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Original Research Article

An Investigation into the Alignment Level of Historical Houses in Iran with Sustainable Development Based on the Global Criteria of DGNB Case Study: Zeinat-ol-Molk House, Shiraz, Iran

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Abstract

Problem statement: Ever-increasing population and the increasing residential structure, which expands a given city's size, can end in irreversible damage to the environment, thus depriving future generations of the sense of city life. The pioneers in this field of study have sought to resolve this negative phenomenon by proposing sustainable architecture and introducing sustainability assessment systems. In this context, Iran, with its long history and magnificent architectural background, is a vivid example of considering on architecture of construction since ancient times.

Research objective: Assessing the adaptability of environmental components of the historical house(s) of Shiraz through the German DGNB assessment model to achieve an efficient design in strategy.

Research method: A comparative study was run to compare the similarities and dissimilarities of the German DGNB assessment system and the principles of Iranian architecture, to identify the development of construction fundamentals. The data are collected through library and document studies, next to interviews conducted with the residents of Zeinat-ol-Molk House, experts, and technical authorities involved. For this purpose, a checklist of their common criteria is prepared and assessed.

Conclusion: The subject house obtained the minimum score on social and functional qualities, which could have been reversed if the existing drawbacks, like measuring some criteria due to the interference of contemporary humans and visitors, lack of intelligent systems for user control, and the intelligent design system didn't exist, next to negation of the criteria in design by all involved.

Keywords: *Iranian architectural principles, German DGNB assessment system, Sustainable development, Historic houses.*

Introduction

Architecture has always been and is a physical and spatial manifestation of the social, cultural, climatic, and economic conditions of a society (Azizi, 2006). According to the definition of the World Commission on Environment and Development, sustainable development is meeting the needs of the present generation without compromising the ability of future generations to meet their own needs. Other definitions of sustainable development are: responding to the needs of future generations, being attentive to the carrying capacity of ecosystems, human life, and the environment, and integrating conservation and development as a general approach. In architecture, as in other scientific fields, sustainability has been a topic of discussion (Ghobadian, 2015, 240-245). The five prominent building sustainability assessment systems consist of: BREEAM (UK), LEED (US), CASBEE (Japan), DGNB (Germany),

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and HQE (France). In Iran, the Sustainable Building Council codes relate to the correct selection of materials with high-quality specifications that represent criteria, which contribute to how buildings are evaluated, as being sustainable or not. The wide range of planning units through different scales, from regional to project, must be assessed separately (Balouktsi,2018). To assure the sustainability of urban land use, the current and future needs of citizens must be of concern as a unit (Karimi et al., 2021). In this context, the governing principles of traditional Iranian architecture are rooted in the cultural and social setup of this land, which should be carefully assessed (Safian & Mahmoudi, 2007). The traditional residential dwelling architecture is rich in its humanitarian sense and approach with a focus on the security and comfort of the occupants Heydari Delgarm, Bemanian, & Ansari (2022). The concern about the native and traditional architecture of any region is one of the main issues in architectural design (Ojaghlou, 2020). Recognizing traditional Iranian architectural features as a complete manifestation of sustainable architecture is of high essence in providing the occupants' comfort (Mahdavinejad et al., 2016). Considering the lack of sufficient knowledge of traditional construction and the industrial expansion of developing countries, including Iran, it is necessary to define the cultural richness of the past for future generations. The real values of historical buildings should be assessed because the compatibility with the environment and the simplicity of the performance of old houses based on centuries-old experiences in solving the needs of individuals in terms of both application and cost are of major concern. Realizing the solutions obtained by traditional architects regarding architectural sustainability design can be considered as a model of living subject to environmental conditions interpreted as a new construction approach following global standards and promoted in today's architecture as an efficient and effective strategy in design, construction, and functionality. To what extent can this model be effective? This is partially addressed in this study, where the objective is to identify the components of the physical and spatial configuration of historical houses from a sustainability perspective according to German DGNB standards, to the solutions that traditional architects can apply to achieve the principle of sustainability in the built environment, because these environments are built for the people who spend a great part of their lives in such houses. Consequently, the dwellers' health and happiness should be the focal point of design and construction decisions. This principle is built into the DGNB assessment system from the very beginning. In this study, this basic principle is further expanded and consolidated as a new and stronger approach by analyzing the creativity and talent of traditional architects.

Research Question

To what extent are the historical houses of Shiraz compatible with the German DGNB assessment model in terms of sustainability criteria?

Research Objective

To achieve an efficient design strategy, the compatibility of the environmental-social components of the historical houses of Shiraz through the German DGNB assessment model was assessed.

Research Methodology

Do the benefits of historical houses outweigh their functionality risks? The identification of such components was done by experience (Gustaf, 2021, 5). The study adopted a survey and descriptive method based on valid technical documentation, registered in Qajar architectural structural design, which consists of one ground floor on a basement. Due to its descriptive-analytical terms, a comparative method was used to distinguish similarities and differences among the phenomena and define the problem or improve the knowledge in that area (Mckelvey et al., 2018).

The objective is the empirical generalization and testing of the hypothesis. (Garrido & García, 2012). That is, unknowns can be understood from known, topics can be explained and interpreted, and the features of known phenomena and similar cases can be highlighted (Augustine & Okonkwo, 2018). Through this method, the evaluation systems were assessed, and the principles of Iranian architecture were discussed. Then DGNB assessment system was selected and the fundamentals of Iranian architecture were scrutinized in more detail. Afterwards, similarities and dissimilarities between the two architectural indicators were examined and their strengths and weaknesses were presented. The criteria of both systems are categorized and compared and tabulated and the extent of their overlap was shown.

Research Background

The previous studies on this topic are tabulated in Table 1. Past research has shown that the necessity of developing a design guideline for buildings with the aim of optimizing the environment should be in a way that it can take on the responsibility of developing and revising the design and construction regulations with the aim of optimizing buildings in line with sustainability standards. Although this is considered a significant content of sustainability elements, there is a research gap in utilizing the

Table 1. Available studies. Source: Authors.

Number	Authors	Article
1	Haghparast 2024	The objective is to achieve a framework for realizing the adaptation of performance change in the adaptive reuse of historical houses. Among the sub-criteria, "preservation and enhancement of intangible values" has the highest degree of influence and interaction with other sub-criteria, and "technical requirements of conservation (reversibility and minimal interventions)" is at the top of the sub-criteria with a causal nature.
2	Karimi et al., 2022	The applied rating systems can be contributory to the historic houses' sustainability forecast. They state that all three traditional dimensions of sustainability should be balanced when developing or adapting the next generation of rating systems to address/assess the sustainability of historic houses.
3	Tam et al., 2018	In "Modeling Native Architecture with the Aim of Developing Sustainable Architecture," twenty international green neighborhood assessment systems are assessed based on their sustainability and features. The findings reveal that social issues, resources, and the environment are the three important and key aspects of sustainability. The researcher introduces patterns of native architecture corresponding to the development of sustainable architecture.
4	Herrera et al., 2024	Provides an in-depth analysis by focusing on the energy retrofitting of historic houses, exploring challenges, best practices, and lessons learned for balancing energy efficiency improvements with heritage preservation. Valuable insights into successful projects, with highlights on the need for scalability, and knowledge transfer from innovative and targeted policies for successful replication prevail in this article.
5	Bence Guard, 2016	In this study, the focus is on "energy design". Though the complexity of achieving a low-energy house is difficult, the creation of the Integrated Energy Design Assessment (IEED) becomes inevitable, with different approaches, like the Integrated Delivery Project.
6	Dias Pereira et al., 2023	The hydrothermal behavior of heritage houses and climate change: status and main challenges are assessed in this study. This new concept is fundamental for all beneficiaries involved in issues regarding heritage conservation and the assessment of the hydrothermal behavior of houses.
7	Sánchez Cordero et al., 2019	A review of the HQE, BREEAM, LEED, and DGNB systems reveals that the DGNB system is the most fit for sustainability.
8	Hajiamiri et al., 1402	In a study titled "Classification of Global LEED Standard Indicators in Sustainable Architecture of Contemporary Iranian Cities Based on Regional Ecosystem Characteristics: A Case Study of Qom City," it was concluded that in each section of the background indicators, accreditation for sub-indicators was carried out based on existing documented statistical data. Given the final findings, a new classification of the indicators in the basic evaluation table for contemporary urban fabric designs has been presented based on their effectiveness.
9	Ojaghlou., 2020	The architectural design of the old houses in small historical cities like Soltaniyeh is assessed to achieve conceptual and sustainable architecture through the inference of a research-based library approach. The result indicates that the integrated design process prevails as the architectural design process in small historical cities.
10	Eskandari et al., 2024	The Design Builder and Energy Plus tools are applied to run energy simulations and assess the functionality of materials consumed in the historic house. It is revealed that the impact of energy-related features like materials, ceiling height, and shading on temperature, cooling load, and occupant comfort is of high essence.

experiences of the past in Iranian architecture to evaluate and improve these standards. In this research, we have tried to investigate the various aspects of Iranian architecture from the perspective of compatibility and discovery of traditional methods in sustainability criteria used with today's world standards (DGNB). Fig. 1 shows the classification of the principles of Iranian architecture.

Theoretical Foundations of the Study

• Sustainability in the principles of historical Iranian architecture

The concept of sustainable architecture for architects is that the artificial environment be built with the idea of increasing the quality of life of the present and meeting the needs of the future in mind (Azerbaijani & Mofidi, 2003). In Sustainable architecture, the environmental considerations and climatic adaptations in design and construction should be based on the effective use of natural resources. In Iranian architecture, the following aspects prevail: 1) Observing nature and respecting its sacredness. An architectural work, as an observation in the architecture mind from the beginning to the end of its actualization, is infused with the earth where it receives water from the earth and returns it after transforming its appearance and content to certain degrees; it turns its face to the breeze and its back to the winds that bother it and it follows and accompanies nature (Flamaki, 2006, 21) The stages

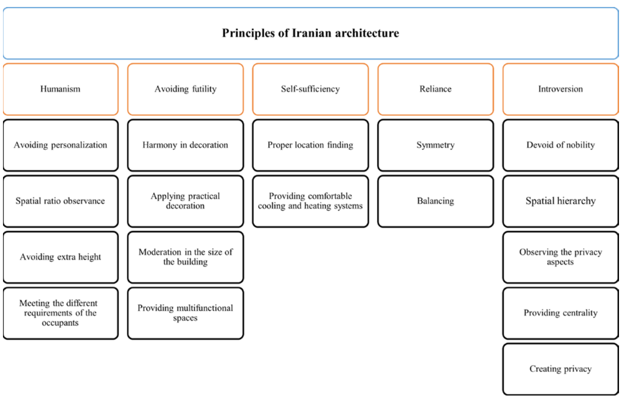


Fig. 1. Pirnia principle. Source: Peyastegar et al., 2017.

of this architecture design type are immediate and sensual, that is meeting the spiritual and physical needs of the inhabitants. Designing according to humanitarian aspects is the most essential principle in sustainability, where the viability of all components of the global biosystem is of concern. This principle is deeply rooted in the need to preserve the elements of the rings that make up the chains of biological systems on which the continuation of life and survival of humans depend (Kim, 2018, 14). These stages include humanitarian, spiritual, introversion, and flexibility (Pirnia, 1380, 31). House stability, one of the features of Iranian architecture, is applying geometry in its designs. A precise understanding of geometry and its sub-elements enables Iranian architecture to present more stable and valuable forms; this is actualized in architecture by resorting to the module and its requirements (Pirnia, 1380, 25). Though Iranian house architecture is a discipline, developed in the last few centuries, its fundamental and related issues are still the subject of debate (Heydari Delgarm et al., 2022).

• Building assessment systems

The emergence of the energy crisis in the 1970s and the seriousness of energy efficiency gave birth to sustainable house assessment systems (Leach, 2010, 7; Haqparast & Rahimnia, 2024). These systems are designed to reduce energy consumption and increase the structure-environment compatibility (Haqiqat et al., 2005). The first house sustainability assessment system, the BREEAM, was devised and launched in the UK by the BRE Building Research Center in 1990. In 1998, the first version of the (LEED) rating system was devised as the Green Building Design Code (LEED) by the US Green Building Council (Maknun, 2015, 8-10). After that, other systems like the GreenStar in Australia, CASBEE in Japan, DGNB in Germany, and HQE in France were devised. As an example, the main structure of DGNB, the main topic of this research, is presented in (Fig. 2).

• German DGNB assessment system

The D. J. N. By. Urban Areas DGNB NSQ, the

Fig. 2. Basic structure of the DGNB system. Pimiskern et al., 2018 , 25)

publication of the DGNB Urban Areas Sustainability Assessment System by the German Sustainable Building Council, is one of the essential achievements of Germany in the field of sustainable urban development. In this system, the scope of assessable projects in terms of area, performance, count of houses, etc., is specified more precisely than in other systems. It is the second version of house assessment (systems that were devised after the initial LEED and BREEAM systems and have adapted these systems to their design generality(Mofidi Shemirani, Tahbaz, Mehraban 1398). This assessment system was devised in Germany, where economic, environmental, and socio-cultural aspects in the planning, construction, and operation of houses are of concern (Fastenrath & Braun, 2019). The criteria of this system consist of the environmental, economic, technical, socio-cultural, functional, process, and site qualities that cover all aspects of sustainable construction. Their approach is based on a life cycle mentality, where all components of sustainability are of concern, next to energy and environmental, socio-cultural, technical, and economic indicators. The scoring system provides quantitative target values based on knowledge-based models (Leach, 2010, 135-180). The scope of the DGNB system sustainability concept includes the following: ecology, economy, socio-cultural and functional aspects, technology, processes, and site topics. This makes the DGNB system the only system that is concerned with the economic aspect of sustainable construction and the ecological qualities of different weights (Butt et al., 2019). In Iran, depending on the specific type of house, the rating assessments can include 40 sustainability criteria, all of which are regularly assessed by an independent panel of experts. Depending on the degree to which a house meets these criteria (based on the DGNB Performance Index), it is awarded a platinum, gold, silver, or bronze rating. This rating includes new, existing, and renovated houses. The objective of sustainable houses is to allow their occupants to enjoy their long-term use. According to its background, the DGNB seeks to improve the quality of the built environment design. This objective is shared with the construction of historic houses criteria, and the degree of similarity is assessed through qualitative and quantitative approaches in this study. The basic structure of the DGNB system is shown in Table 2.

- **Adaptive reuse of historic houses**

Adaptive reuse means changing the functionality of historic houses for new and compatible use, with no detrimental effect on their cultural and historical values (Tootoonchi et al., 2021). This concept was proposed in international charters like the Athens Charter (1931), the Venice Charter (1964), and the Budapest Declaration (1972), where maintaining and increasing the historic houses is highly recommended (Haghparast & Rahimnia, 2024). According to the same researcher, adaptive reuse is a multi-stage process where the physical aspects, social, cultural, economic, and environmental factors are of concern in decision-making, preparation, implementation, and post-implementation. Practical examples indicate that considering the modern needs of users in the modern design of historical houses will lead to improved efficiency and sustainable conservation.

- **Adapting the DGNB criteria to Iranian architectural principles**

Iranian historical architecture indicates that the focus of this method is on principles like adaptation to climate, organic and human-friendly design, next to

Table 2. General structure of the DGNB-System. Source: Leach, 2010.

Criterion	Criteria group	Subject
PRO1.1 Comprehensive project summary PRO1.4 Sustainability aspects at the tender stage PRO1.5 Documentation of permanent sustainability PRO1.6 Urban planning and design PRO2.1 Construction site or the process PRO2.2 Construction quality assurance PRO2.3 Systematic commencement PRO2.4 User communication Planning through FM PRO2.5	Planning Quality (PRO1) Construction quality assurance (PRO2)	PRO PROCESS QUALIT (PRO)
SITE1.1 Local environment SITE1.2 Regional effect SITE1.3 Accessable transportation SITE1.4 Accessibility to facilities	Site Quality (SITE1)	SITE QUALITY (SITE)
ENV1.1 Structure life sample assessment ENV1.2 Local environmental effect ENV1.3 Sustainable industry extraction ENV2.2 Drinking water demand and wastewater capacities ENV2.3 Land use ENV2.4 Environmental diversity of the site	ENVIRONMENTAL QUALITY (ENV) CONSUMPTION AND WASTE GENERATION (ENV2)	ENVIRONMENTAL QUALITY (ENV)
ECO1.1 Life cycle expenditure ECO2.1 Adaptability and flexibility ECO2.2 Commercial sustainability	LIFE CYCLE COSTS (ECO1) ECONOMIC DEVELOPMENT (ECO2)	ECONOMIC QUALITY (ECO)
SOC1.1 Thermal comfort SOC1.2 Indoor ventilation quality SOC1.3 Noise comfort SOC1.4 Visual comfort SOC1.5 User control SOC1.6 Indoor and outdoor spatial quality SOC1.7 Security and safety SOC2.1 Comprehensive design	HEALTH, COMFORT, and USER SATISFACTION (SOC1) FUNCTIONALITY (SOC2)	SOCIOCULTURAL AND FUNCTIONAL QUALITY (SOC)
TEC1.2 Noise insulation TEC1.3 Building coverage quality TEC1.4 Technical integration and use of the structure TEC1.5 Building components' cleaning facilitation TEC1.6 Facilitating recovery and recycling TEC1.7 Air outlet control TEC3.1 Movement fundamentals	TECHNICAL QUALITY (TEC1)	TECHNICAL QUALITY (TEC)

optimal use of natural resources, like natural scenery, climatic conditions, and user comfort, for example, erecting windbreaks, making central courtyards, awnings, by consuming eco-friendly materials like wood and dirt brick. House construction reliability and human-friendly: Iranian architectural structures are based on functional geometry and modularity (Paimon), which ensures the durability and sustainable value of houses (Memarian & Pirnia, 2008, 519-579). In this regard, the degree of conformity of both criteria is shown in Table 3.

• Adapting the DGNB system to Iranian traditional architecture and abridging the integrated solutions

Assessing the Iranian traditional architecture reveals that principles like introversion, use of local materials, and climatic design contribute to constructing sustainable houses. Studies based on a comparative analysis of these principles with global standards like the DGNB and EN 16883:2017 (International Energy Agency), indicate the high compatibility of this architecture with global standards. We have presented the matching and summary of the combined solutions of both criteria in Table 4.

The Study Area

Shiraz, the center of Fars Province with an area of 1268 km^2, is a rectangular-shaped city located in the southwest of Iran. Shiraz is surrounded by a relatively high mountain range, a natural protective measure. The mountains of this range consist of Mount Drak, in the west, and the Bemo, Sabzposhan, Chehel-Maqam, and Babakouhi in the south (from the Zagros Mountain range). The altitude of Shiraz fluctuates between 1480 and 1670 m above MSL. The history of this city dates back to the Persian era. This geographical range is shown in Fig. 3.

Table 3. Table of matching DGNB criteria with architectural principles. Source: Authors.

Related resources	Comparing Iranian architecture	Iranian architectural principles	DGNB system criteria
Pirnia & Memarian, 2008; Flamkey, 1975, 261; Leach, 2010	Eco-friendly materials (wood, brick), a central courtyard for natural ventilation, thick walls for temperature regulation, and high ceilings. Use of internal and external awnings. Construction methods with low impact on the environment. DGNB in optimizing energy consumption and reducing negative environmental impacts.	Self-sufficiency, reliance	Environmental quality
Brown et al., 2012; Butt et al., 2018; Nasiri et al., 2022.	Efficient use of resources, reducing long-term costs with long-term design. Creating efficient and multifunctional spaces. This approach is in line with the DGNB's objectives of reducing long-term costs and creating economic value for users and society.	Avoiding vanity and self-sufficiency	Economic quality
Pirnia & Memarian, 2008; Sheila Conejos, 2013; Pimiskern et al., 2018	People-oriented design, human proportions, and maintaining the visual and social identity of houses. A building promotes a sense of belonging to the place. The principle of introversion with central courtyards and private spaces is similar to that of the DGNB in improving the quality of life and recognizing local culture.	Humanitarian, introversion	Socio-cultural quality
Leach, 2010; Bond & Worthing, 2019	Lack of modern technologies; Possibility of adapting new technologies to traditional structures. The principle of resource efficiency is the optimal use of existing facilities and knowledge. The DGNB technology quality criterion is interpreted within the principle of the resource efficiency framework and applies modern optimization technologies in improving the energy performance and sustainability of houses, with no conflict with the principles of traditional architecture, but complements it.	Reliance	Technological quality
Pirnia & Memarian 2013; Adel, Sati Abbas, 2020; Leach, 2010	Precise geometric structure and modularity, with a focus on resource management and harmonious physical design. Traditional construction processes based on local knowledge, the experience of local craftsmen, and community participation are consistent with the DGNB's emphasis on sound project management, from design to implementation and operation, with a focus on the social aspects of the project.	Humanitarian Self-reliance	Process quality
Flamkey, 2010, 603; Haqfarest, 1403; Pimiskern et al., 2018	Climate-friendly site selection, introspective design to reduce environmental impacts, and access to natural and social resources that are consistent with the DGNB's objective approach to assess the house's location and have optimal use of the site's potential, especially in terms of natural resources and energy.	Self-sufficiency, reliance	Site quality

Table 4. Comparing the DGNB criteria with architectural principles and abridging integrating solutions. Source: Authors.

Reference	Abridged integrated solutions	DGNB Basics	Traditional Iranian architecture features
Hanachi & Shah Timuri, 2021, (Bond & Worthing, (2016	Combining modern technology with traditional techniques to improve energy efficiency	Reducing the need for energy consumption by providing natural ventilation	Use of windbreaks and central courtyards
Herrera et al., 2024; Hanachi & Shah Teymurry, 2021	Native materials like adobe and brick, combined with retrofitting systems	Using sustainable materials minimizes waste	Use of natural and native house materials
Nasiri et al., 2021. Bond &Worthing, 2016	Devising modern security tools to accompany the introverted elements of Iranian architecture.	Assuring structural safety and visual comfort for users	Introverted design and spatial security

Fig. 3. Location of Shiraz City. Source: Shiraz cultural heritage.

- **Assessment of the historical houses of Nasir al-Molk, Zinata al-Molk, Bayat, and Forough al-Molk**

The elongation and configuration of the structure components are designed in the hall form to compensate for wind movement (Mohammadi & Sheikh Bigelow, 2010, 66). Consequently, how houses are located in each region is subject to an effective measure to provide harmony with the climate. In this context, the general setup of the city has a 30° westward rotation, which determines the orientation of houses at 30° southwest (the predominant orientation) or 60° southeast directions.

- **The comparison of the subject made on historical houses through the main criteria of the DGNB assessment system**

The DGNB system, with its six main assessment qualities, including environmental, economic, technical, socio-cultural, functional, and process qualities, is one of the most reputable sustainability assessment systems in the world and is applied in the Table 5 to analyze the subject houses. (Boarin et al., 2014). Because based on the extracted information and the experience of the historical building case study, it highlights some hidden points.

- **Observation**

Nasir al-Molk and Zeinat al-Molk houses have features that highly promote socio-cultural quality and create social interactions, and by observing climate design principles, energy consumption is reduced. The central courtyard, with appropriate design and use of water, promotes green space, allows social interactions, and provides easy access to the outside. It is revealed that each one of these houses has unique features that fit the DGNB sustainability principles, and their strengths can be used in development programs. The Zeinat al-Molk house has the most detailed components (explained in the next stages of this study). In the historical texture of this city, 90% of the houses have special octagonal entrances, while the common entrances have a rectangular/square configuration.

Study Methodology

After comparison, for a more practical and accurate assessment, a researcher devised a checklist of comparable criteria and a scale on Zeinat-ol-Molk house, Shiraz, was scrutinized through fieldwork observations and in-person interviews by researchers, experts, and technical personnel involved, next to resorting to existing documents and maps. The evaluation method here is based on scoring, and this scoring, according to the 2018 edition of the guidelines, where the micro-items related to the criteria and the explanations related to the items obtained in the checklist tables are provided to devise a table containing the abridgments and the weight coefficients of each criterion. As to Iranian architectural criteria, because the criteria related to the mandatory criteria chapter are expressed in the checklist, by running specified analyses on each criterion and method, the compliance or non-compliance related to the review of these criteria is discussed.

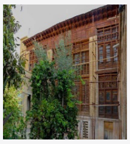
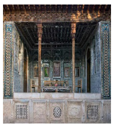
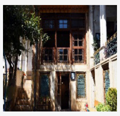
Variables and Data Collection

To begin with, a general understanding of the criteria of interest in both subjects of comparison is essential to generate a general view regarding their similarities and dissimilarities for explaining the criteria that are most consistent and the issues that should be considered in the future.

- **General comparison of DGNB system criteria with Iranian architectural criteria**

The similarities and dissimilarities of the DGNB assessment system and Iranian architectural

Table 5. Comparison of the subject historical houses through the main criteria of the DGNB assessment system. Source: Authors.

House	References	Site quality - design template	Process quality	Technological quality	Socio-cultural quality	Economic quality	Environmental quality
The house of Nasirolmolk 	Pimiskern et al., 2018 Borin et al., 2014 Memarian & Pirnia, 2013	Appropriate location with easy access to the central courtyard and columned verandas, endowed with natural lighting and proper spatial proportions	Natural and mechanical ventilation systems	Natural and mechanical ventilation systems	Promoting socio-cultural interactions by providing religious spaces and public spaces to preserve historical and cultural values	Optimal utilization of resources with lower maintenance costs: reflective tiles for energy saving.	Reflective tiles for increased brightness, local materials to reduce environmental impact, central courtyard for natural ventilation and reduced energy consumption, cooling ceilings and natural ventilation in accordance with the climate
The house of Zinatolmolk 	Yenal et al., 2023 Pirnia & Memarian, 2008 Mashadi & Sinai 2021	Located in the historical context and proximity to natural lighting and spatial arrangement for best ventilation -Garden space design of the garden space and its centrality in the courtyard. Entrances in the corner of the courtyard	Sustainable resource management and development of house preservation processes	Sustainable resource management and development of house preservation processes	Strengthening cultural identity and social interactions, spaces for artistic education and reproduction, and maintaining open and shared spaces for cultural interactions	Best use of resources with lower maintenance costs	Climatic design of a central courtyard with a garden and a fountain to reduce the thermal effects of native and local resources, to increase economic potential
The house of Bayat 	Cabeza et al., 2018. Zarrin et al., 2021 Zarei et al., 2017	Easy access to urban services and green spaces, and connecting the house with the surrounding environment.	Planned for local community participation in the reconstruction and operation process	Appropriate design management systems for providing shade and reducing the need for artificial ventilation systems	Preserving historical identity through spatial arrangement providing social services for social spaces, and strengthening cultural interactions	Using native and local materials to reduce costs and increase property value	Natural shading provided by Planted trees, shrubs, etc improves outdoor air quality. Consuming traditional and local materials to reduce environmental impacts
Forough-ol-Molk House 	Yenal et al., 2023. Pimiskern et al., 2018 . Pislow et al. 2018. Zarrin et al., 2021	Access to public transportation services. Columned porches and a central courtyard with a pond and garden, semi-open space, and appropriate division of places.	Adhering to sustainability principles in construction and operation	Proper house design to create shading and reduce the need for artificial ventilation systems	Cultural and service spaces, social connection, preservation of architectural elements, development, and encouragement of citizens' participation	Reduced maintenance costs with durable materials and resources, with lower maintenance costs	Climate-friendly materials and a central courtyard with minimal sky visibility and maximum shading for thermal comfort

principles were assessed. It should be noted that some of the criteria of interest in the DGNB system deal with dimensions that do not fit into the subject of this topic. In the table below, number 5 has 37 criteria in six main qualities of the system aligned with Iranian architectural principles were categorized into five topics and applied. The comparisons between the criteria DGNB system and Iranian architectural principles are tabulated in Table 6.

The Iranian Architectural Criteria Are Defined

Humanitarian: 1) The most basic perception of the human vs. structure scale is observing its size, proportion, and physical dimensions, 2) Futility

Table 6. DGNB standard Principles of Iranian architecture. Source: Authers.

Criteria	Sub-criteria	Humanitarian	Avoiding Futility	Self-sufficiency	Reliance	Introversion
ECO	ECO 1.1 Life Cycle Cost	-	-	-	-	-
	ECO 2.1 Flexibility and Adaptability	*	*	*	*	-
	Commercial Durability 2.2 ECO	-	-	-	-	-
ENV	Dwelling Life Cycle Assessment ENV 1.1	-	-	-	-	-
	Local Environment Impact 1.2 ENV	*	*	*	*	*
	Sustainable resource extraction 1.3 ENV	*	-	*	-	*
	Drinking water demand and wastewater volume ENV 2.2	-	-	-	-	-
	Land Use 2.3 ENV	-	-	*	-	-
	Biodiversity on site 2.4 ENV	-	-	-	-	-
SOC	Thermal comfort 1.1 SOC	*	*	*	*	-
	Indoor air quality SOC 1.2	*	*	*	*	*
	SOC 1.3 Audio Comfort	-	-	*	-	*
	Visual comfort 1.4 SOC	*	*	*	*	*
	User Control Soc 1.5	*	*	-	-	*
	Quality of indoor and outdoor spaces Soc 1.6	*	*	*	*	-
	Safety and Security Soc 1.7	*	*	-	-	*
	Design for all Soc 2.1	*	*	*	-	*
TEC	Sound insulation TEC 1.2	-	-	*	-	-
	House Coverage Quality TEC 1.3	-	*	*	-	-
	Applying and integrating TEC1.4 House Technology	-	-	-	-	-
	Ease in cleaning of TEC 1.5 house components.	*	-	*	*	-
	Ease in recovery and recycling TEC 1.6	-	-	*	-	-
	Controlling the emission of pollution from the house to the outside TEC 1.7	*	-	*	-	-
	Transportation Infrastructure 3.1 TEC	*	*	*	-	-
Process	Comprehensive Project Summary PRO1.1	-	-	-	-	-
	Sustainability aspects in the tendering phase PRO 1.4	-	-	-	-	-
	Documentation for Sustainable Management PRO 1.5	-	-	-	-	-
	Urban Planning and Design Procedure PRO 1.6	*	*	*	*	*
	Construction Site/Construction Process PRO 2.1	-	-	-	-	-
	Construction Quality Assurance PRO 2.2	-	-	-	-	-
	Systematic commencement PRO 2.3	-	-	-	-	-
	User Communication PRO 2.4	*	*	-	-	*
	Planning following FM PRO 2.5	-	-	-	-	-
Site	1.1 SITE local environment	*	*	*	*	*
	Regional dominance 1.2 SITE	*	*	*	-	*
	1.3 SITE Access to transportation	-	-	-	-	-
	Access to SITE 1.4 amenities	-	-	-	-	-

avoidance: Establishing a balance between the needs of users and the structure size, 3) Self-sufficiency: Self-sufficiency is in applying the available and accessible facilities and consuming environmentally friendly materials, 4) Neighborhood: It is a set of computational and static matters, next to material science, and selecting and consuming the most appropriate materials economically, and 5) Introversion: Protecting the privacy of residents in the house by assigning special spaces. Among the assessed subject houses, as to social and functional qualities in the DGNB system, the Zinatat Al-Muluk has the most common features, because it has the highest score regarding the available information sources.

The greatest overlap between the principles of Iranian architecture and the DGNB assessment system is in the social and functional quality concepts, thus the focus of this study. Assessing the other qualities will be another study task in the future. Fig. 5 below shows the criteria extracted from the DGNB system with the principles of Iranian architecture in the process of this research.

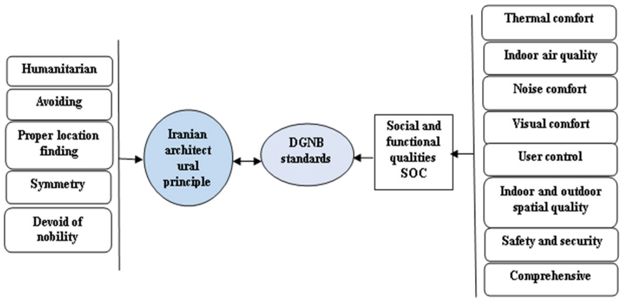


Fig. 5. Location of the Zinata-ul-Muluk house (Shiraz cultural heritage). Source: Authors.

Fig. 6. Location of Zinat al-Molk House. Source: Shiraz Cultural Heritage.

Characteristics of the Study Area

The Zeinat-ol-Molk House covers 2700 m^2 with 20 interconnected rooms on a 3290 m^2 land section about one alley length from the Qavam House. This mansion is built on a longitudinal axis, with the entrance door on the east. Two platforms of marquetry are installed on each side of this door, next to which two Achaemenid soldiers' statues with spears in hand guard the entrance. Fig. 6 shows the location of historical houses in Shiraz.

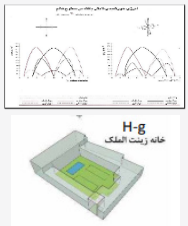
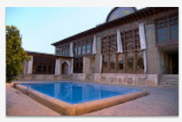
- **The procedure**

In this study, the criteria were assessed through field observations and interviews made with residents and facility technicians, and observation of the existing construction maps and documents.

Findings

To assess the criteria obtained from the DGNB assessment system and the principles of Iranian architecture, a researcher devised checklists based on the regulations and criteria stated in the previous sections because the scoring method must be applied for each criterion in the DGNB assessment criteria, (e.g., to obtain a platinum certificate, a performance index of at least 65 is required for each subject), gold certificate requires an index of at least 50, and silver certificate requires at least 35. The scoring indexes of this house are given in brief explanations. As to assessing Iranian architectural regulations and criteria, compliance or non-compliance with the criteria must be determined. The approved items meet the minimum requirements outlined in that criterion, while the reason for not approving other items is given in the explanation section, where the assessments are made based on the climate and Iranian architectural criteria of the subject house. In The Table 7, The thermal comfort criterion (operating temperature) that usually does not require simulation in the subject house should be calculated through the weighted average of the area. In this house, passive systems are not observed

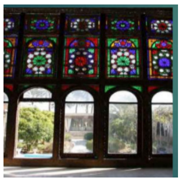
Table 7. Criteria extracted from social and functional qualities related to thermal comfort in the house. Source: Authors.

Criteria			Coefficients	Cooling period Compliance	Heating period Compliance	Influencing factors Score	Influencing factors Description	Images
Self-sufficiency Introversion Demanding 3 points for 10 points	Radiant temperature 7.5 to 15°C	Living room	1.1	*	*	10	Pay attention to the size of the courtyards; the height to the width of the courtyard's ratio; adaptive measures like watering plants, etc., and orientation; 27° of rotation of the courtyard and house. Climate model outputs by the met-ENVI software for two time periods of 9 am and 5 pm.	H-G The subject house 
		Shared room	1.2	*	*	10		
		Resting room	1.3	*	*	10		
	Indoor air temperature 5 to 10°C	Living room		*	*	10	Indoor Air Quality and Air Velocity Measuring Device 440 Testo, the maximum temperature at 31°C. Shutters, sashes, and bridle. Through this air exchange and contact with the ceiling and wall, the cooling load of the air is reduced. Wood burning is the best type of material that transfers heat slowly. Partial compliance with category B of DIN EN ISO 7730 and summer and winter occupants	
		Shared room		*	*	10		
		Resting room		*	*	5		
	Indoor air temperature 5 to 10°C	Living room		*	*	10	The thermometer is a 44-degree thermometer, and the humidity is measured from 0 to 99.9 of a percent. This value decreases during the cooling period. The ponds are outside. There exists relative humidity in the house. The brick has a high thermal and moisture capacity. Creating a basement throughout the house to raise the groundwater level and creating an airflow tunnel under the first floor to facilitate the evaporation of the existing moisture.	
		Shared room		*	*	5		
		Resting room		*	*	10		

in a predefined way, but according to the appropriate windows-to-wall ratio, some points from this section can be of concern. The following indicators are part of the assessment: 1) Operating temperature/indoor air temperature/heating period (quantitative), 2) Asymmetry of radiant temperature and floor temperature/heating period (qualitative), 3) Relative humidity/heating period (quantitative), 4) Operating temperature / indoor air temperature/cooling period (quantitative), 5) Drafts/ cooling period (qualitative), 6) Asymmetry of radiant temperature and floor temperature/cooling period (qualitative), and 7) Relative humidity/cooling period (quantitative). In total, 100 points can be given for this criterion. The heating and cooling facilities are designed and calculated appropriately, based on observations and interviews with the technical authority of this subject house. The temperature here is within the 18 and 35 °C range. In some cases, physical activities at temperatures above 26 °C can lead to health risks. The target cold room temperature is 21 °C, and the target hot room is 24 °C. The room-to-window area ratio is between 40% to 70% with a Uw value ≤ 1. 3 W/m² K. The single-person room setting is heated by a fast-acting heating system (e.g., heating sail, radiator, convection heater). Air velocity and its SD of 40 to 50% should be assumed for the discrepancy in ventilation, while a 20 to 25% degree of turbulence should be assumed for disturbance in ventilation. The asymmetry of radiant temperature and floor temperature (heating period) indicates that the indoor surface temperature complies with the following limit values: Ceiling max. 35°C and glass surfaces of facade/wall min. 18°C. Glass surfaces of facade/wall max. 35°C and floor temperature 29°C. Indoor humidity diminishes during the heating period (even at low outdoor temperatures or dry outdoor air), that is, the indoor humidity meets the following conditions Greater than or equal to: ≥ 25%, of Agenda 2030 Award - Climate Adaptation Resilient Thermal Comfort. The excess frequency for the house in the heating and cooling period is determined through future climatic data projections for the year 2030. That meets the conditions based on the points earned in this item.

The summer section of the house is light and hollow compared to the winter section, for better ventilation and cooling by creating double-layered slatted roofs with air ventilation between them, with thatch and thick walls due to the reduction of the transfer of radiation from the roof to the interior space. The existence of verandas and awnings controls light penetration and protects the facade and wooden windows from wind and rain. The details related to the indoor air quality criteria are expressed in Table 8. Room specifications vary throughout the region. The objective is to ensure that the indoor air is of sufficient quality with no negative effect on the health and well-being of the occupants. Humans spend up to 90% of their time in closed spaces; indoor air quality is essential for performance and health. Assuring high air quality in rooms through low-emission products and providing adequate air exchange rate increases the dwellers' well-being, productivity, and satisfaction, thus, volatile organic compounds (VOCs). A house has exceeded the IRK/AOLG if its TVOC concentration exceeds 3000 $\mu g/m^3$ or its formaldehyde content exceeds 100 µg/m3. Any situation where the substance limits exceed the specified I Guideline Value is not sustainable, because the natural perspiration of the

Table 8. Criteria extracted from social and functional qualities; criteria related to indoor air quality in the house. Source: Authors.

Criteria		Cooling period	Heating period	Influencing factors		Images
		Compliance	Score	Score	Description	
Humanitarian Self-sufficient Introversion	Health/Wellbeing Promotion 5 to 30	*	*	20	Increasing the number of air recirculations per unit of time using sash and louvers. Types of louvered windows for ventilation 440 Testo, Indoor air quality and air velocity measuring device 440 Testo	
	Air pollution Effects of chemicals, air, water, and soil pollution					

occupants and the CO^2 are detrimental for breathing. The total ventilation rate quote (= airflow per person + airflow for the house component) is defined as the user satisfaction rate according to the following equation EN.

$qtot = n * qP + A * qB$

Where n is the count of the room occupants, and A is the floor area.

Ventilation efficiency for displacement ventilation is assumed to be = 1.3. The area of the house on the ground floor is 1500 x 20 people per day on average. P is the ventilation rate for occupancy or use per person, l/s, per person. The CO^2 concentration shall not exceed 1000 ppm.

The acoustic comfort criterion is assessed through separate indicators based on different room types, Table 9. Depending on the size and use of a room, different measures may be necessary to have proper acoustic conditions. In rooms designed for conversation, the focus is on a good level of speech intelligibility between the speaker and the listener. In call centers and dining rooms, achieving a low background sound pressure level and good speech intelligibility at short distances is a priority. In music rooms, promoting the musical experience throughout the room is a priority. Compliance with the different requirements described in the DGNB criterion is required to achieve proper room acoustic conditions. Weighted assessment based on actual usable area ratios (NUF) (R) according to DIN 277-1; Each of the indicators is weighted by percentage according to the usable area. The coefficient of zero means that there should be no noise or sound in the residential area. The Trotec sound meter measures and documents the acoustic classes of the rooms as A, B, or C classes, the Shahneshin or Mirror Hall, the Ghoshvareh (two rooms adjacent to the Shahneshin), and the rooms known as Panj Dari, the Zaviyeh, Bahar Khab, on the left and right sides of the Ghoshvareh room, which had a way to the basement but is now blocked. The room with two doors: A room with two doors to the courtyard, which was popular during the Qajar period. The room with three doors: A room with three doors to the courtyard, which was mostly for sleeping. The room with five doors: The guest reception room (the most formal space in the house). According to the standards, the noise level in the courtyard is 45 to 55, the bedrooms are 20 to 25, and the living rooms are 30 to 40. The sanitary and bathroom facilities are 35 to 45. According to the measurement tools, these values are 72, 39, and 45, respectively, due to because the visitor attendance was high.

According to Table 10, the visual comfort criterion of mirror mosaic works on the walls makes the space brighter, and the presence of colored glass windows indicates a 20-40% increase in light provided that Atot = ADL + AND. TN. a) We calculated the total area illuminated by daylight according to the relation $A_{tot} = ADL + AND$. b) For spaces that do not have daylight (ANDL), 50% of the area must be at least equal to or greater than $\geq 1\%$ according to DIN V 18599 standard, with precise documentation of the obstruction (shading) index, daylight factor, which is at least 1.0%. If the building has a sun/light protection system but visual contact with the outside is possible, it

Table 9. Criteria extracted from social and functional qualities; criteria related to acoustic comfort in the house. Source: Authors.

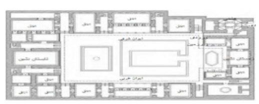
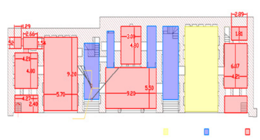
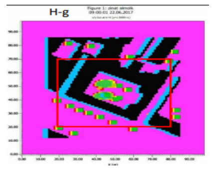
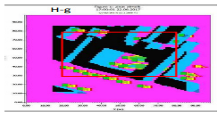
Criteria			Compliance	Score	Influencing factors Description	Images
Humanitarian (meeting the needs of different people) Introversion	Audio comfort	Rooms	*	10	No proportional sound propagation from inside to outside	
		Study	*	10	No proportional sound propagation from outside to inside	

Table 10. Criteria extracted from social and functional qualities; criteria related to visual comfort in the house. Source: Authors.

Criteria				Influencing factors: Compliance	Score	Description	Images
Avoiding futility	Visual comfort	Glare 10 -25	Shared rooms 1.1 Resting room 1.3 Living room 1.5	*	20	Most of the daylight source is through sunlight is measured through the simplified method DIN V 18599-4. Use of functional decorations, like mirrors for lighting. Average hourly radiant temperature curve. Average hourly radiant temperature curve 17	
		Artificial light	Study	*	*	Due to limitations and interference in lighting	

receives a score of 8 to 10. In the evaluations performed, the duration of exposure to daylight on 17 Dey was ≥ 1 hour, and the duration of exposure to daylight during the equinox was ≥ 4 hours, which complies with DIN 14501 standard. In Table 8, the evaluation based on the formula (0 to 4) of sun/glare protection $0.02 < \tau_{v,n\text{-}dif} \leq 0.04$ was performed in the spaces. According to the mentioned formula, the living room with an area of 52.44, of which 50% was considered, was estimated with an angle of incidence of 70. A daylight factor of 0. 3 was considered (0. 5 to 0.2%), which is within the standard range. The architect cleverly leads the person from the relatively dark entrance hall towards the outdoor courtyard, creating a hierarchy in lighting and preparing them for entering the brightly lit courtyard.

In Table 11, the visual comfort criterion is evaluated with an emphasis on traditional design elements and modern architectural techniques. The use of mirror work increases the interior lighting and, along with the use of colored glass, trees, and the proper orientation of the building to the light, adequate natural lighting can be achieved. This design not only provides sufficient light but also prevents glare. Daylight access for the entire residential building is estimated to be between 20- 40 percent. In this method.

In Table 12, Provisions promoting communication, user provision, and facilities for families, children, and the elderly are proper key performance indicators (KPIs) to report on. Nine KPIs indicate efficiency. The maximum score for families in a house is 20. The quality of spaces is described by using qualitative and quantitative indicators. The number and quality of external and internal areas are assessed. The communication areas are primarily used to analyze the proportionality of three indexes within the three range sets. Communication spaces are secondary, with the least decoration.

Table 13 shows the criteria related to safety and security where a maximum of 100 points can be obtained. The assessement and scores are presented in the table The subjective perception of safety and protection against attack includes: 1) The visibility of public areas (entrances, main passages. Inner courtyard paths) and under/over ground multi-story car parks or roof parking (if any) that provide a clear view, and 2) The level of illumination of main passages with sufficient light, paths leading to the parking lot and bicycle parking. The documentation includes evidence showing the light intensity (illuminance) or light density (luminance), provided by an excerpt from the design drawings. Preventive safety measures like Indicator 1.3. A wide range of different forms of documentation are listed below. The documentation should comprehensively demonstrate compliance with the requirements of the assessment objective of each indicator.

In preparing the barrier-free design of a house, the degree of accessibility and equal use of the house by all occupants is assessed Table 14, All houses that are to be certified must comply with the requirements of the

Table 11. Criteria extracted from social and functional qualities; criteria related to user control in the house. Source: Authors.

Criteria				Influencing factors: Compliance	Score	Description	Images
Introversion	User Control Max. 30°C	Air quality	Control room conditions, e.g., temperature and lighting, to suit individual preferences (improving user comfort and well-being)	*	10	Sash. Window. Shade and/or protection. Central courtyard... Items 1 and 2 are assessed in the previous criteria.	
		The temperature is at least 15 to 30°C		*	10	The temperature can be adjusted for each living space. The air quality for a specific room can be controlled in that room 18	
		and high user satisfaction		*	10	The room air quality in a particular room can be controlled if necessary, by separate adjustments. Calculation method and user satisfaction	

Table 12. Criteria extracted from social and functional qualities; criteria related to the quality of internal and external spaces in the house. Source: Authors.

Criteria				Influencing factors: Compliance	Score	Description	Images
Introversion and Introversion Avoiding Futility	Quality of indoor and outdoor spaces	Spaces to facilitate communication (innovative solutions for user well-being)	Communication areas Max. 15	*	10	The vestibule is an intermediary space. The corridor that connects the vestibule to the mesara (central courtyard), and the orientation of the mesara, is the result of the geometric drawing of a rectangle in a regular hexagon.	
			Availability of shared rooms Max. 20	*	15	Multi-family residence. And family privacy. Kitchen in connection with the entrance vestibule and winter quarters.	
			Inner courtyards Max. 10	*	10	Green open spaces promote thermal comfort. Golden ratio mezzanine: balance and symmetry of alternative places to work and enjoy relaxation, promote interaction between users, and increase public acceptance.	

Table 13. Criteria extracted from social and functional qualities; criteria related to the safety and security of people in the house. Source: Authors.

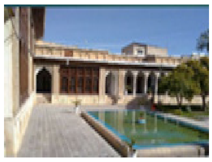
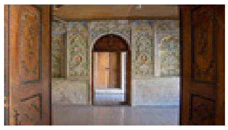
Criteria			Cooling period Compliance	Heating period Score	Influencing factors Description	Images
Humanitarian and introverted 1.1% Reliance	Personal safety and security 2.1%	View level max. 20	*	10	The courtyard is surrounded on all four sides by rooms or at least by walls.	
		Brightness level max. 20	*	10	Direct avoidance of strategy paths like introversion	
		Technical safety apparatus	*	*	None	
		Preventive safety measures max. 10	*	5	The presence of a vestibule at the entrance and the latticework of some wall surfaces. The basement	

Table 14. Criteria derived from social and functional qualities; criteria related to design for all people in the house. Source: Authors.

Criteria				Cooling period Compliance	Heating period Score	Influencing factors Description	Images
Humanitarian, Avoidance of futility	Design for all (Everyone should be able to enjoy the same benefits of the house, regardless of their physical capacity) 4.3%	People with disabilities max. 20	Building entrance	*	*	There are stairs in the entrance hallway. Barrier-free bathroom facilities should be provided in residential units.	
		Extra points for quality level 3	After entering the house	*	10	Human-scale design, the relationship between the physical environment	

house regulations for barrier-free design. Following the generally accepted rules of good engineering practice, where full accessibility, maneuvering areas, the width of doors and corridors, and the provision of grab rails near toilets are of concern. The house showed that the design of the spaces was made taking into account their physical dimensions and type of function, but the entrance was not considered to facilitate the movement of disabled people. The requirements for the barrier-free design are subject to the quality level (according to the DGNB SOC 2. 1 criterion). The barrier-free floor space to usable area ratio is assessed ("NUF" in DIN 277). Relevant plans (e.g., floor plans) showing circulation areas between all use areas, ground floor plan with outdoor facilities and transitions to public spaces including parking 1. Relevant details (transit, navigation systems, operational elements, fixtures, equipment, etc.) 2. Photographic documentation 3. Confirmation from the architect or appointed expert is as per Annex.

Based on the collected data and the explanations given in the checklist tables, the subject receives 333 points in the technical quality criteria of the DGNB assessment system, where each criterion is assigned a weighting factor according to its importance, and in Table 15, these factors are applied to the points obtained in the subject house.

As observed in the table above, the total score of the subject house, after applying the coefficients, is 794, which is lower than the minimum possible score in social and functional qualities, 830 points. The issues not considered in this house, which caused it to receive the minimum score, are non-compliance with disabled access, limitations in measuring some criteria due to the interference of modern humans and visitors, and low application of intelligent systems for user control.

Conclusion

As to the social and functional quality criteria of the DGNB assessment system and the Iranian architectural criteria, there exist some issues that do not fully meet the necessary expectations in both principles, consequently, they can be applied together as complementary for better yield. Thermal comfort is provided in the best way in the subject house. The principle of introversion and people-oriented is of high concern in this principle. Based on the study files, it can be said that the principles of Iranian architecture are in complete or relative compliance with many of the functional and social quality criteria of the DGNB assessment system. The criteria of thermal comfort, internal and external space, and visual comfort are well compatible with the traditional principles. The criteria of user control and accessibility are limited due to the weakness in the use of modern technology and tools. The results obtained are precisely stated in Table 16. The proposed strategy is to integrate natural Iranian architectural solutions with the modern tools and technologies of the DGNB assessment system, to comprehensively meet sustainability and accessibility standards and challenges, next to preserving historical values.

Table 17,The proposed strategy is to integrate natural Iranian architectural solutions with the modern tools and technologies of the DGNB assessment system, to

Table 15. Summing up the scores of each criterion and applying the weighting coefficient. Source: Authors.

Criteria	Total points	Weighting factor	Total
Thermal comfort	101	4	404
Indoor air quality	20	5	100
Noise comfort	20	0	20
Visual comfort	20	3	60
User control	30	2	60
Quality of indoor and outdoor spaces	25	2	50
Safety and security of occupants	25	1	60
Design for everyone	10	4	40
Summing up the points			794

Table 16. Results of matching the social and functional quality criteria of the DGNB assessment system with the principles of Iranian architecture. Source: Authors.

Iranian architectural principles	DGNB criteria	The Iranian architecture executive strategies in sustainable architecture	Suggestions for improving the DGNB aspect/criterion	Compliance analysis
Self-sufficiency. Introversion (location, providing thermal and cooling comfort)	Thermal comfort findings	Appropriate location and orientation of the house volume, adaptive measures, summer and winter dwellings, outdoor ponds, and high thermal and humidity capacity	Modern apparatus for intelligent temperature and ventilation control	Good compliance with DGNB criteria, while improvement of heating and cooling systems should be checked Avoiding waste (optimal use of resources)
Humanitarian. Self-sufficient. Introverted (meeting the needs of different people)	Indoor air quality	Increasing the number of air changes per unit of time by sash and earring elements		Proper adaptation

Rest of Table 16.

Iranian architectural principles	DGNB criteria	The Iranian architecture executive strategies in sustainable architecture	Suggestions for improving the DGNB aspect/criterion	Compliance analysis
Humanitarian (meeting the needs of different people). Introversion. Neediness	Noise comfort	Double-layer roofs. Central courtyard, spatial hierarchy.	Sound absorption, sound insulation	Relative adaptation, the necessity to apply new technologies
Avoiding futility	Visual comfort	The architect cleverly takes the person from the relatively dark portico to the outer bright courtyard, a hierarchy of lighting. The use of functional indoor decorations like mirrors for lighting, lattice walls, colored glass, rotating facades	In compliance with DGNB artistic and visual standards. Continuous maintenance and restoration of decorative works to preserve their historical value.	In full compliance with DGNB artistic and visual standards. Avoiding waste (optimal use of resources)
Humanitarian. Introversion User control	Awning. Window. Shade and/or protection. Central courtyard. Proper courtyard design for gatherings and interactions	Lack of modern cultural-social spaces	Relative adaptation, and the necessity of creating new spaces while preserving the originality of the house	
Reliance and introversion reliance Quality of indoor and outdoor spaces	Family privacy. The kitchen is connected to the entrance vestibule areas. Internal courtyards. Golden ratio: balance and symmetry, access to welfare services (close to service centers)	Convenient location in the city, easy access to service centers. Possibility of use change	Compliance	
Humanitarian Introversion Safety and security of occupants	The courtyard is surrounded on all four sides by rooms or at least by walls. No nobility.	The need for modern security systems. Fire, theft Introversion (privacy)	Relative compliance; no up-to-date security features are visible in the house.	
Being human, avoiding vanity Design for everyone	Stairs in the entrance hallway, human-scale design. Relationship between the physical environments	Installing ramps and small elevators with a design compatible with traditional architecture, creating appropriate access routes	Incompatibility: not designed for all users.	

Table 17. Proposed strategy, integrating natural Iranian architectural solutions with modern tools and technologies of the DGNB assessment system. Source: Authors.

Suggested strategies	Opportunities	Challenges
Combining modern technologies with traditional approaches to increase energy efficiency.	Using traditional techniques such as windbreaks and natural ventilation.	Lack of modern equipment for energy sustainability
Adding ramps, small elevators, and modern equipment without affecting the historic appearance.	Flexibility of traditional structures for redesigning and modernization	Lack of accessibility for people with physical disabilities
Using simulations and AHP or ANP analyses to develop a better match.	The originality and flexibility of traditional Iranian architecture in accepting changes	The complexity of adapting the modern DGNB assessment system criteria

comprehensively meet sustainability and accessibility standards and challenges, next to preserving historical values.The results of the adaptive design of DGNB standards with the functional social quality criterion based on Iranian architectural principles are presented in Fig. 7.

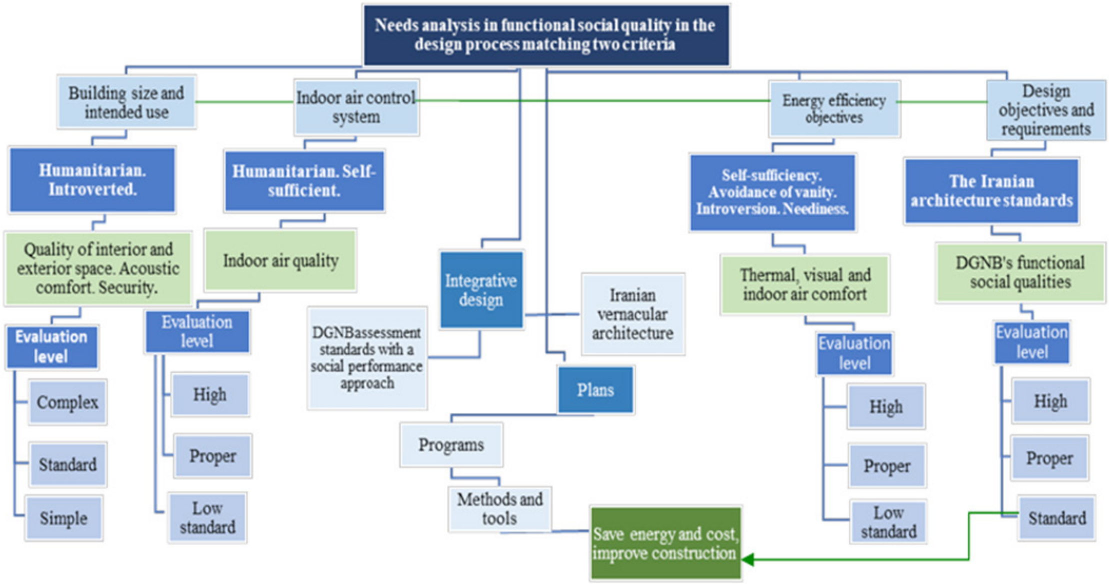


Fig. 7. Results of the design process of adapting DGNB standards to the social and functional quality criteria with Iranian architectural principles. Source: Authors.

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