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| RESEARCH ARTICLE

Effective Factors in Applying Sustainable Design to Architectural Projects: Shiraz Case

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| ABSTRACT

There is currently significant interest in the concept of sustainability. Sustainable architecture often serves as a symbol of sustainability in contemporary cities. The negative environmental impacts of buildings are worsening, making it crucial to find ways to minimize these effects and maximize the use of sustainable building materials. Architects and builders use various construction methods to reduce the environmental impact of structures. In architectural practice, the three core principles of sustainability—social, economic, and environmental factors—are often overlooked by architects during the design phase. Furthermore, sustainability has not been prioritized in architectural education and practice. Given the growing construction activities to meet Shiraz's development needs, applying sustainable design principles is a necessity. The aim of this study is to examine how sustainable design principles are applied by architects in Shiraz in their projects. To this end, 106 building architects were surveyed using a questionnaire. The data was analyzed using SPSS software and Pearson correlation coefficient. The study's results revealed that a significant number of architects apply sustainable design principles in their projects. Additionally, economic and environmental factors were identified as the most important considerations for implementing sustainable design principles in architectural projects, according to respondents. Statistical analysis also indicated a meaningful relationship between awareness of architectural concepts and their implementation in architectural projects.

| KEYWORDS:

Sustainable design principles, Renewable energy, Economic considerations, Environmental considerations, Shiraz city

| ARTICLE INFORMATION

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1- Introduction

The unprecedented growth of the global population and rapid urbanization have placed increasing pressure on the architecture and construction sectors to support sustainable development through resilient and environmentally friendly buildings and infrastructure [1]. Population growth, particularly in emerging regions, combined with accelerated rural-to-urban migration, has led to increased resource demand and sustainability challenges [2,3].

Sustainable development goals are widely pursued worldwide, and the architecture, engineering, and construction industries have also sought to develop strategies to achieve these objectives [4]. The goal of sustainable architecture is to reduce environmental impacts, enhance energy efficiency, and promote sustainable living through principles such as energy efficiency, resource conservation, and improved indoor environmental quality. Sustainable architecture offers multifaceted benefits, encompassing environmental, economic, and social dimensions. However, it also faces challenges, such as higher initial costs, regulatory barriers, and technical complexities. Despite these limitations, future trends and innovations in sustainable materials, design approaches, and policy advocacy are promising.

Thosiac' study explored sustainable architecture, discussing various design strategies and technologies, including the use of renewable energy systems and smart building technologies. The findings highlighted the necessity of sustainable architecture in

addressing environmental and social challenges, paving the way for a more sustainable and resilient built environment [5]. Sustainable architecture integrates methods for energy production and conservation within buildings to provide a clean and affordable energy source for continuous use [6].

Sustainable development refers to meeting the needs of the present society without compromising the ability of future generations to meet their own needs [7]. Under global changes and accompanying climate impacts, as well as resource scarcity due to human misuse of the environment and the influence of lifestyle on the ecosystem, architecture has emerged as one of the most influential industrial environments affecting life and surrounding ecosystems. Architects increasingly adopt environmental design, incorporating the interaction of architecture and the environment into architectural formation. This approach views buildings as living entities in harmony with the environment, utilizing sustainability strategies in architectural composition and integration [8].

The concept of sustainability emphasizes the efficient and balanced use of resources and capabilities, both environmentally and architecturally. It involves addressing current needs without jeopardizing the ability of future generations to meet their own [9]. Sustainability in architectural design entails the intentional design of buildings and environments by architects and other professionals in the construction industry to implement social, economic, and ecological sustainability principles. Fundamentally, architectural design for sustainability aims to minimize the environmental impact and energy consumption of buildings. Failing to integrate sustainable approaches as a core design principle during the early design stages negatively impacts the design outcomes [10].

According to UNESCO and the International Union of Architects, architectural design must incorporate factors that affect the built environment and how it is designed, planned, landscaped, and maintained. In this regard, deep knowledge of the connection between architecture and sustainable development is essential, as the relationship between architecture and sustainability forms the foundation for achieving an environment free of excessive natural resource consumption. Any architectural design without integrating sustainability contributes approximately 50% to the exploitation of natural resources [11]. Architects must reduce energy use and carbon technologies through sustainable architectural design principles. Achieving this requires shifting the current architectural design paradigm toward sustainability [12].

The design of a building can have a direct impact on how we absorb, learn, and interact with others. A building holds the potential to educate and convey new methods through which sustainable principles are realized. In this way, architects take on the role of educators, as their designs stimulate users to utilize spaces optimally [13].

The goal of sustainable design is to create living environments that minimize human material use and greenhouse gas emissions, thereby reducing adverse effects on the environment, health, and comfort of building occupants. Today, sustainability is a fundamental necessity in architectural design [14]. Architects play a pivotal role in implementing advanced strategies to reduce energy consumption in office buildings, including the integration of renewable energy sources such as solar and wind power [15].

As noted [16], architects in recent times have increasingly embraced sustainability principles in their designs, moving beyond conventional approaches to integrate green building technologies, passive design strategies, and renewable energy systems to minimize environmental impacts.

Given that buildings are a major contributor to greenhouse gas emissions, architects, as key players in the construction industry, bear the responsibility of addressing these issues. This involves not only designing for aesthetics but also incorporating sustainable design principles into their projects to help create a built environment that reduces ecological impacts.

Sustainable architecture integrates energy efficiency, resource conservation, site selection, passive design strategies, renewable energy sources, and occupant well-being into the design process [17]. However, incorporating these principles at the ideation stage of a project requires thorough consideration, as it significantly shapes space utilization, material selection, and operational impacts.

Factors such as gaps in specialized knowledge, regulatory constraints, and client preferences hinder the mainstream adoption of green building expertise by key decision-makers like architects [18]. This can create a disconnect between industry aspirations and the realities surrounding sustainability commitments. Limited evaluations exist that examine the alignment between academic exposure and practical workflows regarding green integration in building life cycles. Despite advancements, gaps in understanding the architectural community's readiness for sustainability commitments, organizational capacities, and field-level implementation barriers emphasize the value of targeted evaluations based on sustainability.

Additionally, aspects such as the ability to adapt to regulatory changes, client engagement skills, upskilling capacities, and readiness to adopt technology warrant thorough investigation. This backdrop underscores the importance of specialized, urban-focused research that explores formal sustainability commitments and the readiness of designers.

The selection of Shiraz as the focus of this study is due to several notable reasons. Shiraz, as a rapidly growing urban center with the highest concentration of architects in southern Iran, faces mounting pressure on its built environment and natural resources. The city's architectural landscape is undergoing significant transformation, making it an ideal case study for examining the integration of sustainable practices. Moreover, Shiraz serves as a representative example of the challenges and opportunities faced by Iranian cities in adopting sustainable architecture. As such, this study provides insights that can potentially be applied to similar urban contexts across Iran.

Therefore, the aim of this paper is to explore the role of architects in integrating sustainability principles into architectural design within the metropolitan area of Shiraz, Iran.

To achieve the above objective, the following goals were pursued:

- Examining the percentage of sustainable design principles applied in architectural projects in Shiraz, with a focus on resource efficiency and the use of renewable energy.
- Investigating the factors influencing the adoption of sustainable design principles in implementing architectural practices, including changes in design methods and consideration of environmental aspects.

The hypothesis examined in this study is that there is no significant relationship between awareness of sustainable design concepts in architecture and architectural design performance in Shiraz.

2-Literature Review

The current conditions and the need for effective sustainable solutions to global climate change issues have brought significant challenges to the architecture profession, calling for transformation and adaptation. [11]
Architects must deepen their understanding of sustainability principles while creating and transforming spaces into more energy-efficient buildings. [19]
To implement sustainability as a fundamental aspect throughout a building's lifecycle, sustainable principles must be integrated into architectural design. [20]

According to Margarida and Miguel, the principle of architectural design should be rooted in flexibility and inclusive planning, aligned with the goal of sustainable development. The design phase, as the first decision-making stage in any building project, has a significant impact on the building's performance throughout its lifecycle. Therefore, the architectural design principle or concept employed by architects should be based on sustainability principles. [11]

This can be achieved through the introduction and implementation of strategies such as deconstruction, passive design, adaptive design, and human-centered comfort design as a foundational architectural principle. The aim is to use these architectural concepts as sustainable tools to reduce energy consumption in buildings. [21, 22]

The findings in ref [23] revealed that stakeholders in sustainable architecture, including architects, builders, policymakers, and consumers, must collaborate to advance the use of green building materials. Policymakers should establish supportive regulations and incentives to encourage the adoption of sustainable practices. Builders and architects need to stay informed about the latest material innovations and incorporate them into their projects. Consumers play a critical role by demanding and supporting sustainable building practices. These collective efforts drive the transition toward more sustainable construction practices, fostering a healthier environment and contributing to the overarching goal of sustainability in architecture.

3- Principles of Sustainable Architecture

Sustainable architecture includes a design philosophy focused on minimizing the environmental footprint of buildings, improving energy efficiency, and enhancing the health and well-being of occupants [24, 25]. The principles of sustainable architecture are guided by three main domains: reducing environmental impacts, energy efficiency, and health and well-being. One of the key principles of sustainable architecture is minimizing resource consumption, which involves the more efficient use of materials and resources throughout the lifecycle of a building, from construction to demolition. Sustainable design prioritizes the use of renewable, recycled, and upcycled materials to reduce the demand for virgin resources [26]. For example, incorporating recycled steel or reclaimed wood not only conserves natural resources but also reduces the environmental impacts associated with extracting and processing new materials. In addition, sustainable architecture emphasizes water efficiency through low-flow fixtures and rainwater harvesting systems, which reduces the consumption of precious resources.

Another important aspect of reducing environmental impacts is the reduction of waste and pollution [27]. Sustainable architecture aims to minimize construction and operational waste through strategies like modular design, which facilitates prefabrication and reduces on-site waste. Furthermore, materials with low or zero emissions are preferred to ensure that pollutants are not released into the environment. The goal of sustainable architecture is to reduce the overall environmental footprint of buildings, focusing on waste reduction and pollution prevention.

Energy efficiency in sustainable architecture is achieved through a combination of passive and active design strategies [28]. Passive design strategies involve optimizing the building's orientation, thermal mass, and natural ventilation to minimize energy consumption for heating, cooling, and lighting. For instance, placing windows and shading devices strategically can increase natural daylight, reducing the need for artificial lighting. Additionally, designing buildings to utilize prevailing winds and thermal mass helps regulate indoor temperature, decreasing reliance on mechanical heating and cooling systems. Active design strategies complement passive design by incorporating technologies that actively manage energy consumption [29].

These strategies include high-efficiency air conditioning systems, programmable thermostats, and energy-efficient appliances. By integrating advanced technologies with passive design elements, sustainable architecture can achieve energy savings and reduce overall energy consumption. The integration of renewable energy sources is a key component of sustainable, energy-efficient architecture. Solar panels, wind turbines, and geothermal systems are commonly used to generate clean, renewable energy on-site. Photovoltaic solar panels can convert sunlight into electricity, while solar thermal systems can provide hot water for household use [30].

Indoor air quality (IAQ) is a critical factor in the health and well-being of building occupants. Sustainable architecture prioritizes the use of materials and systems that enhance IAQ by reducing indoor pollutants and ensuring proper ventilation [31]. Advanced ventilation systems and air filters can improve air quality by removing pollutants and ensuring a constant flow of fresh air. Healthy indoor environments contribute to the comfort and productivity of occupants and are an integral part of sustainable building practices. Natural light and ventilation play an important role in enhancing the well-being of building occupants [32].

Sustainable architecture maximizes natural light through the strategic placement of windows, skylights, and light shelves, which can reduce the need for artificial lighting and improve mood and productivity. Natural ventilation, which is achieved through operable windows, vents, and passive cooling strategies, helps maintain indoor air quality and regulate temperature without heavy reliance on mechanical systems [33, 34]. Sustainable architecture supports physical and psychological well-being by creating environments that connect occupants with natural light and fresh air. The principles of sustainable architecture—reducing environmental impacts, improving energy efficiency, and enhancing health and well-being—serve as the foundation for designing buildings that are both environmentally responsible and beneficial for occupant health [35].

By minimizing resource consumption and waste, optimizing energy use through passive and active strategies, and improving indoor air quality and natural lighting, sustainable architecture addresses the pressing challenges of modern construction while promoting a healthier and more sustainable future.

4- Approach to Sustainable Architectural Design

The concept of the sustainable architectural design approach has been introduced to combine concerns for the well-being of the planet with continuous growth and development. This requires an awareness of the full short-term and long-term consequences of any environmental changes [36].

There are five main elements of sustainable architectural design approaches, which are:

a) Sustainable Site Design [12]
This is achieved by minimizing urban sprawl and unnecessary destruction of valuable land and habitats, which are common consequences of inefficient, low-density development. Higher-density urban development, urban renewal, and urban revitalization should be promoted as a means of preserving green spaces.

b) Water Conservation [12]
Maintaining the existing natural water cycle and designing sites and buildings in a way that closely follows the natural hydrological systems of the site prior to development. Emphasis should be placed on stormwater retention and infiltration on-site and the recharge of groundwater using methods that closely follow natural systems.

c) Energy and Environment [12]
Minimizing adverse environmental impacts (air, water, land, natural resources) through optimal building siting, building design, material selection, and aggressive energy conservation measures. Maximizing the use of renewable energy sources.

d) Indoor Environmental Quality Principles [12]
Creating a healthy, comfortable, and productive indoor environment for building occupants and visitors. Designing buildings to provide the best possible conditions in terms of indoor air quality, ventilation, thermal comfort, access to natural ventilation and daylight, and effective control of the acoustic environment.

e) Material and Resource Conservation [12]
Minimizing the use of non-renewable building materials and other resources such as energy and water through efficient engineering, design, planning, construction, and effective recycling of building waste. Maximizing the use of recycled-content materials, engineered materials with efficient use of resources, and composite structural systems with efficient resources.

5-Sustainable Architectural Design Strategies
The emergence of environmentally conscious design reflects a broader social shift toward sustainability, where the built environment is harmoniously integrated with natural ecosystems. When planning and designing a building, there are multiple strategies that serve as a reference for sustainable architectural design. Below are some of the key strategies that have been central to environmentally conscious architectural practices:

Resource efficiency: Another vital element is resource efficiency. The integration of advanced technologies such as smart lighting systems, advanced HVAC technologies, and high-efficiency insulation materials optimizes energy consumption and reduces operational costs. These innovations enable buildings to dynamically respond to occupancy levels and environmental conditions, further minimizing energy waste. Resource efficiency also extends to water consumption. Low-flow fixtures and graywater recycling systems help conserve water and reduce the environmental impacts of new construction.

Selection of environmentally friendly materials: This plays a crucial role in sustainable design. There is an increasing emphasis on the use of local, renewable, and low-impact materials to reduce the overall environmental burden of construction [37]. By selecting materials that require less energy to produce and transport, architects can reduce the carbon footprint of their projects. Sustainable materials often include recycled wood, metals, and natural fibers, which not only contribute to environmental sustainability but also add aesthetic value to the design.

Sustainability education: Architects are increasingly taking on the role of educators, informing clients and users about the sustainable features of their designs and how to use them effectively. This educational aspect is essential to maximize the benefits of environmentally conscious design.

Timeless design philosophy: Creating designs that remain functional and attractive for long periods is seen as a way to reduce waste and resist the throwaway culture. This sustainable design philosophy encourages quality over quantity and strengthens a more enduring relationship with the built environment. While pursuing sustainable architecture is filled with exciting opportunities, the journey toward its implementation is often complicated by a range of challenges.

An important barrier includes justifying the higher upfront costs associated with sustainable building practices. Since many environmentally friendly materials and technologies require a higher initial investment, architects are urged to sensitively guide clients toward their long-term benefits. This often involves presenting comprehensive analyses that highlight potential savings in energy and maintenance, as well as increased property value over time. Convincing clients that these investments are not merely costs but steps toward a more sustainable future requires a combination of analytical skills and empathetic communication.

The limited availability of some environmentally friendly materials can also complicate the design process. Architects may encounter difficulties in finding specific sustainable options, leading to delays or cost increases that could jeopardize project timelines. While some clients are eager to incorporate eco-friendly elements into their designs, others may view them as secondary or even unnecessary. Architects must navigate these varying levels of interest by adapting their proposals to align with each client's values and aspirations. This may involve educating clients on the benefits of sustainable practices and helping them visualize how these features can enhance their projects both functionally and aesthetically.

Additionally, the rapidly evolving landscape of sustainability regulations adds another layer of complexity. Architects must stay informed about new codes and standards to ensure compliance and take advantage of potential incentives or certifications. This requires a commitment to continuous professional development and engagement with industry trends that may be in demand in an ever-changing context.

To overcome these barriers, professional architects must foster interdisciplinary collaboration and seek insights from engineers, environmental scientists, and urban planners. This collaborative approach often provides innovative solutions that align with sustainability goals while addressing practical challenges. Keeping up with technological advancements is equally vital. With the emergence of new materials and techniques, architects can incorporate advanced solutions into their designs to enhance performance and sustainability.

6-Conceptual Framework and Theoretical Foundation

In general, the concept of sustainability in architecture encompasses a wide range of approaches aimed at reducing the environmental impacts of buildings while simultaneously enhancing social and well-being effects. This article, with a focus on design approaches, includes the following sustainable architectural practices:

- Increasing the well-being of building occupants
- Increasing the use of renewable resources in buildings
- Increasing the energy efficiency performance in buildings
- Increasing economic factors at the macro level of society

The mentioned items are based on the general principles of sustainable architecture, which include environmental, welfare, and economic considerations. In general, it can be stated that sustainable architecture is employed when the design takes into account the reduction of environmental harm, improvement of economic performance, and respect for the social status of citizens. The focus of this study is on the performance of architects in applying sustainable architecture in building design. Consequently, it can be stated that the results of this study, in addition to improving the performance of architects in Shiraz in applying sustainable architecture in building design, can also be applied in other communities.

7-Research Methodology

7-1 Study Area

Shiraz, as the capital of Fars province in Iran, is located at a longitude of 52 degrees and 32 minutes and a latitude of 29 degrees and 35 minutes. The average elevation of the city above sea level is about 1519 meters [38]. Shiraz is situated in the Zagros Mountain range and has a temperate climate. The annual average temperature is 18°C, and the annual precipitation in Shiraz is 337 millimeters. The city is bordered to the west by the Derak Mountain, to the north by the Bemo, Sabzpoohan, Chehel Maqam, and Baba Koohi mountains of the Zagros range. According to the latest administrative divisions, the city of Shiraz is divided into 11 independent urban regions and covers an area of 17,889 hectares [39].

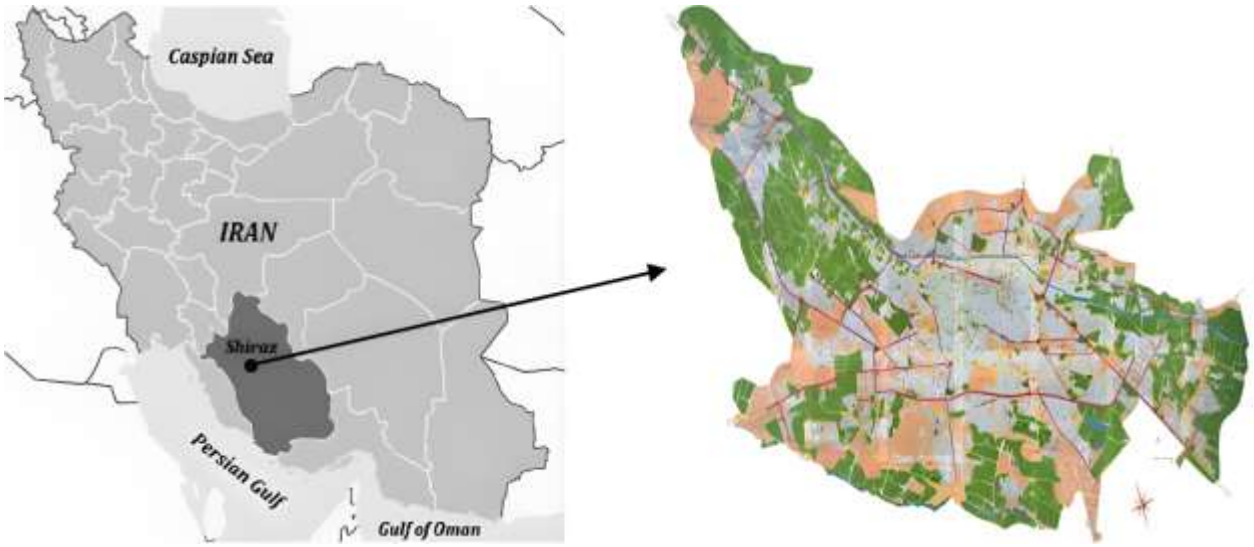

Figure 1 Shiraz City Map

Shiraz is located in a position that faces natural limitations due to the surrounding elevations. In fact, the city is situated in a topographical valley, with steep slopes to the north, and as the valley extends east and west, the steepness gradually decreases. To the south, it leads to the Maharlu Lake, where occasional dangerous floods create problems for neighborhoods located downstream. These factors result in significant challenges for accessibility to various parts of the city. While some areas have an optimal radius, others face very imbalanced access. Furthermore, encroaching upon the dry riverbed and uncontrolled construction during the river's flooding periods lead to numerous issues and challenges [41].

The city's location among the mountains has resulted in numerous physical development limitations. The most suitable slope for urban development is between 5% to 6%, but residential complexes and urban infrastructure are also constructed on slopes of

up to 9%. However, any development on slopes higher than 9% faces numerous challenges and risks. Regarding the sustainability and instability of the land, slopes below 5% are considered stable, while slopes above 5% can lead to potential instability depending on the rock formations. The map below illustrates the slope conditions in Shiraz. Since Shiraz is one of the major cities in the country, and given its topological position surrounded by mountains, its urban development has taken a linear form, and the placement of urban functions is often unsuitable and not aligned with scientific principles due to the factors mentioned. The lack of a logical, scientific approach in the distribution of urban functions in Shiraz has resulted in coordination issues in the distribution of urban services [42].

Environmental issues are a significant factor in the instability of Shiraz's urban area. Estimates indicate that more than 50% of air pollution in the city is due to transportation. The high population density and spatial distribution of land uses in Shiraz justify the extensive use of public transportation systems. To improve the efficiency of the transportation system and respond to travel demands—many of which have multiple origins and destinations—a comprehensive public transport system, including metro, buses, and public taxis, should be focused on, assuming that the city's spatial structure can be revised and the resources for the planned metro development are available [43].

Shiraz was selected for this case study because the region has great potential for research in urban and environmental sciences. Additionally, the cultural and economic status of the region is growing, creating an opportunity for further exploration. The city's infrastructure is undergoing significant growth, and in order to improve the economic situation, this growth is being accompanied by urban planning policies and industrialization. This includes plans for mass housing construction, the establishment of various commercial institutions, and improvements to traffic and transportation systems. In many cases, construction activities and resource usage are ongoing despite a lack of awareness of sustainable development [44].

Given the factors mentioned, it can be stated that comparing the architectural design methods with the general principles of sustainable development is a cautious process.

7-2 Research Methodology

The overall objective of this study is to use statistical methods and a survey approach to investigate the implementation of sustainable architecture in design by architects. The reason for using the survey method in this study is to gather opinions and perspectives from experts in the field of architecture. The statistical sample in this study consists of architectural design specialists working in the city of Shiraz, with the aim of statistically examining the factors influencing the implementation of sustainable development principles in architecture. In this study, stratified random sampling was applied, with samples being selected from designers in the 11 municipal districts of Shiraz.

It is important to note that all samples were randomly selected to ensure unbiased responses. This sampling method ensures that the samples encompass a wide range of architectural design approaches. Based on the studies conducted, the objectives mentioned in this study were used to develop a researcher-designed questionnaire.

The questionnaire initially examines demographic issues and then addresses the general principles of this study, including the awareness and use of sustainable architecture design principles, factors influencing the implementation of sustainable architecture design, and the incorporation of sustainable design principles into architectural education. The questionnaire was designed and validated under the supervision of a group of architecture experts (4 urban planning experts in sustainable development, 4 architects with more than 10 years of experience in sustainable architecture design, and 2 university professors specializing in sustainable design development).

The aforementioned specialists reviewed the questionnaire for content analysis, clarity of questions, and relevance to the overall research objectives. To increase accurate responses and clarify the questionnaire questions, an interview method was used. Throughout the data collection process, informed consent forms were obtained from all participants, ensuring the confidentiality of their responses. Data analysis was performed using SPSS Statistics version 27.0.1. To analyze the data and identify factors related to sustainable architecture design perspectives, frequency percentages, mean, and standard deviation were used.

To test the hypotheses related to the relationship between sustainable architecture development and architects' design methods, Pearson's correlation coefficient was determined at a significance level of 0.05. Two factors were chosen for testing the hypotheses, which are as follows:

- Application of architectural design
- Awareness of the general goals of sustainable architectural design

Respondents were asked to indicate through the questionnaire whether their knowledge of sustainable architectural design goals influenced their performance in architectural design. To analyze the responses to this question, a simple "yes" or "no"

option was used. A positive response was considered as the dependent variable, and a negative response was considered as the independent variable.

As previously mentioned, Pearson's correlation coefficient was used to test the hypotheses at a significance level of 0.05. The primary goal of this study was to examine the relationship between architects' awareness of sustainable architectural design goals and the architectural designs executed in the city of Shiraz. The results obtained from the questionnaire responses reflect perspectives on the relationship between awareness of sustainable architecture principles and their application in architectural design. Analysis of the results from the statistical data provides clear insights into the impact of sustainable architectural design on architects' design approaches.

8-Analysis of Study Results

Of the 120 architect designers surveyed, 106 completed questionnaires were returned, representing an 88.3% response rate. The high response rate from the surveyed samples increases the reliability of the research findings. Moreover, this high level of response indicates the architects' interest in the application of sustainable architectural design principles in building designs within the study area. The first part of the questionnaire addressed demographic issues. Table 1 presents the details related to the demographic characteristics of the respondents.

Table 1 The information related to the demographic characteristics of the respondents (n=106)

Characteristics	Number	Percentage (%)
Age		
20 years or younger	6	5.66
21-35 years	28	36.41
35-50 years	57	53.77
Older than 50 years	15	14.15
Education Level		
Bachelor's	29	27.35
Master's	59	55.66
Ph.D.	18	16.98
Work Experience		
1-5 years	6	5.66
6-10 years	11	10.37
11-15 years	32	30.18
15-20 years	48	45.28
20 years or more	9	8.49
Gender		
Female	51	48.11
Male	55	51.88

According to Table 1, 51.88% of the respondents were male and 48.11% were female. The close percentage between the number of male and female respondents indicates that a large population of women, alongside men, are involved in architectural design in the study area. On the other hand, the highest number of respondents were aged between 35 and 50 years (53.77%). Additionally, the results of Table 1 show that a significant portion of the respondents had extensive experience in architectural

design, with 53.77% having 15 years or more of experience in architectural design. This high level of experience among the respondents allows for the examination of diverse viewpoints. The professional experience of the majority of respondents indicates their full understanding of architectural design principles, construction laws, and other urban planning regulations. One of the crucial aspects of the respondents was their expertise in architectural design. According to the results in Table 1, 55.66% of the respondents held a master's degree in architecture, which contributed to the increased accuracy of the findings.

In the second part of the questionnaire, the respondents' attitudes toward the implementation of sustainable architectural design goals, their awareness of sustainable architectural design principles, the factors affecting the implementation of architectural designs based on these principles, and the incorporation of sustainable architectural design principles in architectural education were examined. Table 2 presents the level of awareness among the respondents regarding sustainable architectural design principles.

Table 2 The level of awareness of the respondents regarding the principles of sustainable architectural design.

Variable	Response type			
Sustainable Architectural Design Principles	No		Yes	
	Percentage	Count	Percentage	Count
	11.33	12	88.67	94

According to Table 2, it can be stated that most respondents (88.67%) have sufficient knowledge regarding the principles of sustainable architectural design. This indicates the high level of awareness among the respondents of the questionnaires studied in the region under review regarding the principles of sustainable architecture.

Figure 2 examines the implementation of sustainable architectural design principles in architectural projects. According to the chart, it can be stated that most of the cases studied (49.06%) have incorporated sustainable architectural principles into their projects. Additionally, 27.36% of respondents have implemented sustainable design principles in most cases. Moreover, 16.98% have used these principles in some of their projects, indicating barriers that prevent the consistent application of sustainable design principles. A small number of respondents (4.27%) have used these principles in limited cases in their projects. Furthermore, two individuals in the study have not used these principles in any of their projects, highlighting the importance of investigating the reasons behind their non-application of these principles.

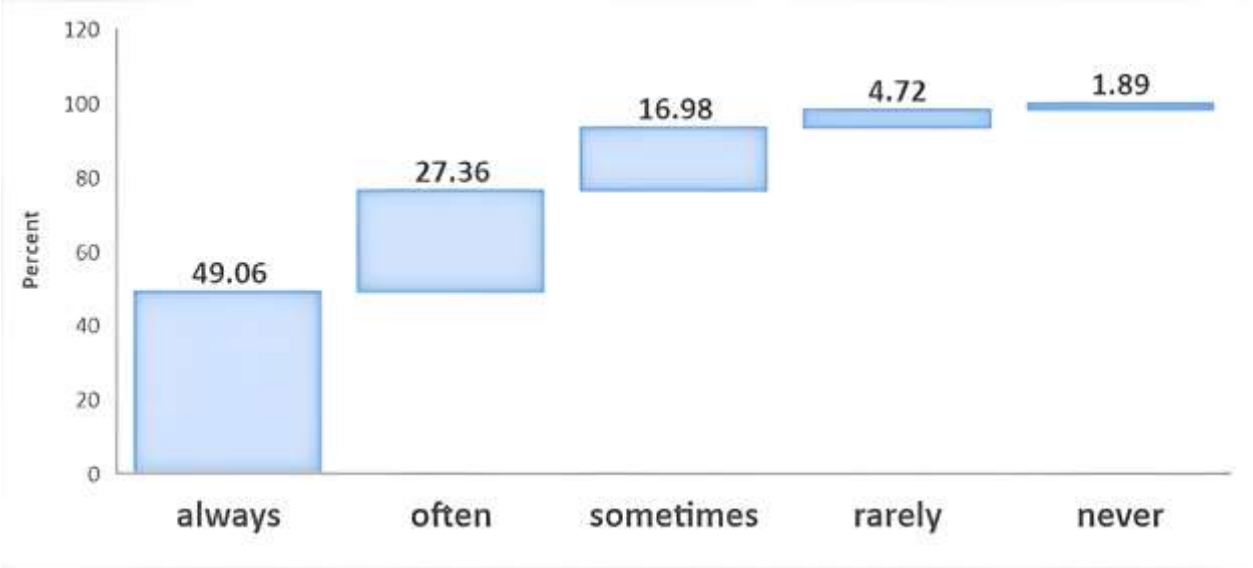

Figure 2 The application of sustainable architectural design principles in architectural projects.

Figure 3 examines the respondents' views on the impact of resource performance in implementing sustainable design principles. According to the chart, it can be stated that about half of the respondents (47.17%) emphasized the necessity of resource performance in sustainable design, indicating a high sense of responsibility among the respondents towards materials. Additionally, 52.83% of respondents also considered the efficiency of resources important in sustainable architectural design. Based on the responses obtained, it can be concluded that all respondents emphasize the efficiency of materials in sustainable design principles.

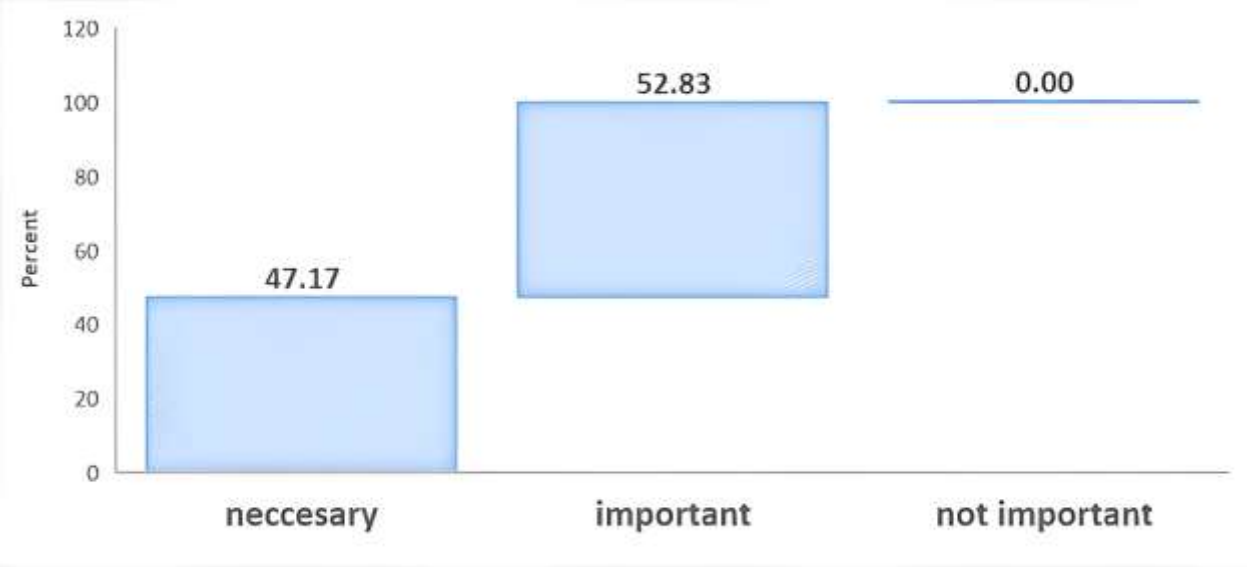

Figure 3 The respondents' opinion on the impact of resource performance in the application of sustainable design principles.

In the next section, the respondents' views on the use of renewable resources were examined. Figure 4 investigates the use of renewable resources in architectural projects. 30.19% of respondents always use renewable energy in their projects, and 54.72% do so in some cases, indicating their inclination towards sustainability. 15.09% of respondents rarely use these resources. According to the chart, none of the respondents selected the option of not using renewable resources, which suggests that the use of renewable resources in architectural design has been collectively accepted.

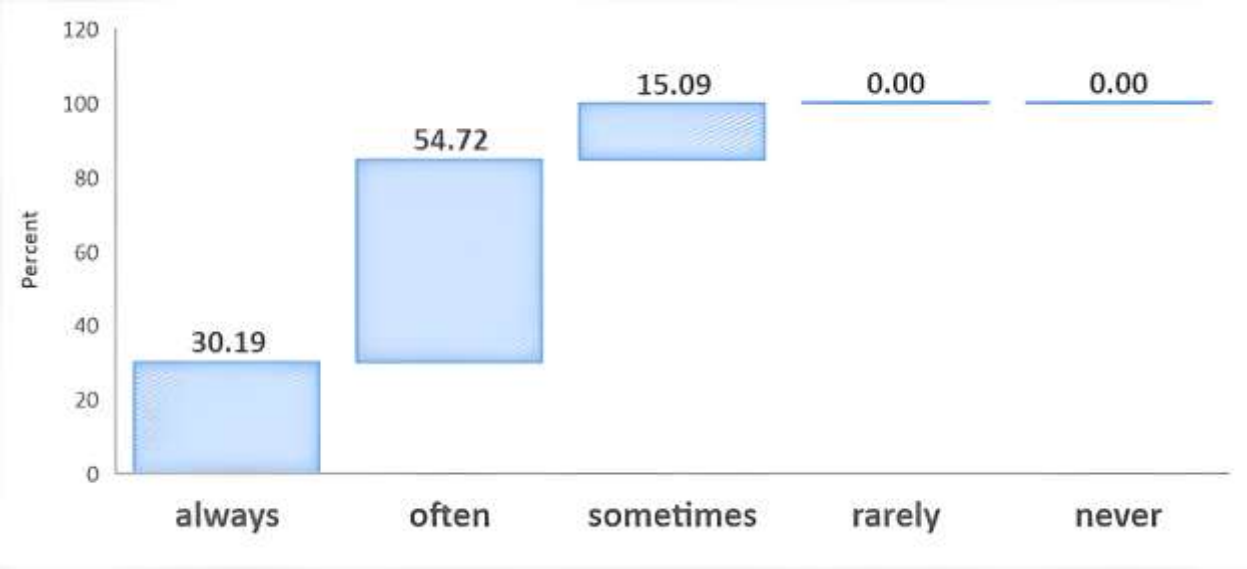

Figure 4 Examining the use of renewable resources in architectural projects

In the next section of the questionnaire, the prioritization of factors influencing the implementation of sustainable architectural design principles was addressed. To this end, based on previous studies, five factors were selected, and respondents were asked to rate these five factors from 1 to 5. To analyze the results, the total score given by respondents to each factor was used as the criterion. The selected factors are as follows:

1. Environmental considerations
2. Building automation
3. Client needs
4. Architect's positive attitude towards sustainability

5. Economic considerations

Table 3 shows the prioritization of the factors based on the scores received from the respondents. According to the results in Table 3, the most important factor from the respondents' perspective is economic considerations, which reflects the high importance of economic issues in architectural design. Environmental considerations are ranked second in priority. The third factor is client needs, indicating the significant impact of client requirements in design. The factors of the architect's positive attitude towards sustainability and building automation are ranked in the following priorities, but it should be noted that the scores for these two factors are very close to each other, indicating their equal importance.

Table 3 The priority of factors influencing sustainable design principles based on the scores received by the respondents

Variable	Total Score (106 < X < 530)	Rank
Environmental Considerations	448	2
Building Smartness	356	5
Customer Needs	403	3
Architect's Positive Attitude towards Sustainability	368	4
Economic Considerations	483	1

In the next section, the designers' willingness to change their design approach was examined. Figure 5 shows the results regarding the respondents' willingness to adopt new architectural design methods. According to the results, 48.11% of respondents have a strong desire to change their architectural design methods, which reflects the architects' attitude towards adopting new design approaches. On the other hand, 28.3% of respondents agree with this issue, suggesting that most respondents have a positive attitude towards sustainable design methods. Additionally, a small number of respondents (15.09%) had no opinion on this matter, while 8.49% of respondents expressed a preference for traditional architectural design methods and disagreed with the adoption of new approaches.

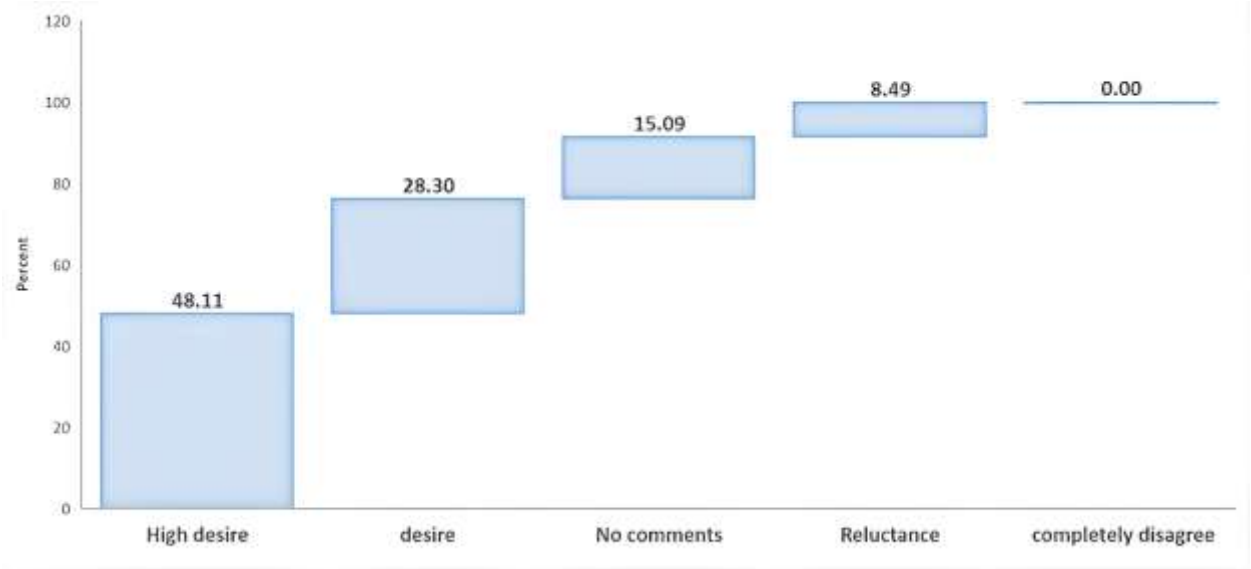

Figure 5 The respondents' willingness to apply modern architectural design methods

The issue of implementing sustainable architectural design principles in architectural education was also examined in this study. Figure 6 shows the results regarding the respondents' views on the extent to which sustainable architectural design principles are incorporated into architectural education.

According to the results, it can be stated that 86.79% of respondents acknowledged that sustainable architectural design principles are considered in architectural teaching methods. Based on this, most respondents had a positive attitude towards the

teaching approach and expressed satisfaction. On the other hand, 13.21% of respondents stated that these principles are not incorporated into the teaching methods. Given the limited number of these individuals, it can be concluded that there is a cautious stance on this issue, which increases the need for improving teaching methods in the architecture sector. Additionally, based on the results of this section, it can be concluded that there is overall satisfaction regarding the integration of sustainable architectural design methods and architectural education.

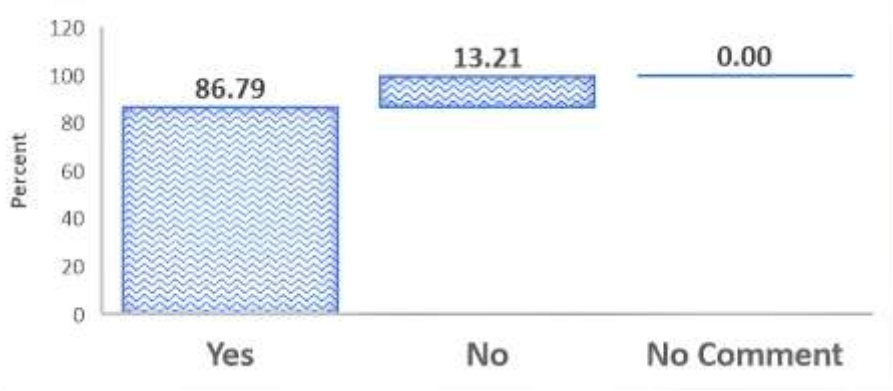

Figure 6 The respondents' opinion on the extent of the application of sustainable architectural design principles in architectural education

The examination of respondents' answers regarding whether they received training on sustainable design principles during their architectural design learning period is shown in Figure 7. According to the chart, 70.75% of respondents stated that they received training on sustainable design principles during their architectural studies, indicating a positive understanding of their readiness in this area. Additionally, 21.7% of respondents indicated that they received some training on this subject, suggesting that these individuals have limited experience but significant opportunities for improving the application of sustainable design principles. In contrast, a small number of respondents (7.55%) stated that they did not receive any training on this subject, highlighting a gap between these individuals and sustainable design principles.

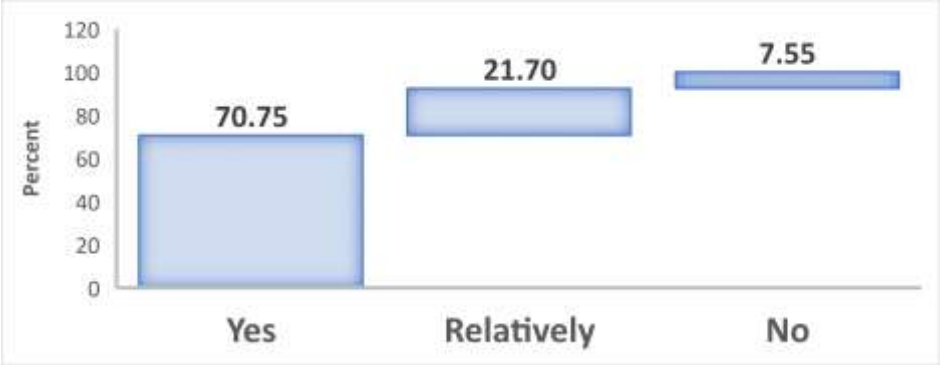

Figure 7 The respondents' learning about sustainable design throughout the architectural education program

The level of awareness among the individuals studied regarding the impact of architects' knowledge of sustainable design principles on architectural design execution methods in Shiraz was examined.

Null hypothesis (H0): There is no significant relationship between awareness of sustainable design principles and architectural design performance.
Alternative hypothesis (Ha): There is a significant relationship between awareness of sustainable design principles and architectural design performance.

Based on the analysis of the relationship between awareness of sustainable design principles and the level of architectural performance, the calculation of the Pearson correlation coefficient showed a result of P = 0.001.
$r(3) = 0.78, p < 0.05$

Since the P-value is less than the significance level of 0.05, the null hypothesis is rejected. It can be concluded that, according to the respondents' views, there is a significant relationship between awareness of sustainable design principles and architectural

design performance. As a result, it can be stated that as awareness of sustainable design principles increases, sustainable architectural performance also improves. This significant relationship suggests that with every increase in awareness, the promotion of sustainable architectural design in Shiraz increases correspondingly. On the other hand, it can be stated that the lack of awareness regarding sustainable development in Shiraz reduces the importance of sustainable architectural design.

This significant relationship can be explained based on the following reasons:
With increased awareness within the architectural design community, if early adopters of sustainable design principles spread the benefits of this practice among their colleagues, it will lead to broader acceptance and the implementation of sustainability methods. As awareness increases, architects' approach to sustainable design principles becomes more positive, reinforcing subjective norms among architects. With greater awareness of sustainability, architects are more likely to view sustainable practices positively, feel a social commitment to adopting them, and be able to implement these methods effectively.

Additionally, increased awareness leads to economic growth. As architects' knowledge of sustainable design principles increases, they can better control technological advancements, create new markets for sustainable methods, and strengthen the economic and environmental dimensions of sustainability. Furthermore, increased awareness regarding sustainable architectural design leads to the integration of sustainable development into architects' practices. Due to the characteristics of sustainable design principles and the meaning of sustainable development, the methods of implementing these principles, when continuously applied over time, become stabilized. The increase in awareness among architects represents a specific approach that, through sustainable development and broader support, can shift architectural techniques towards sustainability.

9- Discussion

The results obtained from this study highlight key approaches regarding the implementation of sustainable design principles by architects in Shiraz. The findings can be analyzed on a larger scale and compared with design methods used in other countries. These results indicate important attitudes regarding the architectural methods employed in Shiraz, and these findings will likely manifest on a larger scale as well. According to the results, most respondents exhibit a high level of awareness regarding the concept of sustainable architecture. Awareness is the first step in adopting new methods, followed by persuasion, decision-making, implementation, and confirmation. This level of awareness, as a principle, leads to the implementation of sustainable architectural practices. These findings are consistent with those of Ibiyeye et al. [45].

In this study, awareness of sustainable development methods at various levels was examined. Additionally, Ibiyeye et al. pointed out that awareness was primarily theoretical and had limited practical application. This was clearly evident in the study conducted with architects in Shiraz. Turning sustainable awareness into practical application requires great precision. As 49.06% of respondents indicated that they consistently apply sustainable design principles in their projects, and 27.36% do so in some cases, it can be stated that there is a gap between awareness and its application. From a psychological perspective, the adoption of sustainable methods is influenced not only by individual viewpoints but also by subjective and behavioral norms. This gap between awareness of sustainable development and its application in architectural design methods is not unique to the region studied. A similar result was found by Marsh et al. [46].

This study identified barriers such as lack of customer demand, high initial costs, and limited access to green materials as reasons for the gap between awareness and application of sustainable development. These factors explain why a small number of respondents (4.72%) applied sustainable principles in only a few of their projects, and two respondents did not use these principles in any of their projects. As previously mentioned, a high percentage of respondents acknowledged the efficiency of resources, which reflects a positive attitude toward one of the core principles of sustainable architecture. This aligns with the results of Cole [47]. Cole's study found that water efficiency, waste minimization, and energy conservation are top priorities globally.

On the other hand, based on the results of this study, the use of renewable energy in architectural projects performs well but, according to respondents, has significant growth potential. Since 30.19% of respondents use renewable energy regularly in their projects, and 54.72% do so in some cases, it can be concluded that there is significant growth potential for applying sustainable design principles in architectural projects. These findings align with the studies by Smith et al. [48]. According to Smith et al., the use of renewable energy is a practical factor in the international ranking of architects.

Despite this, 15.09% of respondents rarely use these resources, indicating that there are barriers to the implementation of sustainable design principles, which may stem from social limitations, architects' technical knowledge, and economic issues. Sustainability remains an emerging concept that requires further research and community support for large-scale implementation. Barriers such as inadequate awareness, high initial costs, and others are factors contributing to the acceptance levels of sustainable design principles. According to respondents, 76.42% of architects consistently and, in some cases, apply sustainable architectural principles in their projects. This reflects the growing potential for applying sustainable design principles.

The results regarding the use of renewable resources in the study area are linked to the energy crisis in Iran. In the study by Beyragh Shamshir and Sarkardehi [49], it was stated that architects in the study area show a significant inclination toward using renewable energy, which is in line with the results of this study.

Furthermore, this study emphasized the necessity of applying sustainable development on a larger scale, which is supported by the results obtained regarding the use of renewable resources. The challenges observed in applying sustainable design principles in the study area reflect broader societal issues. For example, rural-to-urban migration increases construction demands and housing needs, which may overshadow the application of sustainable design principles. This conflict between individual community needs and large-scale environmental goals has become a significant challenge in developing countries. This issue was also highlighted in the study by Malek Mahmoudi and Kamali [50] regarding the barriers to adopting sustainable development in Iran.

The growing attitude toward applying sustainable design principles by architects in the study area reflects a shift at the larger scale, driven by concerns about the environmental impact on the economic development of the community. Therefore, it can be stated that the application of sustainable development contributes to economic growth, and consequently, the increasing trend of sustainable development provides significant economic opportunities in Iran's construction industry.

This conclusion aligns with the study by Fathalizadeh et al. [51]. The results of this study, which examined sustainable development methods in Iran, indicate that factors such as economic issues, lack of government regulations, and lack of customer demand hinder the growth of this matter. This suggests that some challenges in implementing sustainable development are shared across various studies, although the intensity of these factors may vary.

On the other hand, according to the respondents, only about half of them use renewable resources in their projects. Considering the energy and climate crises in the region under study, this issue requires further considerations. Since Iran has diverse climates, this situation makes the role of architects crucial in designing high-performance energy buildings. This finding is consistent with the study by Azadkhani et al. [52], which discusses the role of sustainable architectural methods in reducing the environmental impact of buildings in Iran.

The implementation of sustainable design principles involves a range of factors related to various fields. According to the respondents in this study, economic, environmental, customer needs, and building smartness are key factors influencing the adoption of sustainable design principles by architects in the region. This aligns with Lawrence [53], who identified customer demand, technological advancements, and environmental considerations as main factors in sustainable development.

In this study, economic considerations were identified by the respondents as the most important factor. Financial issues are a parameter that should be emphasized in sustainable design principles. At the same time, since financial and environmental issues often conflict, sustainable development in the study region appears to be economically feasible and necessary for the advancement of society at a larger scale.

Another important factor impacting sustainable development is customer needs, which respondents ranked as the third priority. This result aligns with findings from the study by Alsend [54], which states that over 75% of construction companies worldwide face an increase in sustainability-related inquiries from customers.

As customer awareness of environmental issues and sustainable development increases, their attitudes guide architects toward adopting sustainable design principles in their projects. Another key factor is the architect's positive attitude toward sustainability. This intrinsic motivation shows that personal values and beliefs regarding environmental issues impact design practices.

Architects' approach to this factor indicates a growing tendency in the profession toward environmental sustainability. Another factor examined in this study was building smartness, which aligns with the findings of the study by Patil et al. [55]. The results showed that smart building technology and green roofs are very important factors in sustainable development.

The factors mentioned regarding sustainable development also align with studies conducted in other countries. Research by Khrazishvili et al. [56] in Ukraine found that economic considerations are the most important factor in adopting sustainable design principles.

This indicates that in many developing countries, the concept of sustainable development is being studied and considered as a necessity. It is important to note that in addition to the factors examined in this study, more detailed factors related to sustainable development should also be explored. This is consistent with the results of Boros et al. [57], which indicate that contextual factors such as culture, climate, and social barriers also influence the adoption of sustainable development.

Another issue examined in this study was the willingness of designers to change their design approach in the region under study. The results of this study show a high level of willingness to change among architects in the region, with 76.42% of respondents indicating a desire to alter their design methods based on sustainable development. This willingness to adopt sustainable methods is crucial and aligns with the findings of Moghaddan Nejad and Pashayi [58]. Their study revealed that Iranian architects have a strong inclination to change traditional architectural design methods.

This matter is essential concerning the willingness to change design methods based on sustainable development principles in the architectural community. The high level of willingness reported by architects presents an opportunity to align sustainable building methods with economic goals in the region. Strengthening sustainable development in architecture would create jobs, promote economic growth, and, at the same time, address environmental challenges. However, the growth of sustainable development in architecture requires considering all aspects, including economic and environmental factors. The importance of economic considerations can significantly impact the performance of sustainable development. Additionally, implementing regulations for buildings based on sustainable design principles can serve as an effective approach to improving sustainable architecture in the region.

The adoption of sustainable design principles in architectural education plays a significant role in the sustainable development of society. According to the respondents, 86.79% believe that sustainable design principles are appropriately included in architectural education, reflecting a positive approach to architectural education.

Previous studies have emphasized this issue, and research on the necessity of incorporating sustainable design principles in architectural education confirms this. The results of the study by Zahedi et al. [59] support the importance of integrating sustainable design principles in education. Greenfield et al. [60] emphasized the essential role of education in the development of sustainable architecture.

A comparison of previous studies and the results of this study indicates commonalities regarding the need for a targeted increase in the adoption of sustainable development in education. This alignment confirms the importance of improving the teaching of sustainable design principles to enhance the performance of future architects with the necessary knowledge and skills for responsible environmental practice. According to the results, the positive approach in the region indicates that educational institutions are making coordinated efforts to incorporate sustainable design principles into their curricula and recognize its growing importance in architecture.

In this study, 86.79% of respondents acknowledged that sustainable architectural design principles are considered in architectural education methods. Based on this, most respondents had a positive attitude toward the teaching methods and expressed satisfaction. On the other hand, 13.21% of respondents stated that this issue was not incorporated into the teaching methods. The results obtained in this section align with the study by Sayes and Organ [61], which showed a mismatch between sustainable design principles and the performance of architectural graduates.

As a result, it can be stated that while sustainability is considered in education, there may be discrepancies between theoretical knowledge and practical application. 70.75% of respondents stated that they had received training on sustainable design principles during their architectural education. The high percentage in this section indicates that sustainable design principles are being positively adopted in the region. Despite this, 7.55% reported that they did not receive training on this topic, and 21.7% referred to receiving partial training.

The results can be explained using educational approaches. Educational programs play a significant role in spreading sustainable design principles and improving related principles in architectural practice. The findings regarding the high levels of preparedness among individuals indicate that education is significantly contributing to the development of this field. On the other hand, the results of this study highlight the need for more practical education regarding sustainable design techniques. Reducing the gap between theoretical knowledge and practical application in architects' execution projects is crucial and determines the level of preparedness of architectural graduates for practical projects.

This issue aligns with the findings of Saqafi and Kruter [62], which emphasize the need to improve educational performance in line with regional needs to comprehensively expand sustainability principles. The integration of sustainable design principles in architectural education can be considered an important factor in the development of sustainable design principles. Educational sectors, by expanding sustainable design principles, can improve the performance of the architecture field.

10- Conclusion

Achieving a sustainable building and environment begins with the sustainable design approach used by the architect. Therefore, the role of the architect in implementing sustainability cannot be overstated. Architects must intensify their efforts toward reducing and enhancing flexibility, adopting new techniques, and utilizing technologies in the design of buildings that must

support sustainable development. The architect begins their approach to the built environment with architectural design principles, which serve as the starting point for every successful building design and energy-efficient construction achievement. This study examined the challenges related to the application of sustainable design principles by architects in Shiraz. The study explored architects' approaches to the level of awareness of sustainable design principles, factors influencing the implementation of sustainable development, and the impact of sustainable design principles in the education sector.

Based on the results of the respondents' opinions, awareness of sustainable development concepts is at an acceptable level, and most respondents expressed their willingness to apply sustainable design principles in architectural projects. Despite this, to implement sustainable design principles widely in architectural projects, important factors such as customer demand must be supported. The results of this study indicate that by applying sustainable design principles, sustainable development with an emphasis on supporting practical methods for building design will experience significant growth. Updating national building regulations with an energy efficiency approach and adopting renewable energy sources will be a very important step towards sustainable development. Providing low-interest loans and tax discounts to builders for incorporating sustainable development into their buildings can significantly contribute to the expansion of sustainable development. The results of this study will be utilized by policymakers in the education sector, professional organizations, and architects to facilitate widespread changes in the adoption of sustainable development methods for implementation by architects.

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