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Hybrid Study of Quantitative–Qualitative Analysis to Recognize the Most Cost-Effectiveness Criteria to Develop Affordable Mass Housing

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Abstract: Nowadays, providing housing for the low-income groups of society is a concern for governments, especially in developing nations. An attempt has been made to recognize the most significant real criteria for reducing housing project costs and providing affordable housing for them by studying previous research and analyzing the collected information. First, the resources compiled in the field of affordable housing were reviewed, and data were gathered. Next, qualitative and quantitative questionnaires were provided, and the experts' answers were analyzed in three steps (Delphi technique, AHP techniques, and case studies). By analyzing the findings, it was concluded that the current approaches in housing planning need to be revised to achieve the government's goals and policies. Therefore, the physical indicators and patterns of vernacular and traditional houses in different climatic regions should be known and changed in the next step according to the needs of the modern world. The adaptation of today's architecture from the vernacular architectural features of the past is one of the important things that should be considered. In this research, the consideration of housing preparation for low-income groups and reducing housing project costs, by identifying the most important effective criteria mentioned in other previous studies, is the novel contribution of this research.

Keywords: housing; affordability; vernacular architecture; mass housing; sustainability

Citation: Faraji, A.; Meydani Haji Agha, T.; Homayoon Arya, S.; Ghasemi, E.; Rahnamayiezekavat, P. Hybrid Study of Quantitative–Qualitative Analysis to Recognize the Most Cost-Effectiveness Criteria to Develop Affordable Mass Housing. *Buildings* **2024**, *14*, 1057. https://doi.org/10.3390/buildings14041057

Academic Editors: Yung Yau and Davide Settembre-Blundo

Received: 12 February 2024
Revised: 13 March 2024
Accepted: 5 April 2024
Published: 10 April 2024

1. Introduction

Globally, governments at different levels are responsible for providing basic human needs to make citizens' lives meaningful. One of these services, which is one of the basic needs of life, is housing. Housing is important for measuring citizens' living standards and a country's growth. According to Maslow's theory, housing is one of the most basic needs and in the primary ranks. A home is a place that helps people meet basic needs and maintain life. In this regard, the above theory professes that houses not only meet the requirements related to shelter but also the biological needs [1]. Today, construction and housing markets act as growth engines in various economies. Unfortunately, despite the importance of housing and the implementation of mass housing policies, there are still gaps between housing supply and demand [2]. Many studies have explored the effects of the housing deduction on national development. The housing deficit rate is alarming because of the difficult process of land acquisition, the high costs of providing infrastructure, and the scarce access to loan services due to the related laws. Many studies highlight those different layers of the government should formulate and execute people-oriented policies to build affordable mass housing units to increase national development [3,4].

"The lack of housing and the inability to afford it" are problems that will have various effects in cultural, social, economic, human, and even psychological aspects; therefore, the problem of "Not being able to provide suitable and affordable housing and searching for the solutions to solve it" is an issue that should be considered by governments. With rising housing costs, many people are struggling to find a place to live that is both safe and affordable. So, most countries have implemented affordable housing best practices to ensure that everyone has access to safe and affordable housing. There is a discussion about the most important affordable housing criteria that can help cities create more just housing options [5]. Lack of housing generally impacts families whose revenue is at or below the average income level of their city. Also, many tenants spend more than half their salary on housing [6]. Also, other larger policy concerns such as finance, zoning, land use, and Master Plan Development are issues related to affordable housing development [7]. The main purpose of this study is to find the criteria among the success criteria of affordable mass housing projects that, at the same time, can be useful in reducing project costs. Introducing these criteria and observing the principles related to them at different stages of the project life cycle can be effective in reducing project costs. Therefore, there is a need to review the definitions of housing and affordability and their criteria among the studies that have been conducted so far.

Cities are being developed. Subsequently, the need for housing will also increase. Mass housing plays a vital role in addressing the housing needs of a large population, promoting social stability and economic development. By procuring affordable and available housing options, mass housing helps to encourage community well-being and reduce homelessness. Nowadays, people living in smart societies demand the best-quality design and construction based on environmental awareness. Because the relationship between space, housing, and services increases the quality of life [8], it is necessary to carry out this study and identify the criteria that can be useful in solving the housing shortage and making it affordable. The affordability problem is mainly the housing and rules' result. Additionally, the insufficient housing supply compared to the increasing demand leads to high housing prices [9].

Affordable housing often equals poor-quality construction. It is characterized by the selection of cheap materials, and put together in a way to achieve the minimum standards. Considering the building's lifespan and energy efficiency, constructed housing's value degrades over time. It also has needlessly high utility costs and produces an enormous amount of material waste [6]. The tax credits that are allocated to the project reduce the construction cost. They allow the developer to offer newly constructed or rehabilitated buildings at reduced rental prices [7]. It seems necessary to identify how settlements are created to create clear scientific bases for planning by considering the importance of the settlement concept. The most important question is whether the basic features of buildings and their energy systems can provide affordable housing during construction and operation [8]. So, to provide an adequate and comfortable residential place, it is necessary to plan, especially for low-income groups [10].

In this research, with the approach of developing solutions to reduce the costs of housing projects, the goal of introducing effective criteria for reducing costs has been addressed. Thus, an attempt has been made to first identify the effective criteria for the success of affordable mass housing projects, and among them, with the help of experts' opinions, to identify the effective criteria for cost reduction from previous research and confirm their validity. This study's main question is "What are the effective criteria for reducing design and construction costs in a housing project?". After screening references, extracting the effective criteria, and choosing a suitable statistical population, using the experts' opinions in the first qualitative questionnaire and the Delphi technique, effective criteria were selected for reducing costs. The criteria were ranked and their weight was calculated by the second quantitative questionnaire's responses, as well as the AHP technique. Finally, four successful affordable housing projects with the common feature of "Providing housing for low-income groups" were selected, and the degree of compliance with the selected criteria

was analyzed with the help of experts' opinions. Consequently, the degree of importance and accuracy of the criteria were checked. The steps to achieve these criteria are given in the data analysis section. In this research, the main goal is to identify the effective criteria for reducing the costs of affordable mass housing projects, and based on this identification, explanations of the criteria identified by experts are provided in the Results section.

The criteria that have been gathered and introduced in this research are from articles published all over the world. The topic that this research is looking at is "extracting effective criteria in general". Therefore, four projects were selected for the validation of the criteria—regardless of the location of the project—and as mentioned, the only reason for choosing the projects was to achieve cost-effectiveness goals. Due to extracting the criteria and evaluating and measuring them, the factor of geography is not considered and the only primary reason for the selection is "its effectiveness in the success of the affordable mass housing project". After selecting the criteria, the second reason for the selection, "cost reduction", was considered to be extracted as a result of the analysis of the experts' answers, and in the third step, their credibility was evaluated in four successful projects.

It is essential to state that providing a solution to realize the approach mentioned in this research requires more research, which is hoped to be addressed in the next study. In this study, only an attempt has been made to introduce the necessary criteria for the development of the solution and standard definition.

2. Literature Review

A house is a concept of human needs. To satisfy the human requirement for a house, a varied range of concepts have been presented to make houses more affordable [11]. Housing development is under pressure as a result of rapid urbanization. By 2030, around 40% of the world's total population will need adequate housing and access to basic infrastructure such as energy. Until 2030, there is a need to build 96,150 residential units every day. As a result, in developing countries, bad governance has limited access to suitable housing [12]. According to a United Nations study, 50% of the world's population currently lives in cities. This number is expected to increase to 70% by 2050. But, productivity in the construction sector has not increased at the same rate and has affected the housing market. The construction industry is now faced with greater obstacles to creating adequate and affordable living spaces and must change its mindset, and one of the ways is to embrace alternative construction methods [13,14]. In this section, the study of housing architecture as well as the concept of affordability are discussed to extract the effective criteria for providing suitable affordable housing. In Figure 1, this research's purpose in the project life cycle is stated graphically.

In these studies, criteria, and solutions have been mentioned where drawing attention to them during planning, design, and construction by the planner, designer, and builder, in addition to applying the principles related to these criteria, can be useful and positive in the success of the affordable mass housing project.

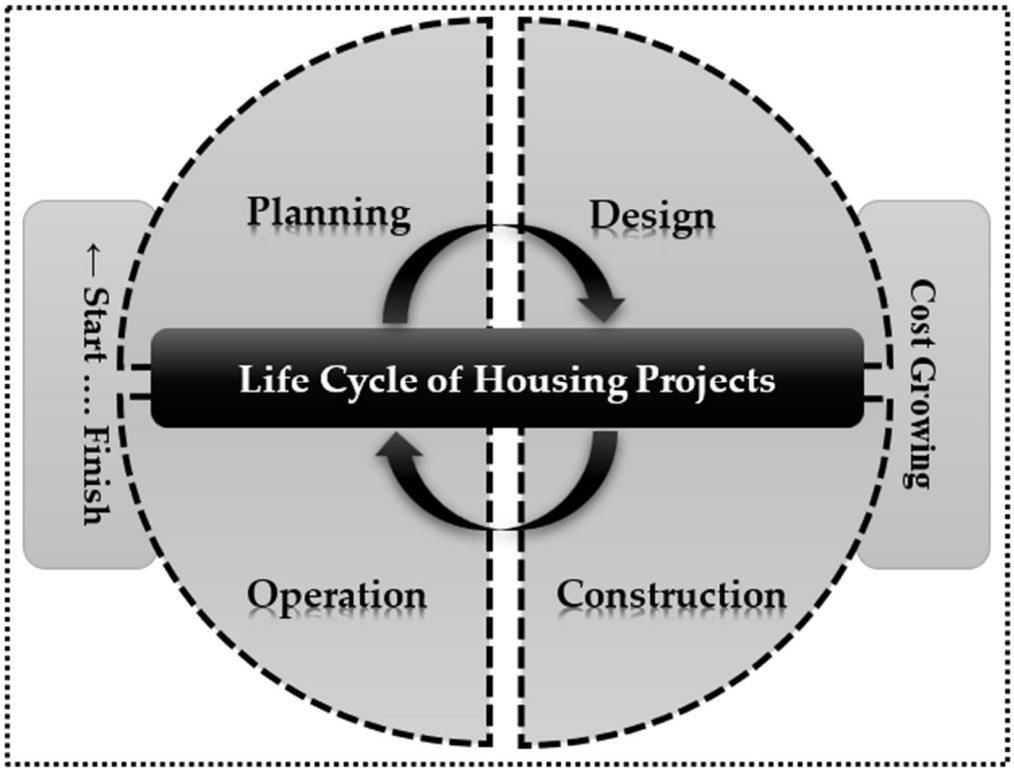

Figure 1. Housing project life cycle [15,16].

2.1. Housing Architecture

Housing design is for living and providing comfort, and it is a basic human need [17]. Housing is a basic and sensitive sector in economic and social development planning, but still, a large number of the world's population lacks an appropriate house [18]. Suitable housing indicates the society's general well-being, and undesirable housing leads to harmful consequences such as diseases, insecurity, and ultimately youth problems [19]. Today, housing and its related issues are global concerns, and planners in different countries are looking for solutions to problems [20]. Housing is a major cause of inequality and social integrity due to its characteristics such as being non-substitutable, capital, durable and expensive, and immovable [21]. Therefore, planning for the stable development of societies has always been desired to avoid negative social consequences (caused by lack of proper shelter) [22]. In many cases, the most important factor influencing a person's satisfaction level depends on environmental conditions [23]. So, the principles of social sustainability must be considered in the definition of dwelling [24]. Neglecting low-income groups in housing provision programs, especially in developing countries, is very important [25]. The ever-increasing population and massive migration to cities have intensified the process of urban development [26]. This will lead to widespread marginalization in cities and increasing housing prices, and will also cause risks to the environment [27]. The spirit of architecture was developed by humans [28]. Human creativity is clearly expressed in the shelters built by them [29]. Home is the place that they return to after experiencing different aspects of the world [30]. Housing is a place where all people are related, of course, not as a need, but as an economic and social behavior [30,31].

Dwelling is the growth and combination of its material elements with the spirit of its inhabitants. A house is part of its residents' identity [32]. The things mentioned in the concept of housing must be considered, such as peace, comfort, and well-being [33]. So, before housing production, its social and human dimensions, cultural considerations, neighborhoods, religious issues, etc., should be considered. Housing problems arise from different aspects. A residential space, which is necessary to provide people's comfort, is not only a covered space. The meaning of "dwelling" is "to protect", which means preventing

the occurrence of damage [34]. A person is established when they have settled down and established their existence [32]. Houses are the first concept that humans have been associated with. Because houses have been wherever human life has flowed, the house architecture is part of civilization's formation [35]. Dwelling achieves a concept of intimacy with a natural place [36]. The shape of housing can be changed by climatic conditions, structural technology, and available materials [37]. The space's identity depends on the physical environment and its quality [17]. The interior spaces consist of enclosed and private spaces, and the external spaces, including open and public spaces, are the two main housing components [38]. Housing is the discovery and intuition of human nature [28]. Therefore, a house is a cover that makes a relationship between the outside environment and human biological phenomena [39]. Also, the social institutions outside the house are complementary to the institution of the house [40].

2.2. Affordability

The importance of improving the built environment conditions is vital for having healthy neighborhoods [41]. There is a lack of studies that discuss the solutions for affordable housing. Low-income households struggle with expensive rents. Because of growing affordability requirements and being environmentally unsustainable, most suburbs need revitalization [42]. Affordable means more than just economics. It means a house for human habitation that is not overcrowded and unhealthy. Family expenses (housing, water, electricity, and gas) must also be considered to accurately present the actual cost [42,43]. The affordable housing definition within the National Housing Strategy requires the rent to be less than or equal to 30% of the median gross income. Research on the community's current situation and affordable housing in Ottawa shows that the majority of low-income and mid-income families are either paying more than 30% of their total income on housing or are in housing need [24]. Affordability does not only mean reducing design and construction costs. Rather, the reduction of housing costs during operation, which refers to the energy consumption cost reduction, is also in the affordability concept [9].

In the affordability definition, an attempt has been made to mention all the aspects that affect affordability. In developing countries, the affordable and sustainable housing issue is vital. Executing a more cost-effective, accessible, and sustainable design architecture will solve some of these difficulties [43]. Also, the green affordable housing concept is helpful. The factors related to green buildings and their effects on environment preservation and life quality for all citizens are included in this concept [44]. Affordable housing is considered to be safe [45], mixed-income, and reasonably priced, and should meet maximum green building standards. The land market conditions, the labor presence or absence, and all material costs have an impact on housing production and price [5]. Factors investigated in suitability determination include topography, zoning, and availability of services [46]. According to statistics, in Ottawa, with every new affordable unit created, there is a loss of approximately seven existing affordable units. The reasons are the rise of inflation, less dense accommodation, and the prioritization of profit for developers [24]. According to the BC Housing Research Center, the keys to success in affordable housing are as follows:

1. Municipal tools;
2. Zoning and density bonus policy;
3. Decreasing costs by simplification agreements and other encouragers;
4. Partnership funding and alternative capital;
5. Design and operational savings;
6. Housing organization and building capacity;
7. Housing strategy;
8. Engagement and communication [47].

The most affordable houses are manufactured homes, modular homes, mobile homes, container houses, integrated dome roof houses, tiny homes, and modular homes. Smaller homes allow for increased density and in areas where land value is very high; this can create significant cost savings for buyers [48]. An interesting idea is homes created with

durable and energy-efficient materials and designed to be livable with little utility costs. Sustainability and affordability linkage could add significant value for both homeowners and the earth [6].

Esruq-Labin et al. have investigated the 20 criteria for affordable housing assessment. They have arranged these criteria into six groups: family's salary, finances, and lodgings, conveniences and services, protection and well-being, quality management, and Grow home [11]. Gonzalo Lizarralde and others (2009), in their book on the direction of Housing Affordability, have categorized the common patterns in informal settlements. They stated that affordable housing should be screened in different housing aspects such as evolution, aesthetics, materials, and function [49]. Some significant affordable housing goals include a decrease in home destitution, sustainable growth, diminishing movement of low-income families, and rental assistance [46]. One of the factors affecting housing costs is related to the construction duration. Fast methods must be used to decrease the construction time. In most cases, the use of new materials significantly reduces the load on the base, which makes it possible to use prefabricated, lightweight foundations [48,50,51].

Other considerations in affordable housing projects are plan creation, using local resources, building in phases, attention to mixed-income housing, designing for the future, being flexible [52], keeping it simple, maintenance planning, enough parking, prioritizing the preservation and rehabilitation [53], considering the use of existing assets, creating flexible local funds, developer subsidies, easing development regulations [54], encouraging old residents to participate in the program, focusing on energy efficiency [46], alternative development models instead of traditional methods [48], sustainable public houses, reducing the height of public houses, improving the laws, regulations, and standards, establishing the government approach to involve all parties to help solve problems, creating short streets with limited entry to residents' areas, creating a pedestrian path to support walkability, exploring the residents' needs, choosing natural and local construction materials, bringing nature inside the house, considering social aspects, and identifying residents' social needs [41]. Some criteria should be paid attention to in the affordable housing design, which will be used for the low-income groups. Previous studies presented that poor housing conditions directly signify poor social conditions. So, a correctly designed affordable mass housing project can provide owners with positive social situations [9]. Cost reduction is only one of the affordability concepts. Studies have shown that if the aesthetic needs of residents are not taken into consideration, costs will be imposed on the project in the future, which will destroy the affordability concept [47,55–57]. If, in the affordability concept, the costs that will be imposed in the future are also taken into consideration, it can be said that providing a dignified and complete life in housing is also a part of the affordable housing concept.

2.3. Selected Affordable Housing Studies

In the previous sections, explanations about housing and affordability and some effective criteria that can be effective were introduced. According to the research objectives, to identify cost-effective criteria, it is necessary to first identify all success-effective criteria.

In previous studies, it has been stated that paying attention to criteria and factors during planning, design, construction, and even operation can reduce costs and lead to the realization of concepts in the affordability definition. Therefore, with this approach, various processes that are mentioned in the studies are studied and analyzed and an attempt is made to collect these criteria, and after determining their importance, they can be used to provide solutions in subsequent research. Many studies have been conducted in recent years regarding affordable housing. But some of the most challenging cases are "What can be done to be effective in the final result of the project and reduce its cost" and "What are the effective criteria in reducing the cost of the project and how important is it?". Therefore, in this study, according to the mentioned problem, the questions and the purpose have been addressed. Table 1 shows some of the previous studies related to the subject, mostly conducted in 2022 and 2023.

Table 1. Previous research and gap analysis.

Ref.	Main Approach	Objectives	Methodology	Findings
[58]	Affordable housing and sustainable development	Identifying the most-used housing models in India	Primary and secondary research and survey form	Small apartments can be a good model
[24]	Affordable housing	Proposing an affordable housing model	Literature analysis and proposal presentation	This thesis proposes a housing model in Ottawa
[42]	Customization and affordability	Investigating the customization impact on affordable housing projects	Case studies and analysis by affordability approach	It is claimed that customization can be useful for affordable housing
[59]	Prefabrication in affordable housing projects	Proposing an affordable prefabricated housing system	Delphi survey and AHP	Using prefabs in the decision-making process
[8]	Affordable and sustainable housing	Providing affordable building through energy-saving approaches	Regression analysis	The relationship between systems in affordable housing and energy-saving
[43]	Affordable and sustainable housing	Affordable housing design by vernacular solutions	Data Analysis	Using vernacular architecture
[41]	Sustainable public housing	Analyzing socially sustainable programs	Review of the literature	Traditional housing methods
[53]	Mass housing	Customization in the housing industry	Literature analysis and proposal presentation	Proposing a framework based on emergent design technologies
[60]	Modern construction	Finding a solution by adopting a modern construction method	Interviews, case studies, and questionnaires	OSM is highly feasible due to its advantages
[61]	Reviewing the state of housing markets	Details and suggestions for more improvements	Survey	Learning from other sciences for housing design
[62]	Mitigating high development costs	Proffering possible policy solutions for housing	Qualitative data collection and analysis	Industrialized building systems
[12]	Analysis of the housing shortage strategies	Analysis of the factors that affect housing production	Interpretive approach and semi-structured interviews	Using modern construction methods
Current Study	**Cost reduction**	**Cost-effective criteria identification**	**Delphi & AHP technique underline and case study**	**Cost-effective criteria for housing projects**

The main goal of this research is the development of affordable mass housing solutions that can ultimately reduce design and construction costs. For this reason, there is a need to focus on effective measures that are documented and extracted from previous research. Therefore, previous research related to affordable mass housing was studied. In most of the studies, the political and economic issues of the government and the bank were investigated regarding reductions in housing construction costs. In this study, an attempt is made to identify the importance of the cost-effectiveness criteria in affordable housing projects.

3. Research Methodology

In this step, among the criteria that can be effective in the project's success, the criteria that can be effective in reducing the cost of the affordable mass housing project are identified, and their weight and importance are calculated. Figure 2 represents the different steps of the research method. Criteria were extracted from each article or study that was reviewed,

and finally, the questionnaire research method was used to analyze them. Therefore, at the beginning of this research, after reading the articles, gathering data, and analyzing them, 22 criteria were extracted.

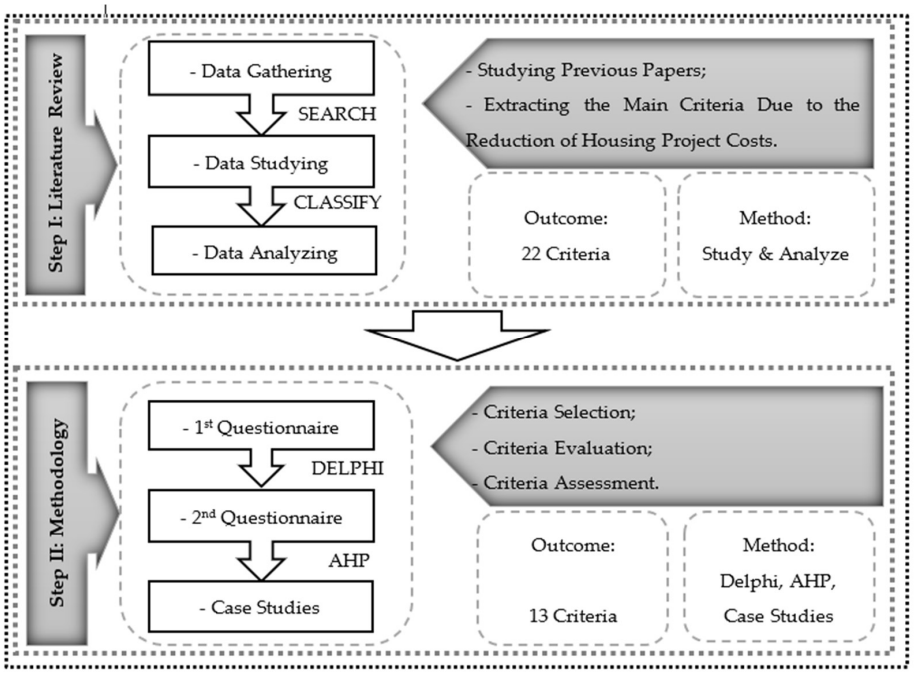

Figure 2. Research process.

In the first step of this research for extracting the criteria, the most important factor for selection and extraction was their consideration in the desired studies. At the end of this research, due to re-analyzing the importance of the criteria, 4 successful case studies are selected and the criteria importance is checked with the same concept as in the first steps, in these 4 cases.

After the literature review, related studies were selected and reviewed based on keywords (237 references). The keywords include affordable housing, sustainable housing, prefabricated housing, traditional construction methods, modern construction, local materials, vernacular materials, and vernacular architecture. References were analyzed. Studies with similar topics were removed and, finally, 129 references were analyzed descriptively and the criteria were derived. The steps of resource selection and criteria extraction are given in Figure 3.

To achieve the research goal, it is necessary to identify the criteria that can be effective in reducing cost among the criteria that can be effective in the project's success. So, experts' opinions are needed to score the criteria. Therefore, the qualitative questionnaire for the first step and the quantitative questionnaire for the second step were prepared and experts were selected to answer the questionnaire. Experts were selected with the following criteria:

1. Master's and Ph.D. degrees in architecture and civil engineering;
2. More than 10 years of practical experience in the field of construction projects;
3. Employment in construction and consulting companies with more than 10 years of experience;
4. Academic career, teaching at universities or other academic institutions.

According to the criteria set, among companies and individuals, 27 persons were approached. Of these 27 persons, 11 persons had experience of about 10–15 years building housing projects. Five experts had worked in first-class consulting companies for more than 10 years. Eight persons worked as contractors in project management and planning, and three persons had Ph.D. degrees and taught at universities. Questionnaires were given to these persons and they expressed their opinions regarding the importance of cost-effective

criteria. In total, 27 questionnaires were distributed and 19 responses were received. Therefore, the final statistical population was 19 persons. Table 2 lists the respondents' demographic data.

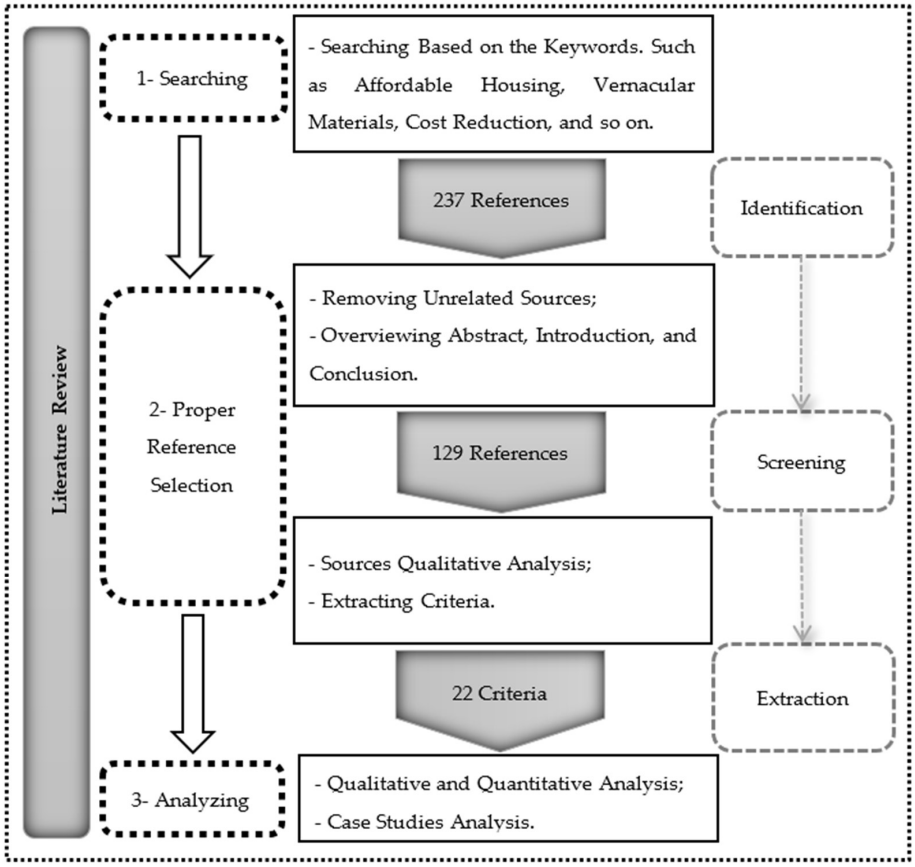

Figure 3. Reference selection and criteria extraction.

In the first step of the analysis, the Delphi method was chosen for this research, since it is a structured communication technique, developed as a systematic, interactive forecasting method that relies on a panel of experts. Delphi can also be used to help reach expert consensus [63]. After the first step, based on the evaluations and the analyzed answers, the second questionnaire was developed. The first questionnaire was for criteria selection and the second was for assessing the selected criteria. According to the results, a quantitative analysis of the criteria was needed. Therefore, a quantitative questionnaire was prepared in the second step and the experts were asked to express the importance of the criteria in the corresponding phase between 0 and 10. It should be noted that the questionnaire was provided to them in the form of a matrix. The goal in the second step was to obtain the weight of the criteria, and the objective was "cost reduction". Therefore, a matrix was prepared whose number of rows and columns was equal to the number of the criteria obtained from the first step. The AHP technique was used to analyze the received answers. With the AHP method, the importance of the criteria is compared through pairwise comparisons [63].

After this, 4 successful affordable housing projects were selected. Again, the experts were asked to give a percentage between 0 and 100 to signify the effect of the selected criteria on the success of these projects. After collecting the scores and calculating the average points for the criteria in each project, the weighted percentage of the criteria fulfillment in the projects was calculated using the averaging method and compared with the weighted percentage obtained from the previous stage. After analyzing the research

criteria and findings, the results were presented in the final section. In Figure 4, the steps of using the Delphi technique and then analyzing the data by the AHP technique are shown.

Table 2. Respondents' demographic information.

Categories	Categories' Sub	Frequency (Persons)	Percentage (%)
Gender	Male	11	57.89%
	Female	8	42.11%
Age	33–38	3	15.79%
	39–44	4	21.05%
	45–50	2	10.53%
	51–56	3	15.79%
	57–62	2	10.53%
	63–67	5	26.32%
Educational Level	Master's	12	63.16%
	Ph.D.	7	36.84%
Profession	Designer	5	26.32%
	Constructor	8	42.11%
	Planner	6	31.58%
Years of Experience	6–12	5	26.32%
	13–19	3	15.79%
	20–26	6	31.58%
	27–33	5	26.32%

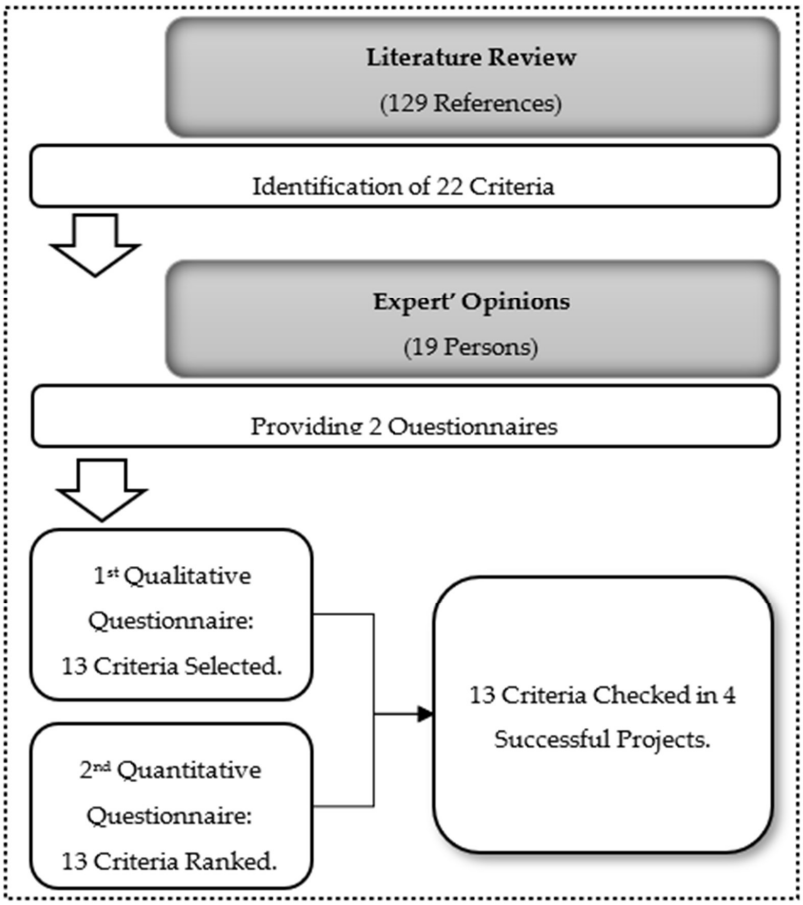

Figure 4. Criteria extraction process.

4. Data Analysis

Based on the literature review, 22 criteria were identified. For criteria identification, the qualitative questionnaire of the first step was prepared with 22 criteria and the main question "Are the following criteria, effective in the success of the housing project with the goal of affordability?". The selected 22 criteria are shown in Table 3.

Table 3. Effective criteria in affordable housing projects.

Code	Criteria	Criteria Description	Benchmark	References
C01	Project's location	The project's distance from the city	City Suburb: More than 5 km Village	[5,6,24,64–67]
C02	Project's scale	The number of units provided	1 unit 1–10 units Mass housing	[5,11,24,58,64]
C03	Materials	Type of materials used at different stages	Traditional and vernacular Modern A combination of both	[5,11,35,50]
C04	Budget	Government helps in different sectors	Using government budget Semi-using government budget Not using the government budget	[46,50,64,68–73]
C05	Number of floors	The number of floors and type of structure	Low rise (1–2 floors) Moderate (3–5 floors) High rise (more than 10 floors)	[35,50,74,75]
C06	The target group	Amount of family's income	Low income Mixed-income High income	[6,41,55,68,76–78]
C07	Future development	Considering future project developments	Considering Semi-considering Not considering	[6,11,46,47,79–82]
C08	Novel technologies	Use of new technologies in the design and construction	Using Semi-using Not using	[50,64,83–95]
C09	Facilities and infrastructures	Considering infrastructure and facilities planning	Attention Semi-attention No attention	[19,24,41,59,96–99]
C10	Biological needs	Attention to people's needs in decision-making, design, and construction	Attention to basic needs Failure to pay attention to basic needs	[11,24,41,55,59,100–103]
C11	Modularity	Using modular or a completely different design	Modular design Semi-modular Different design	[5,50,64,68,84–86,104–111]
C12	Principles of visual aesthetics	Attention to the principles of aesthetics in design	Attention Semi-attention No attention	[47,55–57,112]
C13	Culture	Attention to culture's effect on design	Attention Semi-attention No attention	[56,59,64,113–119]

Table 3. *Cont.*

Code	Criteria	Criteria Description	Benchmark	References
C14	Optimal use of land	Attention to not wasting land	Attention	[11,24,46,50,120]
			Semi-attention	
			No attention	
C15	Contextual design	Design based on project site specifications	Attention	[24,41,56,57,59,121–124]
			Semi-attention	
			No attention	
C16	Car and people's access	Pedestrians and cars access quality	Bad	[6,19,35,41,46,125]
			Medium	
			Good	
C17	Employment	Create job opportunities for the residents	Yes	[5,46,50,68,69,126]
			So-so	
			No	
C18	Construction method	The method considered for construction	Traditional	[11,35,50,96,126–128]
			Modern	
			A combination of both	
C19	Prefabrication	Using different prefab methods	Completely prefabricated	[83–86,110,129–138]
			Semi-prefabricated	
			Construction at the site	
C20	Energy consumption	The amount of energy consumption	The construction is completely based on the principles of saving energy	[9,11,43,47,50,56,139–148]
			Failure to pay attention to saving energy	
			Incomplete attention	
C21	Project implementation cost	The project implementation cost according to the design and planning	Low cost	[5,46,51,59,69,96,143,149–152]
			Medium cost	
			High cost	
C22	Climatic design	Paying attention to the climate and complying with its principles in design	Attention	[9,41,43,56,59,141,142,153–158]
			Semi-attention	
			No attention	

Three columns were placed for each criterion: Yes, No, and the column of experts' opinions. They were also asked to express their opinion in summary regarding the criteria, and the Delphi technique was used in four rounds to analyze their answers. In the first round, out of 22 criteria, 3 criteria received 18, 19, and 18 negative responses out of a total of 19 responses. Therefore, they were removed from the list and the second round was carried out with 19 criteria. In the second round, four criteria received 17, 16, 18, and 16 negative responses and were removed. The third round started with the remaining 15 criteria, and 2 criteria with 16, and 15 negative answers were eliminated, and 13 criteria remained for the last round. In the fourth round, all 13 criteria received positive responses and 19 experts reached a consensus regarding the positive impact of these criteria. Therefore, 13 criteria were selected to prepare the next questionnaire. In Figure 5, the use of the Delphi technique to analyze the qualitative questionnaire of the first step is shown.

After the fourth round, all the experts had a consensus opinion on the remaining criteria and believed that paying attention to these and complying with their related requirements could reduce the housing project costs. In Table 4, the experts' answers are shown.

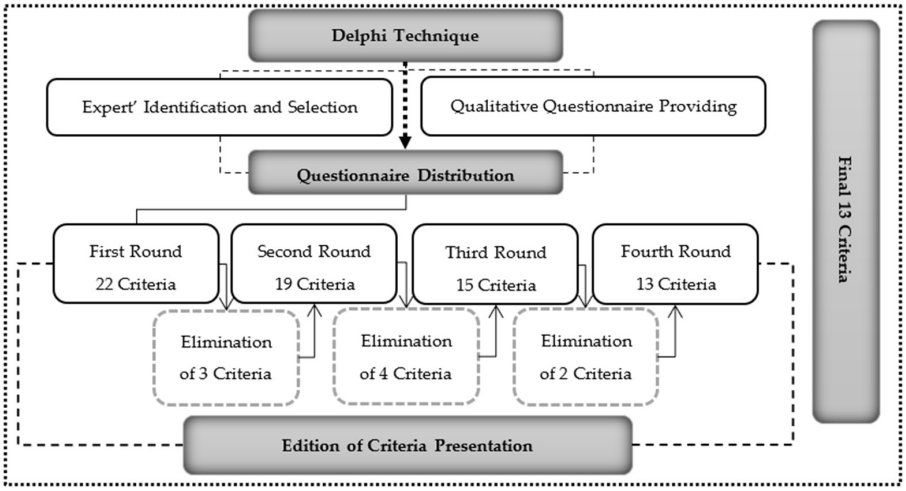

Figure 5. Delphi method for first qualitative questionnaire.

Table 4. Selected criteria based on the experts' views (Delphi technique).

Code	Criteria	1st Round	2nd Round	3rd Round	4th Round
C01	Project's location	✓	×	×	×
C02	Project's scale	✓	✓	✓	✓
C03	Materials	✓	✓	×	×
C04	Budget	✓	✓	✓	✓
C05	Number of floors	✓	✓	✓	✓
C06	The target group	✓	×	×	×
C07	Future development	✓	✓	✓	✓
C08	Novel technologies	✓	✓	✓	✓
C09	Facilities and infrastructures	✓	✓	✓	✓
C10	Biological needs	×	×	×	×
C11	Modularity	✓	✓	✓	✓
C12	Principles of visual aesthetics	×	×	×	×
C13	Culture	×	×	×	×
C14	Optimal use of land	✓	✓	✓	✓
C15	Contextual design	✓	×	×	×
C16	Car and people's access	✓	×	×	×
C17	Employment	✓	✓	✓	✓
C18	Construction method	✓	✓	✓	✓
C19	Prefabrication	✓	✓	×	×
C20	Energy consumption	✓	✓	✓	✓
C21	Project implementation cost	✓	✓	✓	✓
C22	Climatic design	✓	✓	✓	✓

✓ means confirmation of criteria on the round and × means elimination of criteria on the round.

At the end of each round and before the next, the experts' opinions were applied to the remaining criteria. In Table 5, the selected criteria and their changes are shown. After these changes and in the next steps of analysis, the new corresponding phrases of criteria are used.

According to the results of the first step, and the research question "What are the effective criteria for reducing design and construction costs in a housing project?", quantitative analysis of the criteria was needed. So, a 13 × 13 matrix was prepared to compare two pairs of criteria with each other to determine the criteria weight (CW) and was provided to the experts, and the experts were asked to rate the importance of each criterion between the numbers 1 and 10. It was also explained to them that the importance degree of C1 to C2 is the inverse of the importance degree of C2 to C1. Nineteen experts responded to the questionnaire, and as a result, their average scores were calculated for each cell and placed in the left table's cells of Figure 6. The average calculated in each column is summed together and placed in the last row of the left table. The decimal numbers in the cells of the left table are because these numbers are the average of 19 points given by experts. Finally, the CWs and CRs (Criteria Ranks) were obtained using the AHP technique. In the matrix

of the right table of Figure 6, the final results of AHP calculations are placed. In the cells of the right table, the average weight of each criterion (from the left table's cells) is divided by the sum of the weights (from the last row of the left table), and the result is placed in the cell. Also, in the last row of the right table, the obtained weights are added together, which can be seen to be equal to one. In the column "Average of Rows", the sum of the weights of each criterion in the row is divided by the number 13, which is the number of criteria, and the average CW is obtained based on the AHP technique. After calculating the CW, the rank of each criterion was determined. The criterion with the highest weight was ranked 1 and the criterion with the lowest weight was ranked 13. The Consistency Index (CI) of this matrix was calculated. The CI was 0.00095366 and the CR was 0.00061526.

Table 5. Corresponding phrases of criteria after expert consensus.

No.	Code	Criteria	Corresponding Phrase
01	C02	Project's scale	Number of provided units
02	C04	Budget	The type of provided financial resources
03	C05	Number of floors	Complexity of structural requirements
04	C06	Future development	Opportunities for future development
05	C07	Novel technologies	Implementation depended on the non-skilled workforce
06	C08	Facilities and infrastructures	Optimum function for land in the design process
07	C11	Modularity	Using industrial construction
08	C14	Optimal use of land	Considering landscape in the design process
09	C17	Employment	Opportunities for future residents' employment
10	C18	Construction method	Application of vernacular material and methods
11	C20	Energy consumption	Compliance of design with optimum energy consumption
12	C21	Project implementation cost	Applying value engineering in the design process
13	C22	Climatic design	Design compliance with local climate

	Criteria Code	C02	C04	C05	C06	C07	C08	C11	C14	C17	C18	C20	C21	C22
Criteria Code	Objective: Cost Reduction in Housing Projects	Number of provided units	The type of provided financial resources	Complexity of structural requirements	Opportunities for future development	Implementation depended on non-skilled workforce	Optimum function for land in the design process	Using industrial construction	Considering landscape in the design process	Opportunities for future residents' employment	Application of vernacular material and methods	Compliance of design with optimum energy consumption	Applying value engineering in the design process	Design compliance with local climate
C02	Number of provided units	1.00	0.77	0.59	0.50	0.91	0.33	0.67	0.83	1.11	0.17	0.10	0.42	0.25
C04	The type of provided financial resources	1.30	1.00	0.77	0.67	1.25	0.45	0.91	1.11	1.43	0.22	0.11	0.56	0.33
C05	Complexity of structural requirements	1.70	1.30	1.00	0.91	1.67	0.56	1.11	1.43	2.00	0.29	0.14	0.71	0.43
C06	Opportunities for future development	2.00	1.50	1.10	1.00	2.00	0.67	1.43	1.67	2.00	0.33	0.17	0.83	0.50
C07	Implementation depended on non-skilled workforce	1.10	0.80	0.60	0.50	1.00	0.36	0.71	0.91	1.25	0.18	0.10	0.45	0.27
C08	Optimum function for land in the design process	3.00	2.20	1.80	1.50	2.80	1.00	2.00	2.50	3.33	0.50	0.25	1.25	0.77
C11	Using industrial construction	1.50	1.10	0.90	0.70	1.40	0.50	1.00	1.25	1.67	0.25	0.13	0.63	0.37
C14	Considering landscape in the design process	1.20	0.90	0.70	0.60	1.10	0.40	0.80	1.00	1.25	0.20	0.10	0.50	0.30
C17	Opportunities for future residents' employment	0.90	0.70	0.50	0.50	0.80	0.30	0.60	0.80	1.00	0.15	0.10	0.38	0.23
C18	Application of vernacular material and methods	6.00	4.50	3.50	3.00	5.50	2.00	4.00	5.00	6.50	1.00	0.50	2.50	1.67
C20	Compliance of design with optimum energy consumption	10.00	9.00	7.00	6.00	10.00	4.00	8.00	10.00	10.00	2.00	1.00	5.00	3.33
C21	Applying value engineering in the design process	2.40	1.80	1.40	1.20	2.20	0.80	1.60	2.00	2.60	0.40	0.20	1.00	0.59
C22	Design compliance with local climate	4.00	3.00	2.30	2.00	3.70	1.30	2.70	3.30	4.30	0.60	0.30	1.70	1.00
Total		36.1	28.569	22.157	19.076	34.326	12.667	25.53	31.799	38.44	6.2936	3.1956	15.934	10.052

	Criteria Code	C02	C04	C05	C06	C07	C08	C11	C14	C17	C18	C20	C21	C22	Total of rows	Average of rows CW	Criteria Rank CR	Weighted Sum Vector WSV	Consistency Vector
Criteria Code	Objective: Cost Reduction in Housing Projects	Number of provided units	The type of provided financial resources	Complexity of structural requirements	Opportunities for future development	Implementation depended on non-skilled workforce	Optimum function for land in the design process	Using industrial construction	Considering landscape in the design process	Opportunities for future residents' employment	Application of vernacular material and methods	Compliance of design with optimum energy consumption	Applying value engineering in the design process	Design compliance with local climate					
C02	Number of provided units	0.0277	0.0269	0.0265	0.0262	0.0265	0.0263	0.0261	0.0262	0.0289	0.0265	0.0313	0.0261	0.0249	0.3502	0.0269	12	0.3504	13.0061
C04	The type of provided financial resources	0.036	0.035	0.0347	0.0349	0.0364	0.0359	0.0356	0.0349	0.0372	0.0353	0.0348	0.0349	0.0332	0.4588	0.0353	9	0.4592	13.0118
C05	Complexity of structural requirements	0.0471	0.0455	0.0451	0.0477	0.0486	0.0439	0.0435	0.0449	0.052	0.0454	0.0447	0.0448	0.0433	0.5965	0.0459	7	0.5968	13.0070
C06	Opportunities for future development	0.0554	0.0525	0.0496	0.0524	0.0583	0.0526	0.056	0.0524	0.052	0.053	0.0522	0.0523	0.0497	0.6884	0.0530	6	0.6891	13.0128
C07	Implementation depended on non-skilled workforce	0.0305	0.028	0.0271	0.0262	0.0291	0.0282	0.028	0.0286	0.0325	0.0289	0.0313	0.0285	0.0269	0.3738	0.0288	11	0.3739	13.0030
C08	Optimum function for land in the design process	0.0831	0.077	0.0812	0.0786	0.0816	0.0789	0.0783	0.0786	0.0867	0.0794	0.0782	0.0784	0.0765	1.0368	0.0798	4	1.0377	13.0104
C11	Using industrial construction	0.0416	0.0385	0.0406	0.0367	0.0408	0.0395	0.0392	0.0393	0.0434	0.0397	0.0391	0.0392	0.0368	0.5144	0.0396	8	0.5147	13.0082
C14	Considering landscape in the design process	0.0332	0.0315	0.0316	0.0315	0.032	0.0316	0.0313	0.0314	0.0325	0.0318	0.0313	0.0314	0.0301	0.4113	0.0316	10	0.4117	13.0129
C17	Opportunities for future residents' employment	0.0249	0.0245	0.0226	0.0262	0.0233	0.0237	0.0235	0.0252	0.026	0.0244	0.0313	0.0241	0.0231	0.3229	0.0248	13	0.3230	13.0063
C18	Application of vernacular material and methods	0.1662	0.1575	0.158	0.1573	0.1602	0.1579	0.1567	0.1572	0.1691	0.1589	0.1565	0.1569	0.1658	2.0781	0.1599	2	2.0806	13.0152
C20	Compliance of design with optimum energy consumption	0.277	0.315	0.3159	0.3145	0.2913	0.3158	0.3134	0.3145	0.2601	0.3178	0.3129	0.3138	0.3316	3.9937	0.3072	1	4.0040	13.0335
C21	Applying value engineering in the design process	0.0665	0.063	0.0632	0.0629	0.0641	0.0632	0.0627	0.0629	0.0676	0.0636	0.0626	0.0628	0.0585	0.8235	0.0633	5	0.8241	13.0097
C22	Design compliance with local climate	0.1108	0.105	0.1038	0.1048	0.1078	0.1026	0.1058	0.1038	0.1119	0.0953	0.0939	0.1067	0.0995	1.3517	0.1040	3	1.3529	13.0120
Total		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	13.0000	1.0000			

Each criterion in each cell has scored 19 points from 19 experts compared to other criteria. The average of these 19 points is calculated and placed in the corresponding cell.

λ max: 13.0114439
n: 13 , RI: 1.55
CI: (λmax - n) / (n-1) = 0.00095366
CR: CI /RI = 0.00095366 / 1.55 = 0.00061526

Figure 6. AHP technique and final CWs and CRs. CI: 0.00061526.

In Table 6, the weights, ranks, and weighted percentages of the criteria are displayed. Based on this analysis method, it was determined that the criteria complied with their related regulations and that many percentages can be effective in fulfilling the cost reduction objective.

Table 6. The CWs, CRs, and weighted percentages were extracted from the AHP analysis.

Code	Criteria	CW	CR	W Percentage
C20	Compliance of design with optimum energy consumption	0.3072	1	30.72%
C18	Application of vernacular material and methods	0.1599	2	15.99%
C17	Design compliance with local climate	0.1040	3	10.40%
C08	Optimum function for land in the design process	0.0798	4	7.98%
C21	Applying value engineering in the design process	0.0633	5	6.33%
C06	Opportunities for future development	0.0530	6	5.30%
C05	Complexity of structural requirements	0.0459	7	4.59%
C11	Using industrial construction	0.0396	8	3.96%
C04	The type of provided financial resources	0.0353	9	3.53%
C14	Considering landscape in the design process	0.0316	10	3.16%
C07	Implementation depended on the non-skilled workforce	0.0288	11	2.88%
C02	Number of provided units	0.0269	12	2.69%
C17	Opportunities for future residents' employment	0.0247	13	2.47%

Before, it was stated that to further check the validity of the identified criteria, it is necessary to analyze them in successful affordable housing projects. Thus, four projects were selected. The most important reason for selecting the cases was the project target group. Since one of the most important objectives of affordable housing projects is to meet the needs of the low-income group [7,8,42,159–165], it was searched with this goal, and the following four projects were selected:

1. Miner's Township (Morocco, Tinghir, 1987–2000, by Taibi Jaadri) [166];
2. Aranya Low-Cost Housing (India, Indore, 1983, by Balkrishna Doshi) [167];
3. Niamey 2000 (Niger, Niamey, 2016, by United 4 Design Co.) [168];
4. Gourna Village (Egypt, Gourna-Luxor, 1945, by Hasan Fathi) [169], Figure 7.

Figure 7. From left to right: Miner's Township, Aranya Low-Cost Housing, Niamey 2000, and Gourna Village (ArchDaily).

As mentioned in the data analysis in the last stage, 19 experts who participated in answering the questionnaires in the initial stages were asked to state the level of attention to the final criteria in the selected projects and to say how much the percentage of this attention affected the project's success.

After collecting the responses, the percentages of each criterion for each project were summed together and divided by 19, and the average percentages are shown in Table 7. The table that had been provided to the experts was prepared as follows. The criteria were placed in the table's rows and the projects were in the columns. In each cell, the experts scored the effect percentage of paying attention to the mentioned criteria on the project's success and cost-effectiveness, and the averages of 19 points obtained for each cell are shown in Table 7.

In Table 6, in addition to each criterion weight given in the third column, the weighted percentage of the criterion is also calculated and placed in the fifth column. In Table 7, the impact percentage of each criterion on the cost-effectiveness and success of the mentioned project was also calculated, and since four case studies were examined in this research, four numbers were obtained for each criterion. For example, the impact of the criterion "Compliance of design with optimum energy consumption" in the success of the "Miner's

Township" was 5.25%, in "Aranya Low-Cost Housing", it was 2.74%, in "Niamey 2000", it was 4.62%, and in "Gourna Village", it was 3.35%. These numbers are the average of the 19 experts' opinions, and the method of calculation was explained in the previous paragraph. The average of these four numbers was obtained and placed in the seventh column of Table 7. In Table 8, the calculated weighted percentage of criteria based on the AHP technique is in the second column, the weighted percentage calculated based on case studies is placed in the fourth column, and the average of both numbers is given in the sixth column. Finally, based on the percentages of the average of the sixth column, the results of the research are stated in the Conclusion section.

Table 7. Case study analysis using selected criteria.

Code	Criteria	Miner's Township	Aranya Low-Cost Housing	Niamey 2000	Gourna Village	Percentage	Rank
		Average of Experts' Score					
C20	Compliance of design with optimum energy consumption	5.25%	2.74%	4.62%	3.35%	**15.96%**	2
C18	Application of vernacular material and methods	8.21%	9.03%	6.95%	3.64%	**27.83%**	1
C17	Design compliance with local climate	4.62%	3.34%	1.69%	2.51%	**12.16%**	3
C08	Optimum function for land in the design process	2.01%	1.84%	2.73%	1.78%	**8.36%**	5
C21	Applying value engineering in the design process	2.98%	1.96%	3.01%	3.61%	**11.56%**	4
C06	Opportunities for future development	1.65%	1.54%	1.23%	1.14%	**5.56%**	7
C05	Complexity of structural requirements	0.95%	2.03%	1.01%	0.53%	**4.52%**	8
C11	Using industrial construction	1.72%	1.86%	2.14%	1.07%	**6.79%**	6
C04	The type of provided financial resources	0.32%	0.47%	0.52%	0.15%	**1.46%**	10
C14	Considering landscape in the design process	0.82%	0.96%	0.72%	0.71%	**3.21%**	9
C07	Implementation depended on the non-skilled workforce	0.37%	0.21%	0.19%	0.18%	**0.95%**	12
C02	Number of provided units	0.37%	0.28%	0.38%	0.29%	**1.32%**	11
C17	Opportunities for future residents' employment	0.09%	0.11%	0.07%	0.05%	**0.32%**	13

Table 8. Comparing the resulting criteria of AHP and case study analysis.

Code	AHP Analysis		Case Study		Score Aggregation
	Score	Ranking	Score	Ranking	
C20	30.72%	1	15.96%	2	23.34%
C18	15.99%	2	27.83%	1	21.91%
C17	10.40%	3	12.16%	3	11.28%
C08	7.98%	4	8.36%	5	8.17%
C21	6.33%	5	11.56%	4	8.95%
C06	5.30%	6	5.56%	7	5.43%
C05	4.59%	7	4.52%	8	4.56%
C11	3.96%	8	6.79%	6	5.38%
C04	3.53%	9	1.46%	10	2.50%
C14	3.16%	10	3.21%	9	3.19%
C07	2.88%	11	0.95%	12	1.92%
C02	2.69%	12	1.32%	11	2.01%
C17	2.47%	13	0.32%	13	1.40%

Figure 8 shows the comparison of the analysis results in the two steps of AHP and case study analysis. The factor that has been compared in these two methods is "The criteria impact importance in the housing projects cost reduction".

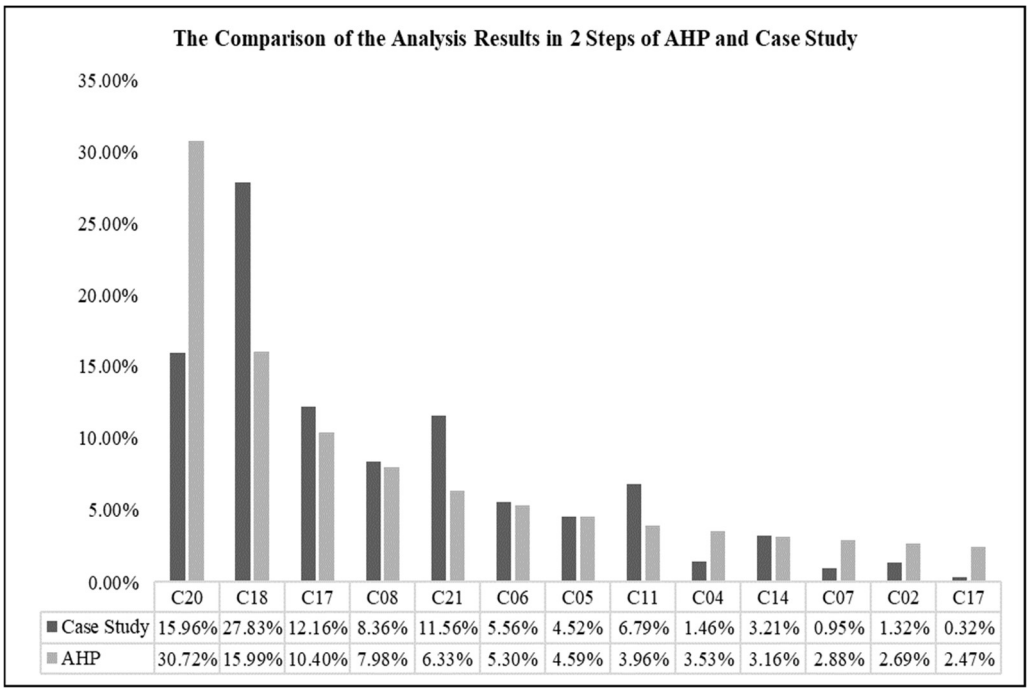

Figure 8. Comparing the success rate of criteria in 2 methods.

In Table 8, the percentages and ranks calculated in the second and third stages are compared. Criteria C20 and C18 have been replaced. Criterion C17 has the same rank as the second stage, and criteria C8 and C21 have been replaced. Criterion C11 has become more important and has been upgraded from rank 8 to rank 6, and criteria C6 and C5 have been reduced by one grade each. Criteria C4 and C14 and criteria C7 and C2 have been replaced with each other, and criterion C17 has remained in place. In the last column of Table 8, the score aggregation is given. The smaller the total number, the more important the criterion. In the last section, the results of the descriptive analysis of the findings are given.

The results of the table show that criteria C20, C18, and C17, which are related to climatical architecture and energy storage, have the most positive impact on the success of

affordable housing projects. The total score of these three criteria is 57.11%. Therefore, paying attention to the requirements of energy storage and design according to the principles of climatical architecture of the region is an important issue that should be considered.

5. Conclusions

In conclusion, the escalating cost of designing new buildings has created economic barriers that exclude many potential housing applicants. Innovative practices like prefabrication and re-engineering tools offer solutions to financial and resource challenges. To create affordable architecture, it is crucial to blend valuable patterns, reinterpret them, and produce region-specific designs reflecting local characteristics and traditions. Housing issues should be addressed holistically, recognizing their interconnectedness with broader country-specific concerns. Traditional construction methods fall short of providing practical solutions for low-income housing. This research identified success criteria for housing projects, studying the literature and employing the Delphi technique with expert input. Emphasizing energy conservation, vernacular architecture principles, and materials sourced locally can significantly reduce housing project costs. Proper land use, economic planning, and consideration of future development contribute to project success. Simple construction methods, government financial support, and attention to infrastructure design further impact cost reduction. Additionally, adopting uncomplicated techniques, providing non-skilled labor opportunities, and generating employment for future residents contribute to achieving affordability goals. The literature review and case study analysis underscore that implementing vernacular solutions enhances a project's identity and resident satisfaction, fostering affordability. Proposing a local, environmentally friendly architectural housing concept aligns with user needs, energy conservation, and sustainable development. Urban housing planning approaches must be reevaluated to align with contemporary sustainable architecture, integrating traditional vernacular practices. Advocating for a local and environmentally conscious housing concept allows users to align with energy conservation, limited resources, and sustainable development. Urban housing planning approaches should be revised to align with contemporary sustainable architecture, emphasizing the continuity of traditional vernacular practices. Understanding the indicators of vernacular and traditional housing in different climates is essential, followed by adapting these features to meet contemporary needs in the modern world.

Author Contributions: Conceptualization: A.F. and T.M.H.A.; Methodology: A.F., T.M.H.A., S.H.A., E.G. and P.R.; Software: A.F. and T.M.H.A.; Validation: A.F., T.M.H.A., S.H.A., E.G. and P.R.; Formal analysis: A.F., T.M.H.A., S.H.A., E.G. and P.R.; Investigation: A.F. and T.M.H.A.; Resources: A.F., T.M.H.A., S.H.A., E.G. and P.R.; Data curation: A.F., T.M.H.A., S.H.A., E.G. and P.R.; Writing—original draft preparation: A.F. and T.M.H.A.; Writing—review, and editing: A.F., T.M.H.A., S.H.A., E.G. and P.R.; Visualization: A.F. and T.M.H.A.; Supervision: A.F., T.M.H.A., S.H.A., E.G. and P.R.; Project administration: A.F. and P.R.; Funding acquisition: P.R. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no internal or external funding from any commercial or noncommercial source.

Data Availability Statement: All data, models, and code generated or used during the study appear in the submitted article.

Conflicts of Interest: The authors declare no conflict of interest.

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