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The Prioritization of Sustainability Features of Buildings from the Viewpoint of Experts

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Abstract: The reduction of environmental impact in buildings and the enhancement of environmental performance in the built environment are the key objectives of sustainable development. To achieve this, the adoption of green buildings requires a comprehensive construction approach that focuses on delivering environmentally friendly solutions throughout the entire construction process. This research aims to bridge the gap between theoretical concepts and the practical realities of construction in Iran. It proposes essential criteria and assigns weights to them for creating green buildings based on the opinions of experts from different backgrounds. To understand how buildings are influenced by the environment, society and economics, relevant factors were identified using library research. Web-based surveys involving experts, including architects, engineers, and environmental specialists, were conducted to gather insights into these criteria. A total of 14 criteria were accepted and categorized into economic, environmental, and social dimensions. The Analytic Network Process (ANP) methodology was employed to assess the opinions of 45 expert participants, as provided in the questionnaire. The findings indicate that, among sustainability features, the environmental factor holds the highest significance in Iran, while the social factor is considered the least important. Looking at the sub-criteria, reducing water consumption, financial incentives, and achieving energy efficiency at a reasonable cost are given the highest priority within the environmental, economic, and social aspects of green buildings.

Keywords: green construction; Analytic Network Process (ANP); sustainable development; multi-criteria decision-making (MCDM)

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1. Introduction

In an effort to reduce the impacts of global warming, the Paris Agreement proposed that the global average temperature increase in this century should be limited to 2 °C, or even 1.5 °C [1]. The United Nations Intergovernmental Panel on Climate Change (IPCC) further stipulated that the world must achieve zero net emissions of carbon dioxide in 2050 [2], i.e., achieve carbon neutrality to reach the aforementioned goals [1]. The building sector is a major contributor to energy consumption, accounting for approximately 39% of global carbon dioxide (CO_2) emissions [2]. Buildings stand out as prominent consumers of energy and materials [3,4]. When taking into account the entire life cycle of buildings, encompassing the production, transportation, and construction of building materials, the construction industry is responsible for almost half of carbon dioxide emissions [5]. In addition, 99.5% of direct energy use in the global construction sector is fossil fuel [6]. In total, the global construction sector creates 315 million tons of direct CO_2 emissions, representing 5.5% of the total CO_2 emissions of this sector [6]. The construction sector in emerging economies, particularly in the Asia-Pacific region, contributes significantly, nearly 60%, to the cumulative global carbon dioxide emissions [1].

While buildings are responsible for generating approximately 40% of global greenhouse gas emissions (GHGs) [7], there is a compelling argument that they could potentially represent one of the most economically efficient solutions for addressing climate

change [8,9]. In addition, the construction industry's activities are closely related to the realization of the Sustainable Development Goals [10,11]. The most important SDGs related to green buildings are affordable and clean energy, climate action, and responsible consumption and production.

The construction and building sector have been identified as a significant contributor to the environmental repercussions associated with human activities [12]. Reduced waste disposal and health costs, and increased indoor air quality, employee satisfaction, and work efficiency, as well as energy and water savings, are some of the advantages of green buildings [13]. If green buildings were built, the worldwide carbon footprint could drop by 15–20% every year [14]. Green buildings and sustainable construction activities are effective in reducing GHGs [15]. Environmental sustainability is generally associated with reduced GHGs, reduced waste production, reduced pollution, and energy efficiency [16]. Furthermore, negative impacts on the environment, as well as on the social and economic aspects of buildings, are minimized throughout the life cycle of sustainable construction [17].

In 2020, energy consumption in the building sector comprised 42% of the EU's overall energy usage, contributing to 35% of energy-related greenhouse gas emissions and a noteworthy proportion of emissions related to air pollutants [18]. Approximately 66% of the 885 representative European cities have implemented climate mitigation plans, and 26% have embraced adaptation strategies [19]. A case study in Ningbo (China) demonstrated that stringent policies and strategic interventions could potentially reduce energy demands by 14% and curb CO_2 emissions by 27% [20]. Similarly, Vantaa city (Finland) executed a noteworthy measure by eliminating CO_2 emissions from heat production, thereby contributing to a substantial 30% reduction in overall carbon emissions [20]. Green building (GB) is one of the measures put forward to mitigate the significant impacts of the building stock on the environment, society, and the economy [21]. GBs have also been recognized as an effective strategy for reducing greenhouse gas emissions and energy consumption [22].

In 2014, the European Commission (EC) took a significant step with the issuance of the Communication on Resource Efficiency opportunities in the building sector. This pivotal document emphasized the necessity for a unified European strategy aimed at elevating the environmental sustainability of buildings across their entire life cycle [23]. This initiative was a proactive response from policymakers aiming to effectively organize the complex landscape of global Green Building Rating Systems (GBRS), with a specific focus on the EU context.

The concept of GBs is a recent response to addressing the problems that stem from the building sector [24]. The World Green Building Council (WGBC) defines a green building as "a building that reduces or eliminates negative impacts, in its design, construction or operation and can have positive impacts on the climate and natural environment". Green buildings use environmentally friendly materials and ensure the optimal use of natural resources, such as water and energy, and minimum waste production [25]. Researchers have analyzed various aspects of GBs, such as technological innovation [26], energy savings [27], risk management [28], influencing factors for development [29], policy incentives and regulations [30], and economic benefits [31].

Iran, a country rich in oil and natural gas reserves, presents a significant challenge that is prominent in today's world. According to statistical data, fossil energy resources constitute the primary source for meeting over 98% of the country's energy demand [32]. Even though Iran has abundant energy resources, such as oil and gas, which are important worldwide, only a small amount of the energy consumed comes from renewable and sustainable sources, which is less than 1% [33,34]. Also, Iran had legislation in place obliging the Minister of Energy to increase the share of renewables and clean power plants to at least 5% of the country's capacity until the end of 2021 [35]. This issue is also evident in how Iran ranks on the Environmental Sustainability Index (ESI), which shows that the country has high CO_2 emissions. The same situation can be seen in the construction industry in Iran, where the use of energy and GHG emissions are much higher than the global average [36]. As Iran works toward creating a cleaner environment through green

building practices, it is important for the country to promote activities that lead to change and to follow well-defined guidelines. This will help Iran moves toward a common goal through the process of adopting GB practices. The principles of GB play an important role in understanding and achieving sustainability in the country's development strategies, making it urgent for Iran to focus on advancing green building initiatives.

This study aims to bridge the gap between theoretical concepts and practical construction practices within Iran. The main goal is to understand how experts with diverse backgrounds value the various environmental aspects of green buildings. To achieve this, the research explores the important factors that contribute to creating green buildings from economic, environmental, and social perspectives. These factors, when combined and in interaction, have the potential to significantly influence the way sustainable construction is approached in Iran. In terms of methodology, this research takes a comprehensive approach that involves collecting data, conducting surveys, and utilizing the strategic framework of the Analytical Network Process (ANP). The ANP is applied to determine the priority weights for different criteria related to the concept being studied. This method allows for a structured and systematic analysis of the importance of various elements in the context of green building construction.

This research is unique in the field of sustainable construction, especially considering how it applies to Iran. While many studies around the world have focused on green buildings, very few have used the method of analysis used here. This research is special, not just because the ANP method is applied, but also because we focus on a country in the Middle East, Iran, which no similar studies have done before. It is important to note that, even though other studies have been conducted in different parts of the world, they generally have not considered the specific conditions in a developing country, such as Iran. In addition, recent data showing that sustainable construction is becoming increasingly important in Iran highlight the need for this type of research. Therefore, our study responds to the growing need for a deeper understanding of how to prioritize economic, environmental, and social aspects in green building construction. This makes our research unique and relevant in today's world, especially in the Middle East.

In the following section, we present the literature pertaining to the aim of our study. In Section 3 (Methodology), we explain how we collected and analyzed our data. Next, we share the results from using Super Decisions software version 2.10 in Section 4 (Results). In Section 5 (Discussion), we discuss the main results and compare them with those of other studies. Finally, in Section 6 (Conclusions), we conclude our study by summarizing the main points we have discovered.

2. Literature Review

2.1. Green Building Standards

The requirement of a complete "ecosystem" for each country has led to the creation of rating systems, the training of design and construction professionals, the development of green products and systems, the growth of green building consulting firms, and the creation of a business case for investors [37]. Therefore, various environmental assessment indicators for green buildings have emerged in recent years. Increasing global awareness of the environmental impacts of buildings has caused a fundamental change in the way the construction industry approaches projects and has provided an imperative for action. As government agencies and private developers increase the demand for green buildings, building professionals and businesses must either adapt or be left behind. Most buildings show a low level of environmental performance, but green buildings clearly show that they can achieve a high level of environmental performance when builders incorporate sustainable practices into their projects [38].

Various terms and meanings are associated with green buildings, and buildings that have obtained one or more certifications through green building rating systems are considered green [39]. In general, green building rating tools are classified into specific rating tools that focus on a single environmental effect and rating tools that address many different

environmental effects simultaneously [40]. The set of credit criteria identified by each green building rating tool has a significant impact on building performance assessment [41].

Mandatory and voluntary certificates have been instituted across numerous countries worldwide, a phenomenon that includes various developing nations. Remarkably, over 50% of Asian countries have embraced labeling initiatives, reflecting their broad recognition and application [42]. A parallel trend is evident in South America, where an impressive 90% of countries have enacted labeling programs, underscoring the widespread adoption of this approach to foster consumer awareness and sustainable practices. An emblematic illustration of the efficacy of voluntary labeling initiatives is offered by the U.S. Energy Star Program, a prosperous endeavor in this domain [42].

Rating systems based on building sustainability indicators have been developed, such as England's Building Research Establishment Environmental Assessment Method (BREEAM) in 1990, followed by France's High Quality Environmental Standard (HQE) in 1996, the 1998 Leadership in Energy and Environmental Design (LEED) in the United States, and Japan's Comprehensive Assessment System for Built Environment Efficiency (CASBEE) in 2001. The Green Building Council of Australia was established in 2002 and the German Sustainable Building Council (DGNB) in 2007. However, obtaining green building certification does not automatically guarantee the comprehensive fulfillment of all sustainable development objectives [43]. Some certifications, such as BREEAM, primarily assess the environmental effectiveness of both new and pre-existing architectural designs, whereas the LEED concept of a green building has gained recognition across different nations and urban centers worldwide [44,45]. Table 1 provides the evolution of the green building and the emergence of green building standards over the years, as adopted from the studies of Ade and Rehm (2019) [40] and Sartori et al., (2021) [46].

Table 1. The historical evolution of the green building.

1990	BREEAM [1] opened a new office
1993	The American Green Building Council (GBC) formed
1995	Energy Star [2] formed for homes
1996	HQE (High Quality Environmental Standard) created
1998	LEED 1.0/Spain GBC formed/BREEM
2000	LEED2.0/Green Globes (Canada) debuted
2001	Japan CASBE Rating system created/Indian GBC formed
2002	Canada GBC and Word BGC formed
2003	First Green Star rating tool, GBC Australia formed
2004	LEED introduced for existing buildings; innovation criteria formed
2005	Singapore Green Mark rating tool launched
2007	German Sustainable Building Council (DGNB) formed
2008	Registration of 1 million buildings and houses in BREEM
2009	Sweden Green Building Council (SGBC) established
2010	BEAM PLUS V,1.0 by the Hong Kong Business Environment Council launched
2014	International WELL Building Standard launched
2016	Fitwel launched for universal use [3]
2022	75+ GB councils representing over 46,000 organizations [47]

[1]—Building Research Establishment Environmental Assessment Method: The method and standard of building quality evaluation is from the point of view of sustainability and energy consumption. This method or standard is the most widely used and longest-running developed method, which is recognized and used by 50 countries. This method was first developed by the United Kingdom. [2]—Energy Star: This is an international standard for how energy is consumed by electronic devices and other commercial products. [3]—Developed by the U.S. Centers for Disease Control and Prevention (CDC). The General Services Administration (GSA) has joined LEED.

2.2. Sustainability in Iran

Iran is located in the Middle East, next to the countries of Turkmenistan, Azerbaijan, and Armenia. The country has valuable natural resources, both renewable and non-renewable, and is surrounded by the Caspian Sea, Persian Gulf, and Oman Sea. It has a population of around 87.92 million and covers an area of 1,648,195 square kilometers. Iran's climate varies greatly due to its diverse landscapes, with mostly semi-arid conditions. The average yearly rainfall is 228 mm, and temperatures range from 19–38 °C in summer to 10–25 °C in winter [34].

Sustainable development was introduced in Iran in 1994, aiming to align its economic plans and environmental protection goals. To coordinate these efforts, a National Committee for Sustainable Development was established, comprised of representatives from various ministries and organizations [48].

From 1990 to 2021, Iran's energy consumption increased by a massive 415%, rising from 53 to 377 terawatt hours (TWh) [49]. Over the same period, carbon dioxide emissions also increased by 415%, from 171 to 748 million tons [50]. Looking ahead, it is projected that Iran's carbon dioxide emissions will further increase to 985 million tons by 2025, with a yearly growth rate of 5% [51].

In recent years, Tehran, the capital city of Iran, has been grappling with several critical problems. These include a rapidly growing population of about 9 million people, as well as significant environmental challenges, such as air, water, and soil pollution, noise pollution, congested traffic, and heavy resource consumption. One reason for these issues is that Tehran is the country's political capital, which grants its residents more convenient access to a wide array of economic, political, cultural, and educational institutions compared to those living in other cities [52]. While the Iranian government is making efforts to enhance renewable energy resources, energy consumption in Iran continues to rise due to factors such as population growth, lifestyle changes, and economic development [36].

The development of GBs in Iran serves as a solution for defining and assessing sustainability within the country's sustainable development policies and elements. Thus, the promotion of GBs across the country is of immense importance. In Iran, considering the prevailing climate and energy consumption conditions, certain initiatives have aimed to construct green buildings. However, the absence of tailored green building certificates that specifically address Iran's climate poses a challenge. As a result, there is no established method for effectively measuring the success rate of these buildings' performance. Currently, the only way to gauge their effectiveness is by observing their performance over time. In countries such as Iran, which are categorized as developing and are grappling with pressing environmental and climate-related issues, such as water and energy scarcity, as well as environmental pollution, there are additional hurdles to motivate society members to effectively adopt green building practices [53].

3. Methodology

3.1. Research Process

To achieve the main goal of this study, which is to understand how different experts in various fields prioritize the environmental aspects of green buildings, participants were chosen from the academic communities of civil engineering, architecture, and environmental studies in Tehran, Iran. The initial criteria definition came from the literature and was then divided into sub-criteria that included all the sustainability features while excluding the overlaps. We also considered the conditions of the construction environment in Iran. Next, we prepared a questionnaire and used the modeling tool to prioritize the sub-criteria based on the experts' opinions. The number of experts in each specific field of this research was 15, for a total of 45 experts. The age of the participants was between 30 and 60, and they were professionals in green building (GB) and sustainable construction in Iran. Of the respondents, 72% had two to three years' experience in GB, and the remaining 28% had more than three years' experience.

3.2. Data Collection

To define the main criteria, the first stage was to select eight different studies from the literature based on the authors' experiences and knowledge. Next, we assessed the selected studies in detail and defined 125 criteria (see Supplementary Materials). We then removed duplicates, overlaps, and non-related criteria while merging those that were similar to others (Figure 1). Among these, 15 criteria were directly related to technology, 55 related to the environment, 17 related to the economy, 25 related to society, and 13 related to organizations or politics. As mentioned, some of the criteria were similar to each other, some were duplicates, and some needed to be merged. This process resulted in 14 final sub-criteria that fit into the three sustainability features for environment, economy, and society (Table 2).

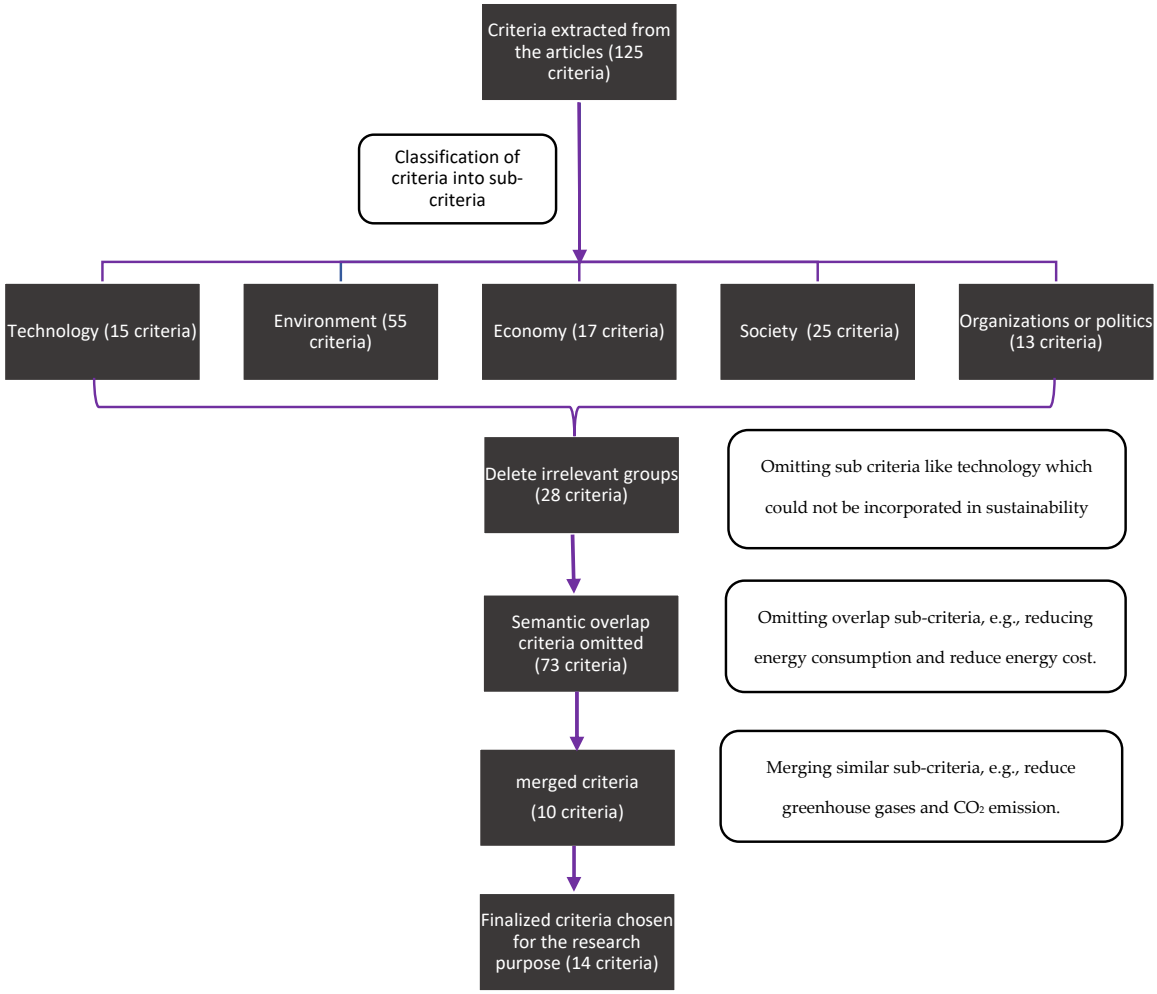


Figure 1. Data collection.

Table 2. The defined criteria and sub-criteria after the literature search.

Criterion		Sub-Criteria	Reference
Environmental	1	Energy consumption	[36,54–58]
	2	Water consumption	[11,36,54,56,58,59]
	3	Greenhouse gas emissions	[11,56,57,59]
	4	Waste/Protection of available resources	[11,36,56,57,59]
	5	Indoor environmental quality (remove or reduce indoor pollution sources; air conditioning and control of pollutants)	[36,56,59]

Table 2. *Cont.*

Criterion		Sub-Criteria	Reference
Economical	1	Construction cost (includes high design costs, materials, and labor)	[36,56,59,60]
	2	Efficiency (energy consumption cost)	[36,56,58,59]
	3	Duration	[56,58]
	4	Cost-effectiveness (lifespan of the building, sales price)	[11,59]
	5	Maintenance and operation costs	[60]
	6	Financial incentives/support schemes (tax cuts and loans)	[37,56,58,59]
Social	1	Mental health and performance of individuals	[56]
	2	Competitive price (achieve energy for a reasonable price)	[11,59]
	3	Experts' knowledge (awareness of green projects, skilled workers, and technology)	[51,58]

3.3. Analytic Network Process Method

Multi-criteria decision-making (MCDM) is the planning and decision-making method used for topics that involve several different and often conflicting criteria. This technique focuses on distinguishing the evaluation criteria and determining the preference structure, i.e., weights [61]. In 1996, Saaty introduced a new MCDM approach known as the Analytic Network Process (ANP). The ANP was specifically developed to address and resolve challenges arising from the intricate interdependencies and feedback loops that exist between criteria and alternatives in real-world decision-making scenarios. By incorporating these dynamic and interconnected relationships, the ANP offers a comprehensive and effective framework for decision-making processes in complex systems. The ANP technique is used for weighting criteria, sub-criteria, and ranking options.

In addition, the ANP is used to model complex cases that have a network and cluster structure. In this method, the relations of mutual and dependent relations between factors and sub-factors are considered, and by considering these relations the criteria and sub-criteria are ranked [62]. The elements of a cluster may influence some or all of the elements of any other cluster [63]. In the ANP, pairwise comparisons between elements and criteria are used to determine the weight and priority of each element in the decision-making process. This scale helps the decision maker in the comparison process by considering numbers 1 to 9 in order of importance (number 1 for the same preference and number 9 to show the most preference; see Appendix A). Pairwise comparisons, which are used in network and hierarchical analysis to determine priorities, are presented in Table 3.

Table 3. Scale preference.

Definition	Numerical Value
Equally Preferred	1
Moderately Preferred	3
Strongly Preferred	5
Very Strongly Preferred	7
Extremely Preferred	9
Preferences between the above	2, 4, 6, 8

The ANP consists of four main steps [64]:

Step 1: Establishing the model and building the network.

The case should be clearly stated and divided into a rational system, such as a network. This network shows how the different clusters are connected. An example of the format of a network is depicted in Figure 2.

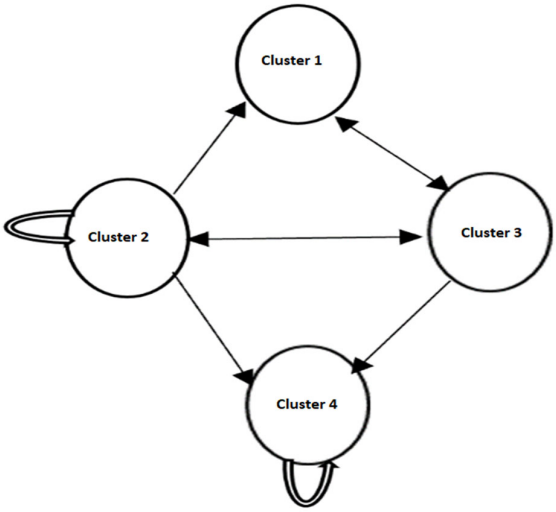


Figure 2. Structure of the ANP network.

Step 2: Preparing the matrix of pairwise comparisons and priority vectors.

The ANP methodology involves comparing pairs of decision elements within individual clusters to ascertain their significance in relation to the criteria. Additionally, the comparisons extend to an evaluation of the contributions of clusters toward the overall objective. Decision makers engage in pairwise assessments, systematically weighing two elements or clusters against higher-level criteria. It is important to highlight that, even within a cluster, interdependencies among constituent elements are evaluated through pairwise comparisons. These comparisons generate an eigenvector, indicating the influence each element has on the others. The ANP is performed in the framework of a matrix, and a local priority vector can be derived as an estimate of the relative importance associated with the elements (or clusters) being compared by solving the following equation:

$$A \times W = \sigma_{max} \times W$$

where A is the matrix of the pairwise comparison, W is the eigenvector (Saaty proposes several algorithms to approximate W), and σ_{max} is the largest eigenvalue.

Step 3: Forming the super matrix.

In the ANP technique, the super matrix serves as a tool to illustrate the interactions and dependencies between decision-making levels. It also helps in determining the relative importance of criteria and prioritizing alternatives. To populate the various matrices within the super matrix, it is necessary to calculate the priority vectors for each pairwise comparison matrix. Once the consistency of pairwise comparisons is confirmed, the relative weights of each pairwise comparison matrix are calculated to establish their importance. These priority vectors are then inserted into the corresponding columns of the super matrix. This results in the super matrix being effectively divided into segments, in which each segment represents a relationship between two clusters within the system.

Step 4: Solving the super matrix and choosing the best option.

If the super matrix formed in Step 3 encompasses the entire network, we can determine the priority weights of the alternatives by examining the alternative column in the normalized super matrix. In cases where the super matrix consists solely of interconnected clusters, additional computations are necessary to establish the overall priorities of the alternatives.

Opting for the alternative with the highest overall priority is advisable, as it emerges as the optimal choice through the application of matrix operations in the calculation process.

3.4. Research Design

To achieve the goal of this research, after identifying the criteria and sub-criteria, a checklist of paired comparisons was designed. The questionnaire presented a pairwise comparison of criteria and sub-criteria in a web-based survey format (a copy of the questionnaire is presented in Appendix A). As an example, the pairwise comparisons of two main criteria, environmental and economical features, which are used in the questionnaire to determine priorities, are presented in Figure 3.

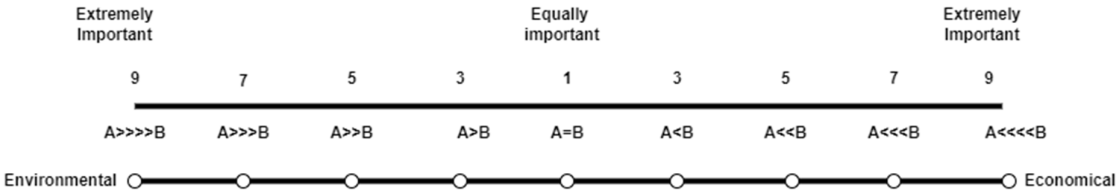


Figure 3. An example of a weighting scale (for environmental and economical features).

A suitable model for network analysis was designed using Super Decisions software. Based on this model, the diagram of the ANP and the relationship between the clusters based on the aim of this article is in the form of Figure 4. The abbreviations for the criteria and sub-criteria used in the Super Decisions software are shown in Table 4.

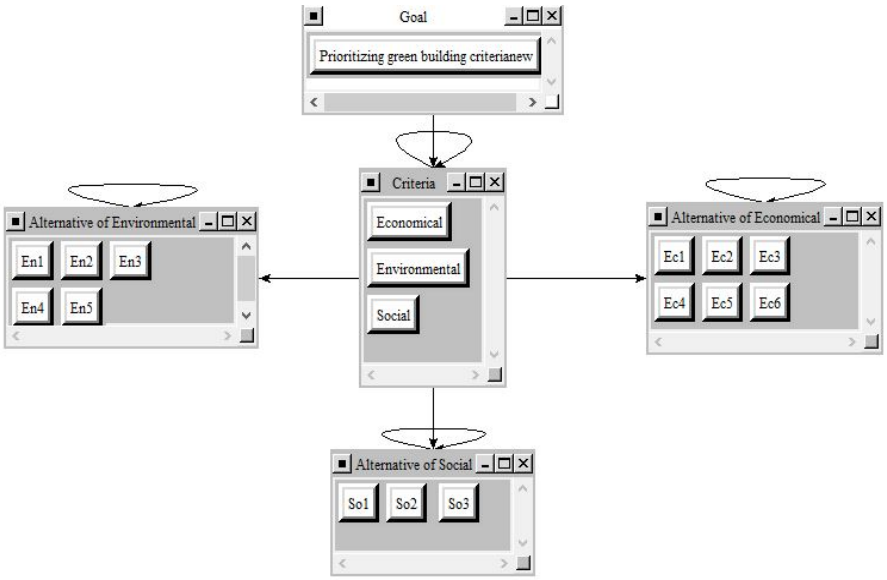


Figure 4. The ANP model (Super Decisions software).

Table 4. Abbreviations used in Super Decisions software and explanations of the criteria.

Criteria	Abbreviation	Explanation
Energy consumption	En1	- Use of renewable and clean energy - Avoid wasting energy
Water consumption	En2	- Optimizing water consumption - Use of gray water (sewage)
Greenhouse gas emissions	En3	- Decreasing air pollution, green roof
Waste/Protection of available resources	En4	- Use of renewable materials - Reducing waste production
Indoor environmental quality	En5	- Removing or reducing polluting sources inside the building - Use of air-conditioning systems - Orientation of the building, correct and optimal use of light - Acoustic design
Mental health and performance of individuals	So1	- Relationship between humans and nature - Productivity of people - The visual and psychological effects of colors in the building
Competitive price	So2	- Achieving clean energy at a reasonable price for buyers; buyers' financial ability and desire
Experts and technology	So3	- Expert workforce; technicians. - The novelty of the subject and the lack of awareness and training for experienced forces - Availability of green building construction materials in the local market
Construction cost	Ec1	- Cost of construction, installation, and training. - The cost of designing and planning someone's green field according to the available technologies
Efficiency	Ec2	- Having an economic justification
Duration	Ec3	- Time spent on construction, installation, and training
Cost-effectiveness	Ec4	- Profitability of green buildings and reduction of energy consumption costs
Maintenance and operation costs	Ec5	- Necessary measures for maintenance and operation of different parts of the building
Financial incentives	Ec6	- Government support programs (loans, etc.) - Reducing taxes, insurance costs, etc.

The output of the Super Decisions software determines the final priority (weight) of the indicators. When the number of comparisons increases, it is not easy to ensure their compatibility, so this confidence should be achieved by using the compatibility rate. The inconsistency rate was 0.09, which shows that pairwise comparisons are favorable.

4. Results

4.1. Weighting Factors for Criteria

The Analytical Network Process (ANP) algorithm was employed to determine the priorities or weights assigned to the alternatives under consideration. This process involved a rigorous evaluation of individual and collective expert judgments, encompassing pairwise comparisons of the alternatives and constituting an integral facet of the ANP methodology, as elucidated by Saaty in 1980 and 1996. To perform the analysis, the main criteria were

compared in pairs based on the goal. The results of the criteria group in the Super Decisions software are shown in Table 5. Based on the results, the environment criterion was the most critical factor among the group of criteria, with a normalized weight of 69.1%. The economic and social criteria importance are 21.76% and 9.14%, respectively.

Table 5. Weight of criteria (%).

Criteria	Weight of Criteria
Environmental	69.1
Economic	21.76
Social	9.14

4.2. Detailed Analysis of Sub-Criteria

To prioritize the following environmental sub-criteria, first, the criteria of energy consumption (En1), reducing water consumption (En2), reducing air pollution (reducing greenhouse gas emissions) (En3), reducing waste production (En4), and indoor quality (En5) were compared in pairs from an environmental point of view. The results showed that the criterion of reducing water consumption had the highest priority (34.6%). The criterion of reducing waste production was the second priority (25.2%), and the criterion of indoor quality in the building had the lowest priority (Figure 5).

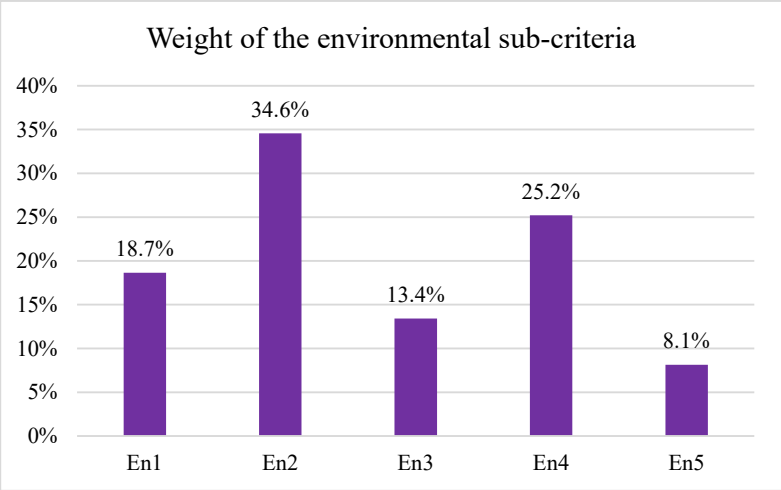


Figure 5. Percentage-based weight of environmental sub-criteria.

The economy is one of the influential factors in the construction of green buildings. In this respect, the criterion of financial incentives (Ec6) was the most important influencing factor, at 39.6%, with cost-effectiveness (Ec4) an important sub-criterion (Figure 6). The sub-criteria construction cost (Ec1), maintenance and operation costs (Ec5), duration (Ec3), and efficiency (Ec2) were the third to sixth priorities, respectively.

In Figure 7, a comparative analysis of the social sub-criteria is presented, demonstrating its relatively lower significance when compared to the environmental and economic criteria. After conducting pairwise comparisons among the criteria, the results indicated that competitive price, or achieving energy efficiency at a reasonable cost (SO2), held the highest importance (52.78%), while the criterion of experts—awareness of green projects, skilled workers, and technology (SO3)—was considered the least critical criterion for the sustainable development of a green building.

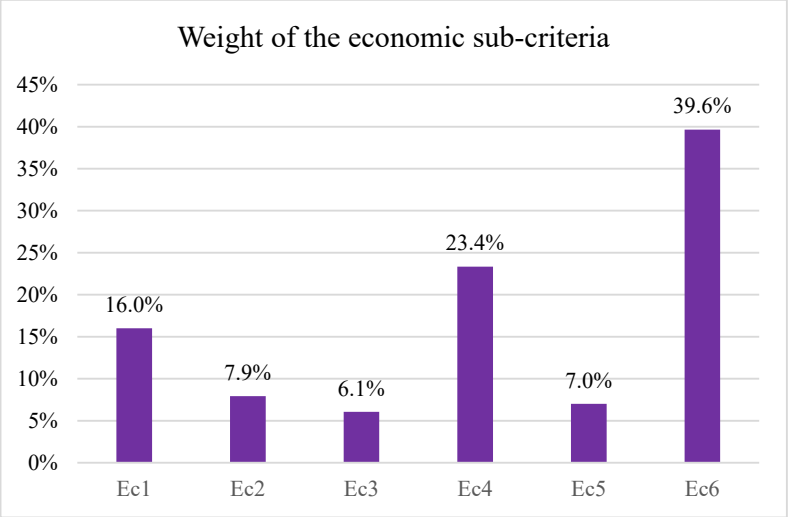


Figure 6. Percentage-based weight of economic sub-criteria.

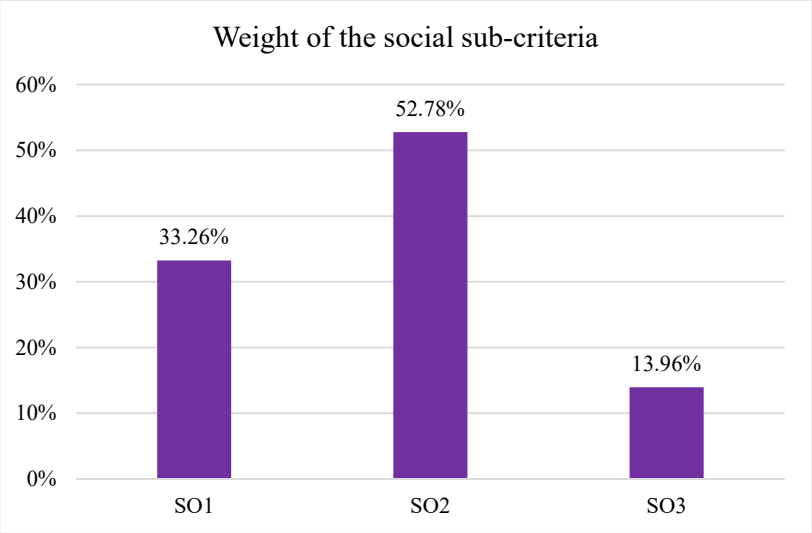


Figure 7. Percentage-based weight of social sub-criteria.

4.3. Comparison of Experts' Opinions

This study shows that, when it comes to green buildings, the environment is the most crucial factor, followed by the economy, and then the social aspects, according to experts in architecture, environmental science, and civil engineering (Figure 8). The study reveals distinct differences in the priorities of architects, environmentalists, and civil engineers in green building projects. Architects focus more on the environmental impact of buildings, showing a strong concern for eco-friendly designs. However, they tend to overlook the social aspects of green buildings, which are valued more by environmentalists, who demonstrate a greater interest in the societal implications of green projects. In contrast, civil engineers prioritize the economic aspect, emphasizing financial considerations and resource allocation. These varying perspectives highlight the multifaceted nature of green building initiatives and the need for a balanced approach that considers environmental, social, and economic factors.

The authors emphasize the profound relationship between green buildings and green design, underscoring how this connection profoundly influences the perspectives of architects and environmentalists. Architects, being primarily concerned with the artistic and aesthetic elements of green buildings, inherently incorporate environmental factors into

their creative processes. As a result, architects tend to place significant importance on environmental considerations, aligning these factors with their design goals while upholding the principles of sustainability.

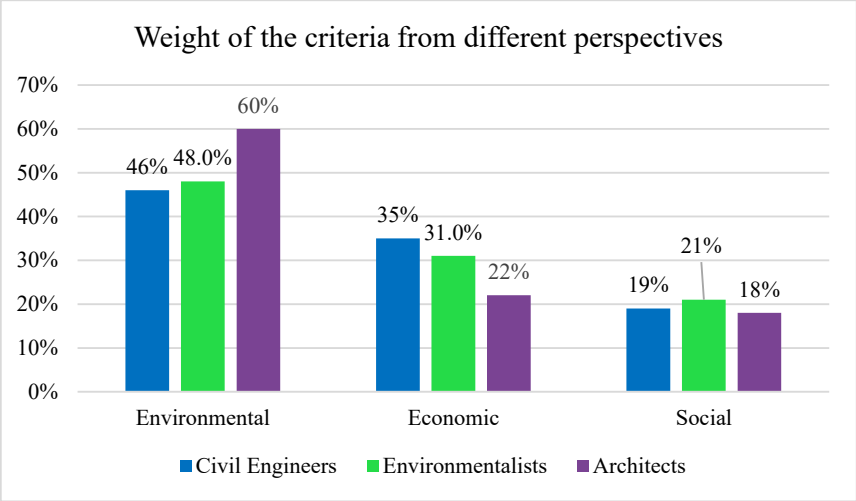


Figure 8. Percentage-based weight of the main criteria from different perspectives.

In contrast, environmentalists, grounded in their expertise in environmental sciences, adopt a more comprehensive and utilitarian approach when assessing green building projects. Their focus extends to overarching environmental concerns, sometimes overshadowing specific architectural intricacies. This broader perspective ensures a thorough evaluation of the environmental impact but might overlook certain finer details of architectural design. The dynamic interplay between these two perspectives highlights the complexity of creating environmentally sustainable and aesthetically pleasing buildings.

5. Discussion

Over the past few years, the adoption of green building (GB) practices has seen substantial growth due to limited resources and the evident consequences of traditional building methods. Nonetheless, despite Iran's notable use of fossil fuels, the development of GBs has been overlooked. Understanding how experts from various fields view the environmental aspects of GBs plays a crucial role in promoting sustainable construction practices across Iran. These insights can contribute significantly to advancing the adoption of environmentally friendly building techniques in the country. To establish the criteria framework for this study, relevant literature was searched, and the criteria were classified into sustainability pillars. To prioritize the criteria, the ANP model was applied using Super Decisions software.

The results of this survey showed that the environment is the most important criterion in creating a GB (69.0%), while the social criterion has the least importance (9.2%). In a related study in China and the UK conducted by Jin Si et al., (2018) [56], the emphasis was placed on the selection of green technologies, a pivotal factor in creating sustainable buildings. Using the multi-criteria decision-making (MCDM) approach, the research considered not only sustainability criteria but also technological factors, distributing resources fairly across the various sustainability aspects. Their study's outcomes are compared with the current analysis results in Figure 9.

As illustrated in Figure 9, a convergence in the primary criteria priorities can be observed between Iran and the UK. Notably, both nations place paramount importance on the environmental aspect of buildings within their respective contexts. However, in the UK, economic considerations emerged as the prevailing priority. The social aspects of GBs were assigned lower significance in each of the mentioned countries. Particularly in Iran, where the weighting assigned to the social aspect amounted to less than 10%, this can be

attributed to Iran's status as a developing nation, where the importance of social aspects in buildings may not be as pronounced as it ought to be.

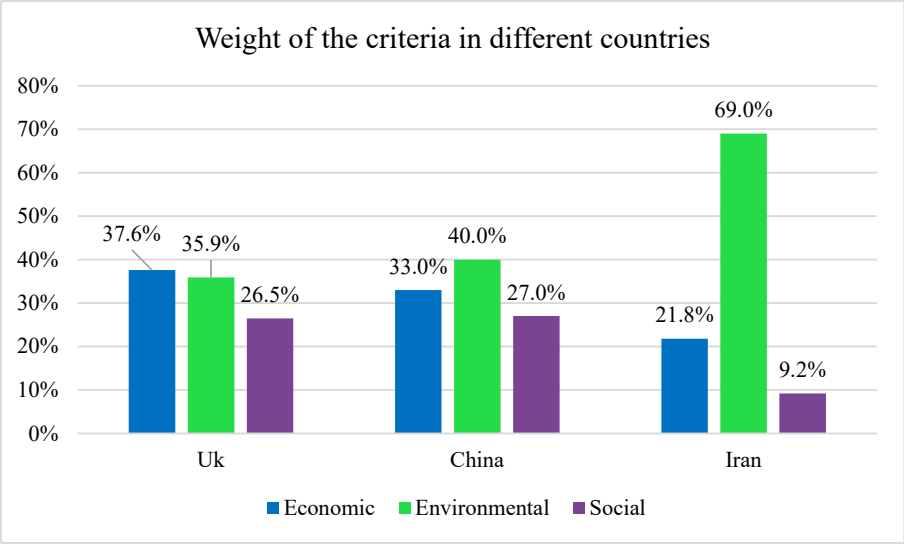


Figure 9. Comparing the weight of the main criteria of this study with Jin Si et al., (2018) [56].

In weighting the sub-criteria, in a separate study conducted in Iran by Shad et al. in 2017 [36], the investigation aimed to identify and propose a comprehensive set of factors suitable for assessing GBs in the Iranian context, particularly focusing on office buildings. The findings revealed that energy efficiency and water efficiency emerged as the two most significant factors, collectively constituting 39% of the total score. This underscores their critical importance, given the vital circumstances of energy and water conservation in Iran. Moreover, in the economic sub-criteria, financial incentives were ranked at the forefront, with an important score of 39.6%. This ranking highlights the scarcity of financial incentives and supportive facilities required for the development of GBs in Iran.

Although Iran relies heavily on non-renewable energy sources at present, it is crucial to acknowledge the growing global and national recognition of the necessity to shift toward cleaner and more sustainable energy options. This increasing awareness of environmental challenges could explain the heightened emphasis on environmental considerations within green building practices, even in a context in which the use of renewable energy sources remains limited. Also, some other oil-rich countries, such as Saudi Arabia, have set ambitious goals to use 50% renewable energy by 2030 [65]. This shows a broader trend toward cleaner energy in countries with a strong oil industry.

Moreover, the prioritization of environmental concerns can be interpreted as a proactive response to mitigating the negative consequences of Iran's substantial dependence on fossil fuels. Green building practices are perceived as a pivotal means of reducing the environmental impact of buildings, which, in turn, contribute to addressing environmental issues within the broader energy sector.

The experts' perspectives, as reflected in this research, emphasize the desirability of efficiency and cost-effectiveness in such endeavors. In addition, the case study conducted by Balaban and Puppim de Oliveira (2017) [24], which analyzed seven green buildings in the Greater Tokyo area, revealed compelling economic benefits linked to reduced energy consumption. The study demonstrated that these GBs yielded substantial annual savings of around $1–1.5 million per building. Such significant cost reductions underscore the tangible economic advantages that arise from the adoption of GB practices. These findings serve as a powerful reinforcement of the profound significance and potential of sustainable approaches within the construction industry. As a result, they provide compelling evidence to encourage the further integration and promotion of sustainable building strategies in both existing and future projects.

Notably, an international survey involving over 1000 construction professionals from 69 countries highlighted that 50% of the respondents' identified "costs" as the principal challenge facing GB projects [66]. In developing countries, the surge in new building construction in recent decades has presented significant challenges. However, embracing sustainable building practices ensures that the design, construction, operation, maintenance, and disposal of building waste are carried out in a manner that preserves natural resources and minimizes pollution. In addition, green buildings offer a multitude of advantages beyond merely diminishing energy consumption and environmental impacts over their lifespan. They also yield social and psychological benefits. For instance, a green office building can enhance the well-being and morale of its occupants, potentially leading to higher levels of job satisfaction and work efficiency compared to conventional office spaces [31].

GBs bring many economic and financial benefits to different parts of society. These advantages include lower utility bills for people living in these buildings because of energy- and water-saving methods. They also increase property values for builders, exert a positive influence on how many people wish to live there, and lower the operation costs for building owners. The findings of this study provide insights and data that can guide the decision-making processes for GB construction in Iran. However, it is evident that further research and development efforts are necessary to enhance and refine GB assessment tools specifically tailored to the Iranian context.

6. Conclusions

In conclusion, this study focused on understanding the priorities of experts from various fields regarding the different aspects of green buildings in Iran. The research employed the Analytical Network Process (ANP) methodology to prioritize criteria and sub-criteria related to green building. The findings revealed that, despite Iran's heavy reliance on non-renewable energy sources, environmental considerations were given the highest priority by the experts involved in the study. This emphasis on environmental aspects can be attributed to the growing global awareness of the need for cleaner and more sustainable energy options, even in regions with strong ties to fossil fuels.

Comparing the results with those of studies from other countries (Figure 9), a common emphasis on the environmental aspect was observed, highlighting its universal importance in green building. The prioritization of environmental concerns can be seen as a proactive response to address the environmental impact of Iran's substantial dependence on fossil fuels.

Economic factors also played a significant role in the experts' perspectives, with financial incentives and cost-effectiveness being the key considerations. This aligns with global trends, in which cost-related challenges are often cited as major obstacles in green building projects. Green buildings offer various economic benefits, including reduced utility bills, increased property values, and lower operational costs.

Globally, various nations have implemented comprehensive green building ranking systems to assess and promote sustainable construction practices. Notably, Iran stands apart, as it lacks its own indigenous system and has refrained from adopting any existing international framework. This unique situation can be attributed to political issues that have hindered the development and adoption of a standardized green building evaluation system within the country. Consequently, this absence poses challenges in ensuring a systematic approach to environmentally conscious construction practices within the Iranian context. Addressing these political constraints could pave the way for the establishment of a localized green building framework, aligning Iran with the global sustainability discourse and fostering environmentally responsible building initiatives within the nation.

This research has some limitations that indicate opportunities for additional exploration. First, the online questionnaire was sent out as part of the study's methodology. Therefore, the responses received from the respondents served as the only valid source of information. While the questions were designed to be straightforward and simple to comprehend to avoid misunderstandings and improve validity, it is feasible that the

respondents might have responded carelessly to the questionnaire. Despite the study's valuable insights, further research and development efforts are required to refine green building assessment tools tailored specifically to the Iranian context. These findings can guide decision makers in promoting sustainable construction practices and contribute to advancing environmentally friendly building techniques in Iran's construction industry. The data were rigorously confined to Tehran, with the goal of assisting in the validation of the paper's conclusions.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/buildings13123021/s1; Table S1: 125 criteria defined.

Author Contributions: Conceptualization, T.D.; methodology, T.D. and A.A.; software, T.D.; validation, T.D. and A.A.; formal analysis, T.D. and A.A.; investigation, E.B.; data curation, T.D.; writing—original draft preparation, T.D.; writing—review and editing, T.D., A.A., E.B. and S.J.; visualization, T.D.; supervision, S.J. All authors have read and agreed to the published version of the manuscript.

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Appendix A. Pairwise Comparison Survey

	Extermly important								Equality imporant								Extermly important	
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Environmental																		Economical
Environmental																		Social
Economical																		Social
Energy consumption																		Water consumption
Energy consumption																		Greenhouse gas emissions
Energy consumption																		Waste /Protection of available resources
Energy consumption																		Indoor environmental quality (Delete or reduce Indoor pollution sources)
Water consumption																		Greenhouse gas emissions
Water consumption																		Waste /Protection of available resources
Water consumption																		Indoor environmental quality (Delete or reduce Indoor pollution sources)
Greenhouse gas emissions																		Waste /Protection of available resources
Greenhouse gas emissions																		Indoor environmental quality (Delete or reduce Indoor pollution sources)
Waste /Protection of available resources																		Indoor environmental quality (Delete or reduce Indoor pollution sources)
Construction cost (Includes high design cost, materials, labor)																		Efficiency (Energy consumption cost)
Construction cost (Includes high design cost, materials, labor)																		Duration
Construction cost (Includes high design cost, materials, labor)																		cost-effective (Lifespan of the building, sales price)
Construction cost (Includes high design cost, materials, labor)																		Maintenance and operation costs
Construction cost (Includes high design cost, materials, labor)																		Financial Incentives / Support Schemes (Tax cuts and loans)
Efficiency (Energy consumption cost)																		Duration
Efficiency (Energy consumption cost)																		cost-effective (Lifespan of the building, sales price)
Efficiency (Energy consumption cost)																		Maintenance and operation costs
Efficiency (Energy consumption cost)																		Financial Incentives / Support Schemes (Tax cuts and loans)
Duration																		cost-effective (Lifespan of the building, sales price)
Duration																		Maintenance and operation costs
Duration																		Financial Incentives / Support Schemes (Tax cuts and loans)
cost-effective (Lifespan of the building, sales price)																		Maintenance and operation costs
cost-effective (Lifespan of the building, sales price)																		Financial Incentives / Support Schemes (Tax cuts and loans)
Maintenance and operation costs																		Financial Incentives / Support Schemes (Tax cuts and loans)
mental health & Performance of individuals																		Competitive price (Achieve energy for a reasonable price)
mental health & Performance of individuals																		Experts awareness of green projects (Skilled worker & Technology)
Competitive price (Achieve energy for a reasonable price)																		Experts awareness of green projects (Skilled worker & Technology)

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