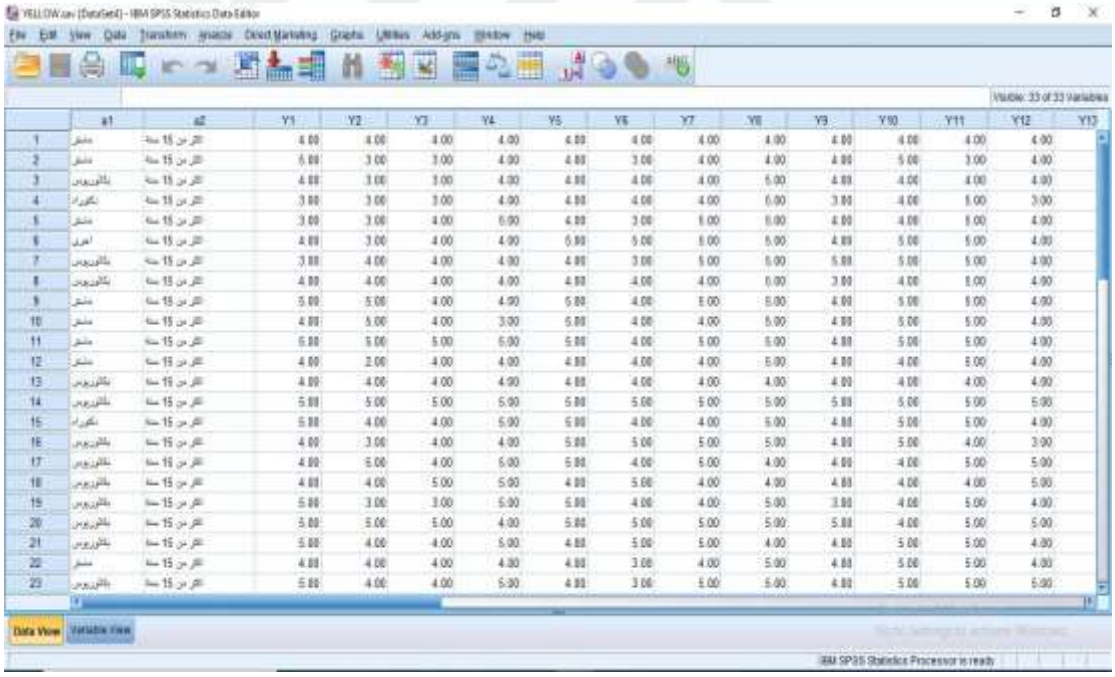
3- The figure below represents the coding of the variables included in the analysis, in addition to giving a name to each coding of the case study questionnaire related to the answers of the study sample of experts on the yellow bricks



	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure	Role
1	a1	String	9	1	qualification	None	None	9	Left	Nominal	Input
2	a2	String	14	1	Experience	None	None	14	Left	Nominal	Input
3	YS1	Numeric	8	2	Human health and safety	None	None	8	Right	Nominal	Input
4	YS2	Numeric	8	2	Use of local material	None	None	8	Right	Nominal	Input
5	YS3	Numeric	8	2	Labor Availability	None	None	8	Right	Nominal	Input
6	YS4	Numeric	8	2	Aesthetics	None	None	8	Right	Nominal	Input
7	YS5	Numeric	8	2	isolation of noise pollution	None	None	8	Right	Nominal	Input
8	YS6	Numeric	8	2	social benefits and development	None	None	8	Right	Nominal	Input
9	YS7	Numeric	8	2	ease of construction (buildability	None	None	8	Right	Nominal	Input
10	YS8	Numeric	8	2	Operational life	None	None	8	Right	Nominal	Input
11	YS9	Numeric	8	2	Maintainability	None	None	8	Right	Nominal	Input
12	YS10	Numeric	8	2	Practicability	None	None	8	Right	Nominal	Input
13	YS11	Numeric	8	2	Fire Resistance	None	None	8	Right	Nominal	Input
14	YS12	Numeric	8	2	Staff expertise	None	None	8	Right	Nominal	Input
15	YS13	Numeric	8	2	Chemical Resistant	None	None	8	Right	Nominal	Input
16	YS14	Numeric	8	2	Time-appropriate handling	None	None	8	Right	Nominal	Input
17	YS15	Numeric	8	2	Repair and reconstruction method	None	None	8	Right	Nominal	Input
18	YS16	Numeric	8	2	Climate change	None	None	8	Right	Nominal	Input
19	YS17	Numeric	8	2	mount of likely wastage in use of material	None	None	8	Right	Nominal	Input
20	YS18	Numeric	8	2	Minimize Pollution and emissions	None	None	8	Right	Nominal	Input
21	YS19	Numeric	8	2	Consumption of resource	None	None	8	Right	Nominal	Input
22	YS20	Numeric	8	2	recycling and reuse	None	None	8	Right	Nominal	Input
23	YS21	Numeric	8	2	material impact on air quality (indoor & c...	None	None	8	Right	Nominal	Input
24	YS22	Numeric	8	2	production and transportation activities	None	None	8	Right	Nominal	Input

Data View | Variable View

4- The figure below represents the entry of data for SPSS26 program, where we note that the data has been coded from 1 to 5 in order of importance.

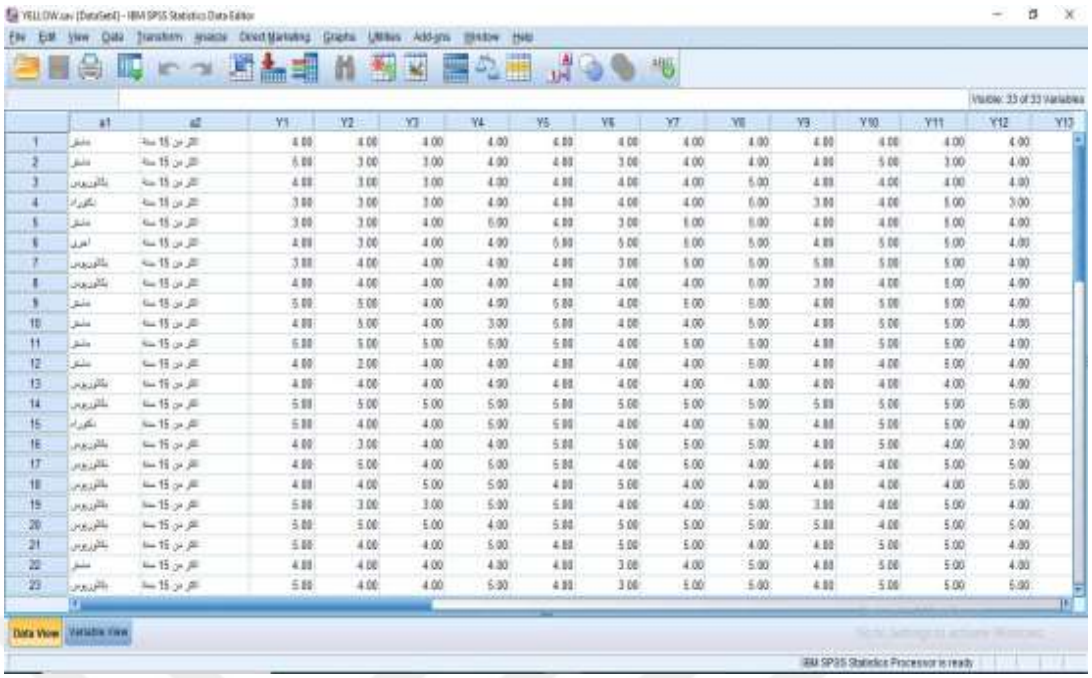


	a1	a2	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13
1	متزوج	اكثر من 15 سنة	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	
2	متزوج	اكثر من 15 سنة	5.00	3.00	3.00	4.00	4.00	3.00	4.00	4.00	4.00	5.00	3.00	4.00	
3	بكالوريوس	اكثر من 15 سنة	4.00	3.00	3.00	4.00	4.00	4.00	4.00	5.00	4.00	4.00	4.00	4.00	
4	دكتوراه	اكثر من 15 سنة	3.00	3.00	3.00	4.00	4.00	4.00	4.00	5.00	3.00	4.00	5.00	3.00	
5	متزوج	اكثر من 15 سنة	3.00	3.00	4.00	5.00	4.00	3.00	5.00	5.00	4.00	4.00	5.00	4.00	
6	اعزب	اكثر من 15 سنة	4.00	3.00	4.00	4.00	5.00	5.00	5.00	5.00	4.00	5.00	5.00	4.00	
7	بكالوريوس	اكثر من 15 سنة	3.00	4.00	4.00	4.00	4.00	3.00	5.00	5.00	5.00	5.00	5.00	4.00	
8	بكالوريوس	اكثر من 15 سنة	4.00	4.00	4.00	4.00	4.00	4.00	4.00	5.00	3.00	4.00	5.00	4.00	
9	متزوج	اكثر من 15 سنة	5.00	5.00	4.00	4.00	5.00	4.00	5.00	5.00	4.00	5.00	5.00	4.00	
10	متزوج	اكثر من 15 سنة	4.00	5.00	4.00	3.00	5.00	4.00	4.00	5.00	4.00	5.00	5.00	4.00	
11	متزوج	اكثر من 15 سنة	5.00	5.00	5.00	5.00	5.00	4.00	5.00	5.00	4.00	5.00	5.00	4.00	
12	متزوج	اكثر من 15 سنة	4.00	2.00	4.00	4.00	4.00	4.00	4.00	5.00	4.00	4.00	5.00	4.00	
13	بكالوريوس	اكثر من 15 سنة	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	
14	بكالوريوس	اكثر من 15 سنة	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	
15	دكتوراه	اكثر من 15 سنة	5.00	4.00	4.00	5.00	5.00	4.00	4.00	5.00	4.00	5.00	5.00	4.00	
16	بكالوريوس	اكثر من 15 سنة	4.00	3.00	4.00	4.00	5.00	5.00	5.00	5.00	4.00	5.00	4.00	3.00	
17	بكالوريوس	اكثر من 15 سنة	4.00	5.00	4.00	5.00	5.00	4.00	5.00	4.00	4.00	4.00	5.00	5.00	
18	بكالوريوس	اكثر من 15 سنة	4.00	4.00	5.00	5.00	4.00	5.00	4.00	4.00	4.00	4.00	4.00	5.00	
19	بكالوريوس	اكثر من 15 سنة	5.00	3.00	3.00	5.00	5.00	4.00	4.00	5.00	3.00	4.00	5.00	4.00	
20	بكالوريوس	اكثر من 15 سنة	5.00	5.00	5.00	4.00	5.00	5.00	5.00	5.00	5.00	4.00	5.00	5.00	
21	بكالوريوس	اكثر من 15 سنة	5.00	4.00	4.00	5.00	4.00	5.00	5.00	4.00	4.00	5.00	5.00	4.00	
22	متزوج	اكثر من 15 سنة	4.00	4.00	4.00	4.00	4.00	3.00	4.00	5.00	4.00	5.00	5.00	4.00	
23	بكالوريوس	اكثر من 15 سنة	5.00	4.00	4.00	5.00	4.00	3.00	5.00	5.00	4.00	5.00	5.00	5.00	

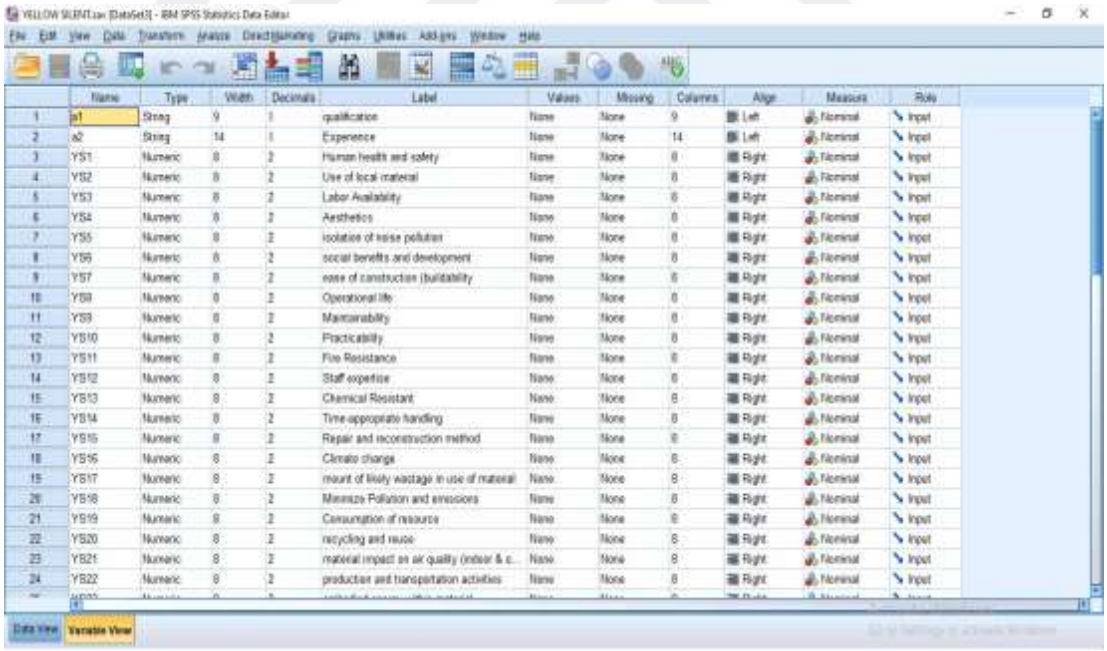
Data View | Variable View

IBM SPSS Statistics Processor is ready

5- The figure below represents the entry of data for SPSS26, where we note that the data has been coded from 1 to 5 in order of importance.

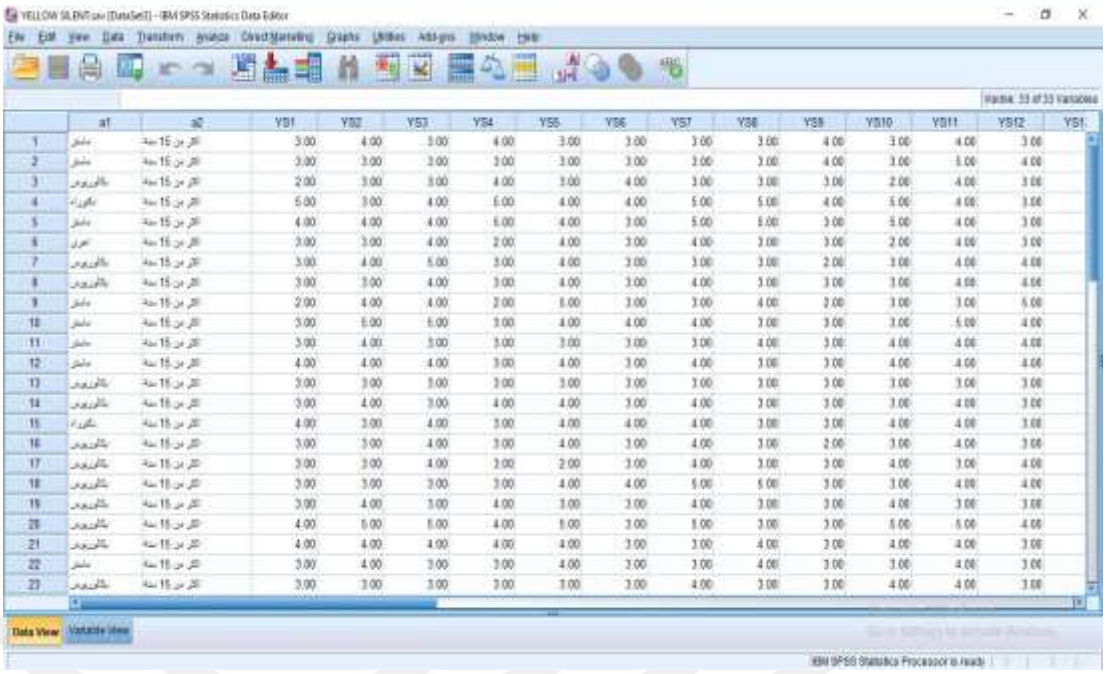


6- The above figure represents the coding of the variables included in the analysis, in addition to giving a name to each coding for the case study questionnaire related to the answers of the study sample from the experts on the solid yellow bricks



	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure	Role
1	a1	String	9	1	qualification	None	None	9	Left	Nominal	Input
2	a2	String	14	1	Experience	None	None	14	Left	Nominal	Input
3	YS1	Numeric	8	2	Human health and safety	None	None	8	Right	Nominal	Input
4	YS2	Numeric	8	2	Use of local material	None	None	8	Right	Nominal	Input
5	YS3	Numeric	8	2	Labor Availability	None	None	8	Right	Nominal	Input
6	YS4	Numeric	8	2	Aesthetics	None	None	8	Right	Nominal	Input
7	YS5	Numeric	8	2	isolation of noise pollution	None	None	8	Right	Nominal	Input
8	YS6	Numeric	8	2	social benefits and development	None	None	8	Right	Nominal	Input
9	YS7	Numeric	8	2	ease of construction (buildability	None	None	8	Right	Nominal	Input
10	YS8	Numeric	8	2	Operational life	None	None	8	Right	Nominal	Input
11	YS9	Numeric	8	2	Maintainability	None	None	8	Right	Nominal	Input
12	YS10	Numeric	8	2	Practicability	None	None	8	Right	Nominal	Input
13	YS11	Numeric	8	2	Fire Resistance	None	None	8	Right	Nominal	Input
14	YS12	Numeric	8	2	Staff expertise	None	None	8	Right	Nominal	Input
15	YS13	Numeric	8	2	Chemical Resistant	None	None	8	Right	Nominal	Input
16	YS14	Numeric	8	2	Time-appropriate handling	None	None	8	Right	Nominal	Input
17	YS15	Numeric	8	2	Repair and reconstruction method	None	None	8	Right	Nominal	Input
18	YS16	Numeric	8	2	Climate change	None	None	8	Right	Nominal	Input
19	YS17	Numeric	8	2	mount of likely wastage in use of material	None	None	8	Right	Nominal	Input
20	YS18	Numeric	8	2	Minimize Pollution and emissions	None	None	8	Right	Nominal	Input
21	YS19	Numeric	8	2	Consumption of resource	None	None	8	Right	Nominal	Input
22	YS20	Numeric	8	2	recycling and reuse	None	None	8	Right	Nominal	Input
23	YS21	Numeric	8	2	material impact on air quality (indoor & c...	None	None	8	Right	Nominal	Input
24	YS22	Numeric	8	2	production and transportation activities	None	None	8	Right	Nominal	Input

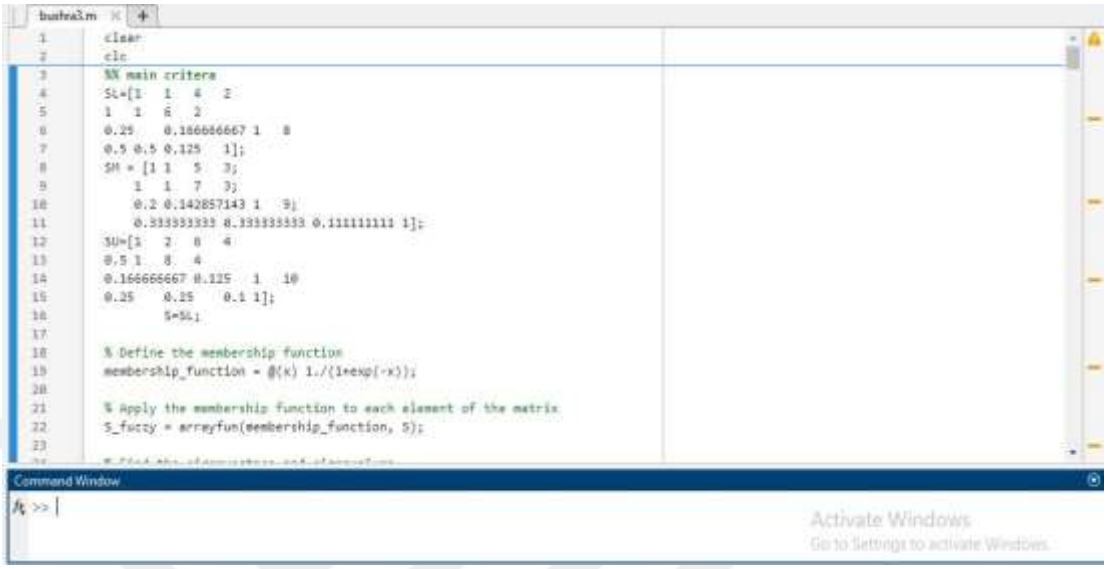
The figure above represents the entry of data for the SPSS26 program, where we note that the data has been coded from 1 to 5 according to importance



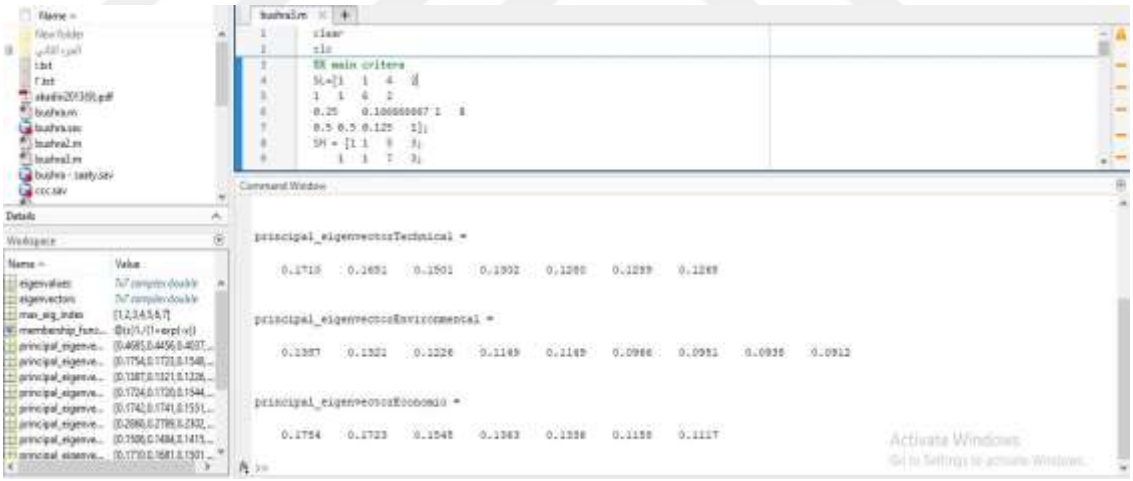
	a1	a2	YS1	YS2	YS3	YS4	YS5	YS6	YS7	YS8	YS9	YS10	YS11	YS12	YS1
1			3.00	4.00	3.00	4.00	3.00	3.00	3.00	3.00	4.00	3.00	4.00	3.00	
2			3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	4.00	3.00	5.00	4.00	
3			2.00	3.00	3.00	4.00	3.00	4.00	3.00	3.00	3.00	2.00	4.00	3.00	
4			5.00	3.00	4.00	5.00	4.00	4.00	5.00	5.00	4.00	5.00	4.00	3.00	
5			4.00	4.00	4.00	5.00	4.00	3.00	5.00	5.00	3.00	5.00	4.00	3.00	
6			3.00	3.00	4.00	2.00	4.00	3.00	4.00	3.00	3.00	2.00	4.00	3.00	
7			3.00	4.00	5.00	3.00	4.00	3.00	3.00	3.00	2.00	3.00	4.00	4.00	
8			3.00	3.00	4.00	3.00	4.00	3.00	4.00	3.00	3.00	3.00	4.00	4.00	
9			2.00	4.00	4.00	2.00	5.00	3.00	3.00	4.00	2.00	3.00	3.00	5.00	
10			3.00	5.00	5.00	3.00	4.00	4.00	4.00	3.00	3.00	3.00	5.00	4.00	
11			3.00	4.00	3.00	3.00	3.00	3.00	3.00	4.00	3.00	4.00	4.00	4.00	
12			4.00	4.00	4.00	3.00	4.00	3.00	4.00	3.00	3.00	4.00	4.00	4.00	
13			3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	
14			3.00	4.00	3.00	4.00	4.00	3.00	4.00	3.00	3.00	3.00	4.00	3.00	
15			4.00	3.00	4.00	3.00	4.00	4.00	4.00	3.00	3.00	4.00	4.00	3.00	
16			3.00	3.00	4.00	3.00	4.00	3.00	4.00	3.00	2.00	3.00	4.00	3.00	
17			3.00	3.00	4.00	3.00	2.00	3.00	4.00	3.00	3.00	4.00	3.00	4.00	
18			3.00	3.00	3.00	3.00	4.00	4.00	5.00	5.00	3.00	3.00	4.00	4.00	
19			3.00	4.00	3.00	4.00	3.00	3.00	4.00	3.00	3.00	4.00	3.00	3.00	
20			4.00	5.00	5.00	4.00	5.00	3.00	5.00	3.00	3.00	5.00	5.00	4.00	
21			4.00	4.00	4.00	4.00	4.00	3.00	3.00	4.00	3.00	4.00	4.00	3.00	
22			3.00	4.00	3.00	3.00	4.00	3.00	3.00	4.00	3.00	3.00	4.00	3.00	
23			3.00	3.00	3.00	3.00	3.00	3.00	4.00	3.00	3.00	4.00	4.00	3.00	

Appendix –C

1- The below figure represents data entry in Matlab2022 for Fuzzy AHP calculation



2- The below figure represents the output of the Matlab2022 program



RESUME

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