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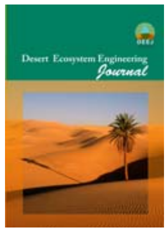

A Framework for Quantifying Biophilic Condition of Cities in Arid Regions: A Case Study of Yazd, Iran

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Abstract

As the primary habitats for humans on Earth, cities are currently experiencing a wide range of environmental issues, including biophilic sickness. Cities in arid and semi-arid regions face more environmental problems compared to other areas, making it challenging yet crucial to manage these issues effectively. To develop strategies for achieving this objective, a comprehensive understanding of the current conditions is essential. Therefore, this study examined the current status of biophilic city indicators in Yazd as a case study. With a rich history of living in harmony with the nature of arid regions, Yazd is a valuable human heritage. However, in recent decades, significant changes in population and land use patterns have occurred. The indicators used to assess biophilic conditions in Yazd included citizens' biophilic knowledge, attitudes, and activities, urban infrastructure, water resources, climate, public health, biophilic institutions, and governance. These selected indicators were quantified using statistical, analytical, and descriptive data. Statistical data were obtained from government reports and offices, while analytical data were derived from satellite images. Descriptive data were collected through a questionnaire. To determine the sample size, Cochran's formula was utilized at a 95% confidence level, resulting in a sample size of 384 individuals based on the Yazd population (529,673 people based on the 2016 census). Finally, the Analytical Hierarchy Process (AHP) method was used to quantify the biophilic status of Yazd based on the weighting and scoring of indicators. The findings indicate that Yazd falls short of being biophilic due to inadequate planning for arid climatic conditions, lack of capacity building in community and education-related management institutions, absence of a citizen-centered culture, and insufficient urban infrastructure. Consequently, substantial modifications in planning and implementation, management practices, educational initiatives, and cultural norms are necessary in Yazd to safeguard the urban environment and enhance biophilic city indicators.

Keywords: Biophilic City, Arid Climate, City Index.

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1. Introduction

Throughout history, the world has experienced significant waves of urbanization and population growth. For example, in 2018, 55% of the world's population lived in cities, and it is projected that 68% will live in cities by 2050 (UNDESA, 2019). During the process of urbanization, forest, pastoral, and agricultural ecosystems have all undergone a remarkable pace and scale of conversion into ecosystems dominated by humans (Wang et al., 2019). This transformation affects the structure and function of Earth's ecosystems, impacting their capacity to support human well-being and provide essential services (Alberti, 2010). Numerous environmental problems caused by urbanization have rendered the majority of world cities unsustainable. If global urbanization continues unchecked, these issues will likely exacerbate as populations gravitate towards urban centers (Wu, 2008).

Arid environments cover more than 30% of the earth's surface, and this percentage is increasing due to climate change. Cities in these regions face numerous complex challenges such as water scarcity, inadequate infrastructure, rapidly growing populations, and urban heat islands (Arup, 2018). Therefore, an integrated approach to strengthening urban greening should be included in planning and decision-making processes to improve the quality of the urban environment (Heidt & Neef, 2007). Nowadays, a new set of design principles and practices has been developed to meet the goals of urban sustainability. One of these principles, called "biophilic cities," is based on the premise that humans are inherently connected to nature (Soderlund & Newman, 2015). The idea of biophilic cities is inspired by the concept of biophilia (Russo & Cirella, 2017). Wilson, an environmentalist, defined biophilia as the innate human desire for other living organisms or life forms (Krčmářová, 2009). Biophilic cities provide close and daily contact with nature while also aiming to raise awareness and foster care for nature (Beatley & Newman, 2013). The goal of biophilic urbanism is to reduce the current urban separation from nature by integrating nature experiences into daily urban life (Kellert, 2016).

The biophilic approach emphasizes the establishment of integrated green systems in cities. The presence of green networks in cities plays a crucial role in improving urban aesthetics, enhancing citizens' quality of life, and providing ecosystem services and products (Russo & Cirella, 2017). These services and products include improved water management and quality (Sadeghian & Vardanyan, 2013; Parivar et al., 2020; Coutts & Hahn, 2015; Tyrväinen et al., 2005; Rowe, 2011); decreased air pollution (Russo & Cirella, 2017; Wang et al., 2015; Sadeghian & Vardanyan, 2013; Bencheikh & Rchid, 2012; Leung et al., 2011; Nowak & Heisler, 2010), reduction of the urban heat island effect (Shishegar, 2014; Sadeghian & Vardanyan, 2013); decreased violence and crime (Bogar & Beyer, 2016; Kuo & Sullivan, 2001), improved mental health (Soderlund & Newman, 2015) and increased property value (Mwendwa & Giliba, 2012; Jansson, 2014).

The expansion of sustainability indicators in urban areas reflects growing concerns about the quality of the urban living environment and the sustainability of environmental systems (Parivar et al., 2016). Many studies have emphasized that biophilic city indicators vary according to the ecological conditions of each region (Huang, 2017). Therefore, it is necessary to select appropriate indicators for each region based on its natural and social conditions. Cities in arid areas face limitations such as climate conditions, water and soil salinity, and a lack of access to adequate open green spaces of suitable quality (Baker et al., 2004). Therefore, these limitations should be considered when selecting indicators for biophilic cities in these regions.

As mentioned above, urbanization and industrialization directly contribute to a significant loss of ecosystem services, leading to widespread environmental issues. Therefore, this study aims to assess the urban environment using biophilic city indexes, with a focus on the case study of Yazd city. The goal is to gain a better understanding of the sustainability status in Yazd and to enhance decision-making in urban planning.

2. Material and Methods

2.1. Case Study

In this study, the city of Yazd, characterized by an arid climate and situated in the central part of the Iranian Plateau, was selected as the focal point (Figure 1). Yazd lies within the heart of the Persian Plateau (Figure 1), nestled amidst the Shirkouh and Kharanagh mountains, at an elevation of 1215 meters above sea level. It occupies a vast plain known as Yazd–Ardakan. While Yazd boasts a rich history of coexisting harmoniously with the natural environment typical of arid regions, recent decades have witnessed significant urban development, exacerbated by population growth and shifts in land use and land cover, presenting numerous challenges for urban planners.

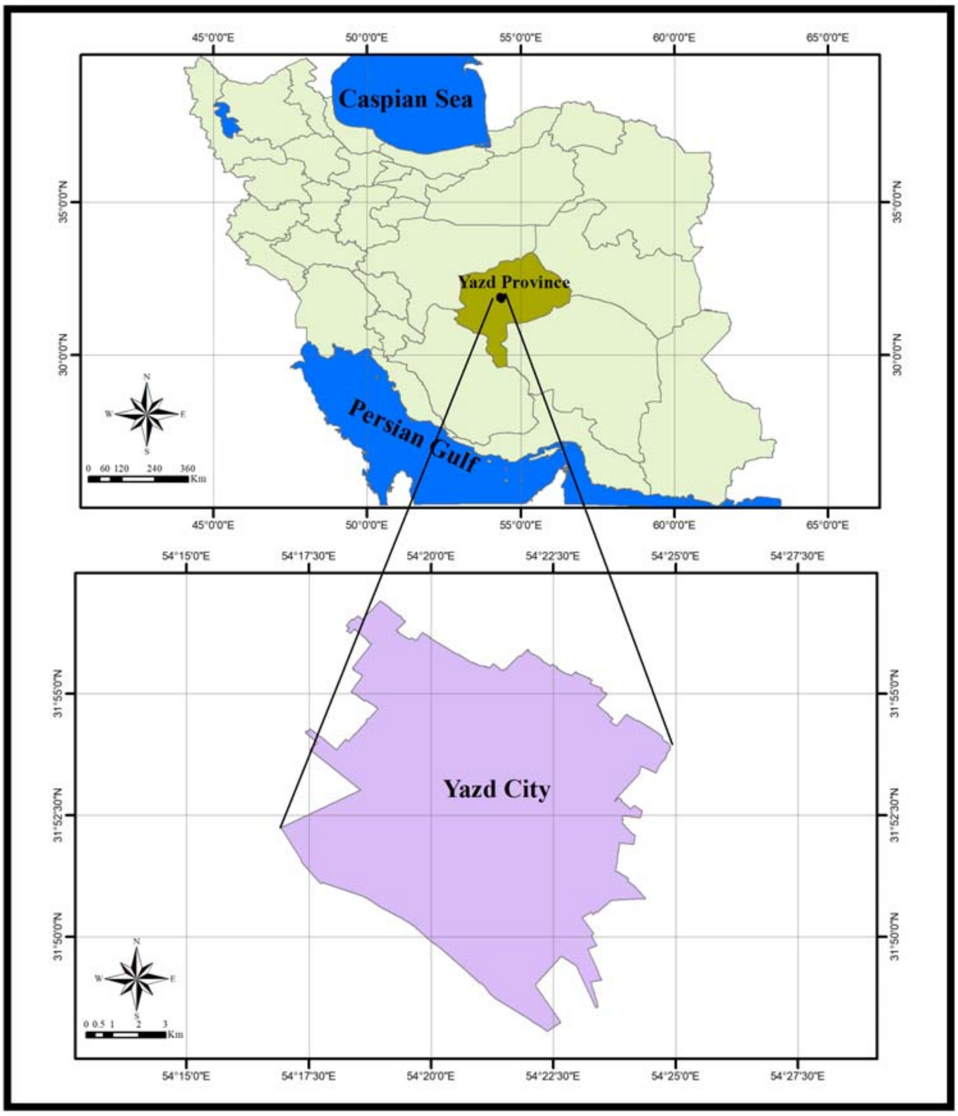

Figure (1): Location of Yazd City in the center of Iran

2.2. Methodology

The urban environment of Yazd was evaluated using biophilic city indicators in this study through four key stages. Figure 2 illustrates the research process diagram. The first step involved gathering various indicators from reviewed sources. Subsequently, experts and specialists in the field were consulted to select the most appropriate indicators for Yazd. Seven indicators, including water, weather, climate, health, biophilic governance, biophilic activity, biophilic knowledge, and attitude, as well as urban infrastructure, were chosen to assess and rank the biophilic conditions of Yazd City. Table (1) presents the indicators and metrics utilized in evaluating the biophilic conditions in Yazd.

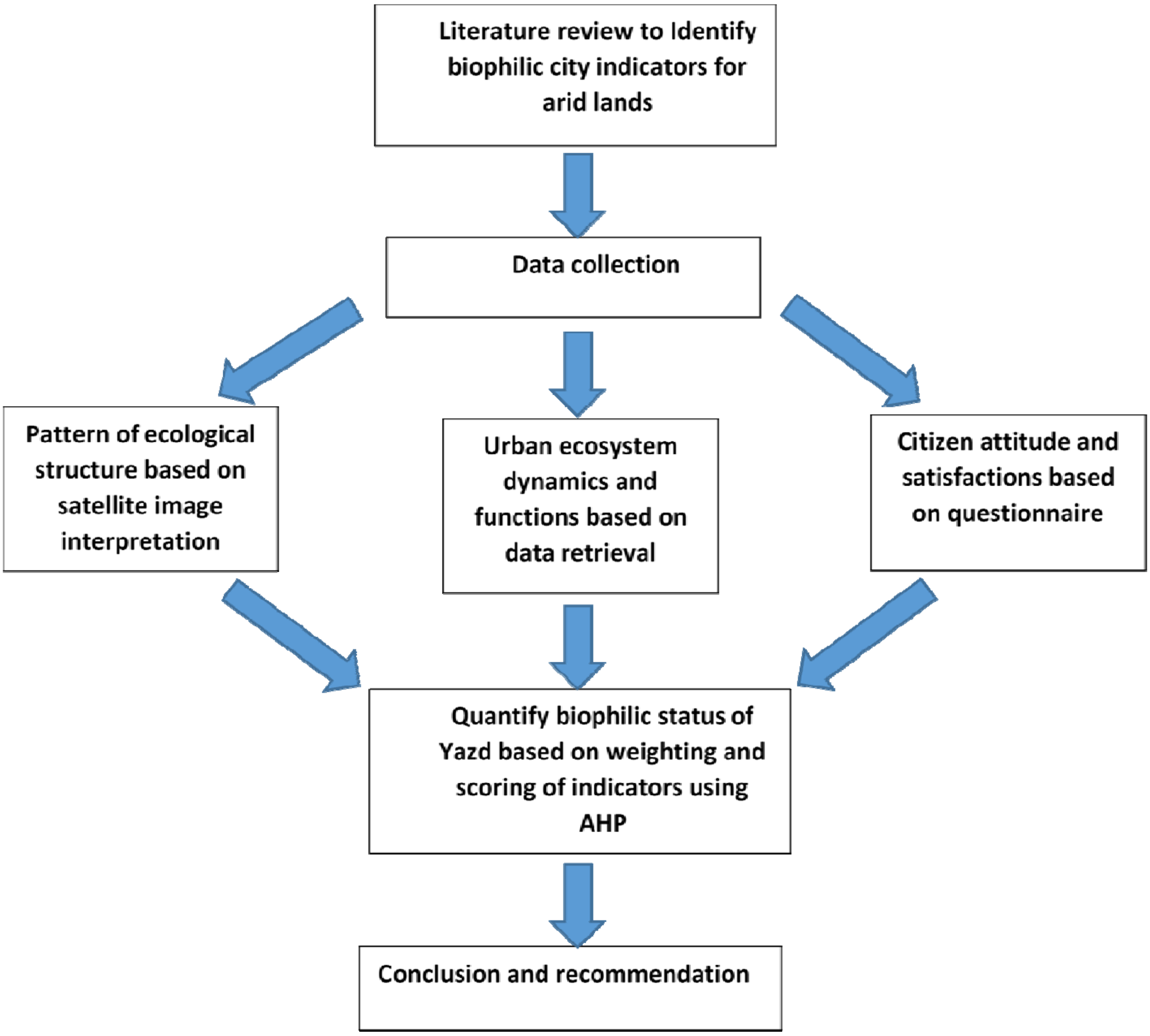

Figure (2): Research process diagram

In the second step, we quantified and mapped selected indicators using statistical, analytical, and descriptive data. Statistical data were obtained from government reports and offices, while analytical data were derived from satellite images. Descriptive data were collected through a questionnaire to measure metrics related to water quality, health, biophilic activity, and biophilic knowledge and attitude. The study's statistical population is 529,673 people according to the 2016 census comprised the residents of Yazd (Statistical center of Iran, 2016). To determine the sample size, Cochran's formula was utilized at a 95% confidence level, resulting in a sample size of 384 individuals.

In the third step of the study, we utilized the Analytical Hierarchy process (AHP) method (Saaty, 1996) to evaluate the key indicators for ranking the environmental status in Yazd City. Subsequently, we administered a questionnaire to 20 experts using a non-random, targeted sampling technique.

Lastly, we ranked every aspect of the biophilic city using a Likert scale and defined the value of each class in accordance with its respective conditions. In this scale, the minimum value is 1, and the maximum value is 5. Finally, we assessed the degree of bio-friendliness for each sub-criterion by multiplying its relative importance and evaluating it based on 21 sub-criteria.(see table 1)

Table (1): The indicators and metrics for evaluation of biophilic conditions in Yazd

Issue	Primary criterion	Secondary criteria	Measure
Water	Water quantity	Surface water	Water consumption rate
		Groundwater	The exploitation of groundwater resources
		Drinking water	
	Water quality		The rate of citizens' satisfaction with the city's water quality
Weather & Climate	Air quality	The concentration of natural pollutants	AQI Index
			The ratio of days to the phenomenon of fine dust in the year
	Drought	The severity of the drought	SPI index
			Z index
		Atmospheric changes	Precipitation trend
			temperature trend
	Climate adjustment	Ultraviolet beam index	UV index
		landcover	Landscape connectivity
Health		Urban population’s access to nature	The percentage of urban population exposed to urban nature for at least 30 minutes a day.
			Percentage of urban population spending 30 minutes of their daily physical activities outdoor
			Percentage of population with 5 minutes of walking access to nature
		Children's access to nature in schools	Percentage of schools that allow children to play and have fun in nature
Biophilic institutions and governance	Rules and Regulations	Design and planning regulations	Percentage of local budget allocated to nature conservation, recreation, education, and related activities Priority of local government attention to nature conservation
		Supporting organizations	Number of local biophysical support organizations
Biophilic activities		Recreation	Percentage of urban population who can walk daily
			Percentage of daily visitors from parks or green spaces
		Environmental NGOs	Percentage of people's participation and voluntary efforts in nature restoration
		Communication with nature	Percentage of residents who have active gardens (including balconies, rooftops, and social gardens)
			The ratio of the area of open spaces and the playing time in schools
Biophilic knowledge and attitudes	Biophilic attitude	General knowledge level	Percentage of population that can identify common plant and wildlife species
			Percentage of citizens with environmental concerns
Urban infrastructure design	Existence of an integrated bio-environmental network, urban green network	Green corridors	The ratio of the area of the backyard
		Urban agriculture	The ratio of the area of farms in the city
			The ratio of the area of local gardens
		Urban parks	Large city parks
	Access to ecological reserves	accessibility	Percentage of the population living within 100 meters of the park or green space
			Percentage of the population living within 300 meters of green space, park, or other natural elements
		Land cover	Percentage of forest canopy coverage
			Number of plant species of flowers and plants
			Compatibility of plant species

3. Results

3.1. Water

Yazd has undergone significant damage to its water resources both in terms of quality and quantity due to persistent droughts. The population growth rate has soared to 2.02%, leading to an average increase in water consumption of 3.14% (see Figure 3). Moreover, the indiscriminate extraction of groundwater resources has resulted in a negative water balance within deep and semi-deep wells and qanats (refer to Table 2). Environmental conditions and human activities have profoundly impacted the quality of drinking water resources. As per the findings from the questionnaire (depicted in Figure 4), 51.36% of the citizens expressed dissatisfaction with the quality of drinking water in the city. Consequently, Yazd finds itself in an unfavorable situation with regard to this biophilic indicator.

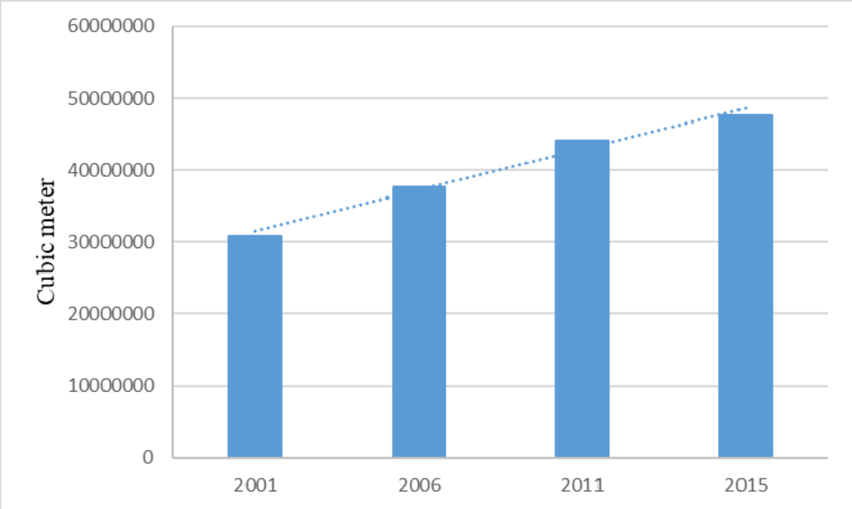

Figure (3): Total water consumption of Yazd

Table (2): Groundwater resources and annual discharge amount of one million cubic meters

year	deep hole		Semi-deep well		Ghanats		Spring	
	Number	Annual evacuation	Number	Annual evacuation	Number	Annual evacuation	Number	Annual evacuation
2001	538	185	86	15.2	34	22.8	0	0
2006	528	116.59	9	1.92	1	0.01	0	0
2011	533	99.41	4	0.01	10	6.35	0	0
2015	502	106.8	45	3.53	10	0.76	0	0

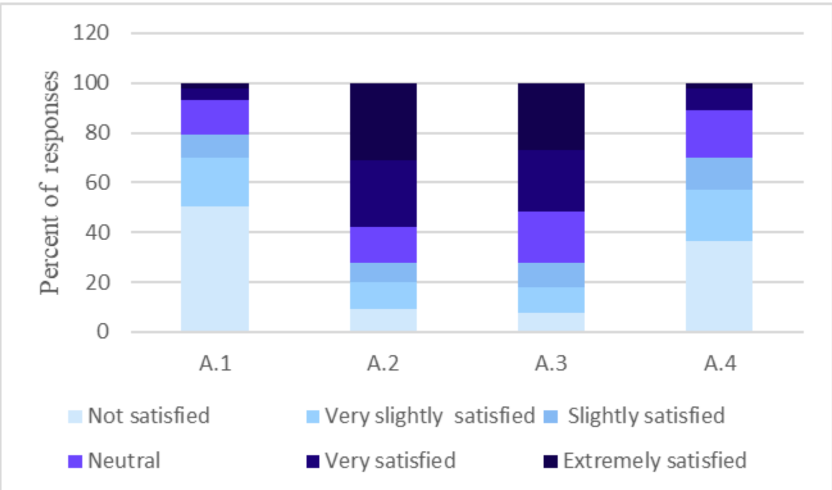

Figure (4): Results of the questionnaire related to Water quality

3.2. Weather & Climate

Air pollution, a consequence of urbanization, increased industrial activities, and escalating consumption of fossil fuels, in addition to environmental destruction and economic losses, is recognized as one of the top ten leading causes of death worldwide. The Air Quality Index (AQI) reveals that the number of days with unhealthy air (Figure 5) and dust phenomena (Figure 6) have risen during the research period. Air pollutants have increased, leading to a significant decline in air quality. This is largely due to human activities, including an increased number of motor vehicles, the presence of industries and production units, destruction of green space, and reduced urban vegetation.

Drought is a recurring feature of different regions, and its effects are not limited to arid and semi-arid areas. The frequency, intensity, and continuity of drought, however, vary from one place to another. The severity of the drought was evaluated utilizing two standard precipitation indices (SPI) and a zero-point index (ZSI) (Figure 7). Both indices show negative values, indicating below-average precipitation and, thus, an increase in drought. Temperature and precipitation represent vital meteorological parameters and are considered the primary climatic factors of a region. The climate change trend exhibits a rise in temperature and a decrease in precipitation.

The UV index and land surface continuity index were utilized to investigate the climate conditions. The UV index ranges from zero to 11, with zero indicating the lowest risk and 11 indicating the highest risk. This indicator is classified into five categories. According to Figure 8, Yazd falls within the high-risk category, indicating an undesirable situation in terms of UV radiation. Metrics such as CA, PLAND, AREA_AM, GYRATE_AM, and ENN_AM were measured at the vegetation level, while NP, AREA_AM, ENN_AM, GYRATE_AM, and CONTAG metrics were measured at the landscape level to determine landscape continuity using FRAGSTATS. The measurements revealed that the area covered by vegetation decreased by 6.47% from 1991 to 2018. The number of vegetation patches increased by 443, and the nearest neighbor distance for vegetation became longer (from 10.22 to 31.14 meters), indicating an increase in small-sized urban green patches. Abandoned lands and vegetation are transitioning into urban areas (see Table 3).

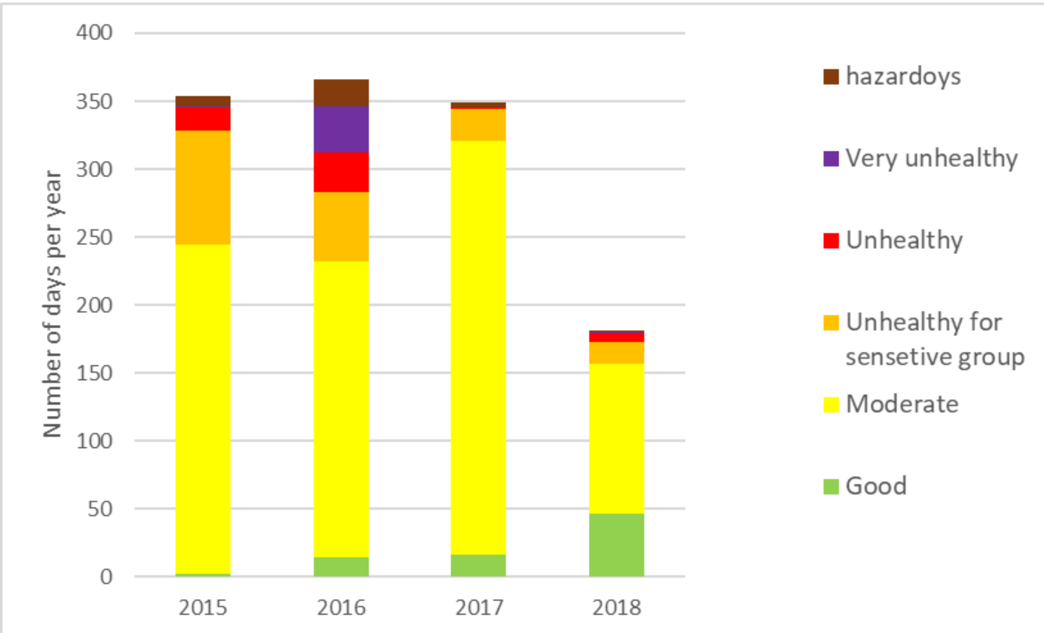

Figure (5): Air quality index

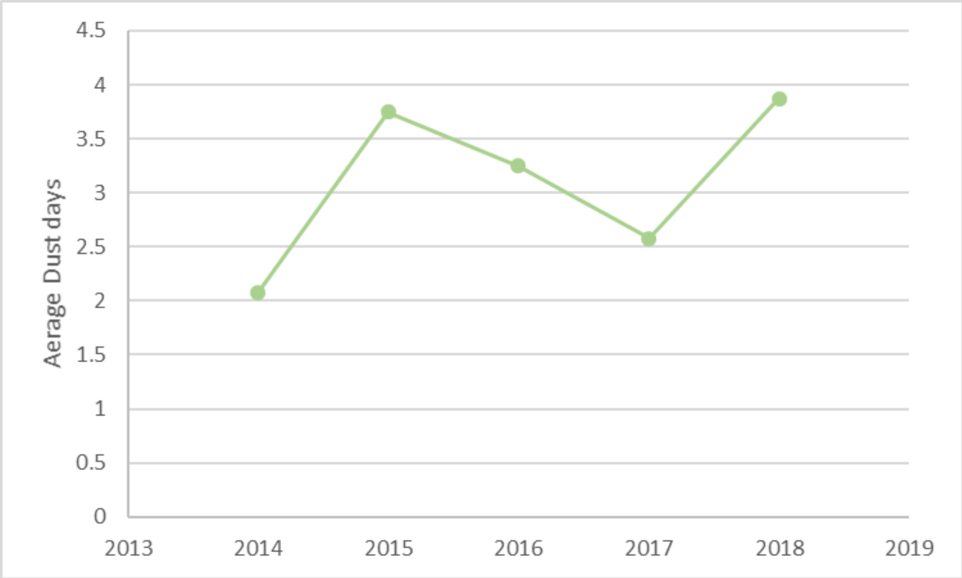

Figure (6): Average number of dust days

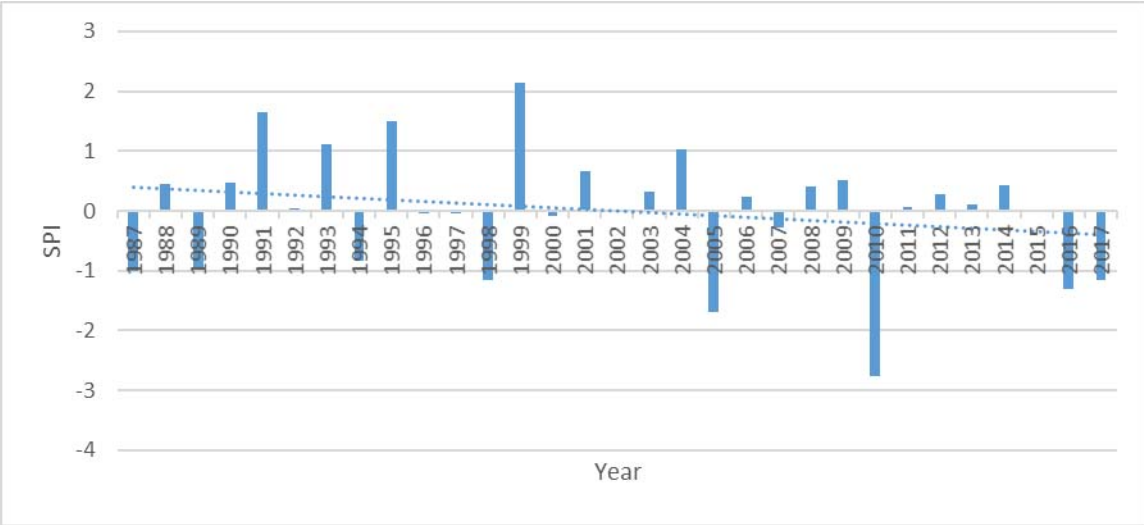

Figure (7): Standardized precipitation index (SPI)

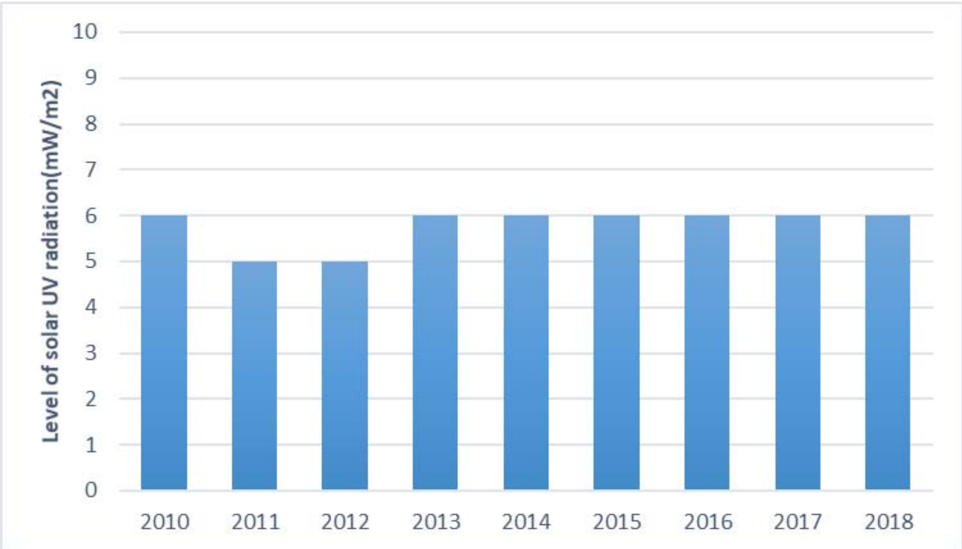

Figure (8): Average UV index (2010-2018)

Table (3): Status of landscape metrics

Year	Name	Land Use	CA	PLAND	NP	AREA_AM	GYRATE_AM	ENN_AM
1991	Landsat 5	Open Space	3240.4	16.14	226	898.3	1213.28	13.945
		Green Space	2617	13.04	330	410.98	957.36	10.224
		Urban Space	4847.2	24.15	213	4019.5	3023.78	8.223
2018	Landsat 8	Open Space	645.13	3.214	340	210.691	660.91	57.850
		Green Space	1317.3	6.562	773	45.458	303.882	31.142
		Urban Space	8743	43.55	138	8513.4	3918.69	15.361

3.3. Design of urban infrastructure

One of the key indicators to evaluate the biophilic nature of a city is the presence of natural spaces and green elements, as well as their accessibility to city residents. Based on this criterion, urban green corridors cover less than one percent of the city's land area. Additionally, urban farming is declining steadily, with the remaining agricultural areas occupying a very small portion, close to 1.5 percent of the total urban land area. A fundamental goal of a biophilic city is to ensure the proximity of at least one park or green space to residential units. However, only 5 to 16 percent of citizens currently have access to local parks. Moreover, the number of parks is negligible compared to the urban population, and even existing parks suffer from unsuitable locations, inadequate spatial arrangements, limited surface areas, and insufficient facilities.

There is a relatively good diversity of plant species present in the city. To assess the compatibility of plant species in the urban environment, a comprehensive list of plant species in Yazd city was initially compiled by the Parks and Green Space Organization. The inventory revealed 145 plant species in the form of trees and shrubs within the city's green spaces and parks. Subsequently, these species were classified into five categories based on expert opinion and ecological conditions: Class 1 signifies good adaptation, Class 2 reflects moderate adaptation, Class 3 denotes low adaptation, Class 4 indicates poor adaptation, and Class 5 symbolizes very poor adaptation. Results show that 15.22% of plant species exhibit good adaptation, 50.69% demonstrate moderate adaptation, 22.91% have low adaptation, 9.7% show poor adaptation, and 1.3% are very poorly adapted to the ecological conditions of Yazd City (Figure 9).

Furthermore, a forest canopy coverage map was generated using the Normalized Difference Vegetation Index (NDVI). The analysis revealed that the area covered by forest shade in Yazd city spans 518.09 hectares, which represents 4.8% of the city's total area. This coverage encompasses all parks, green spaces, urban agriculture, and corridors (Figure 10). Consequently, the amount of greenery and natural spaces within the city is notably limited.

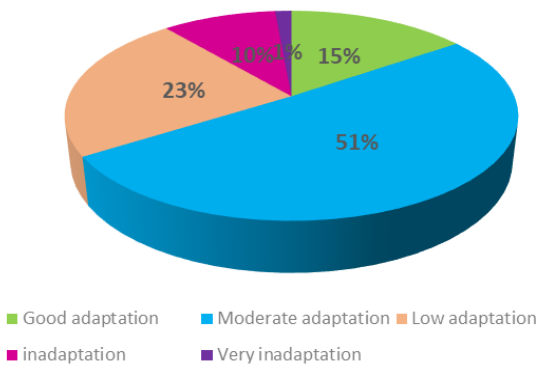

Figure (9): Results of vegetation adaptation

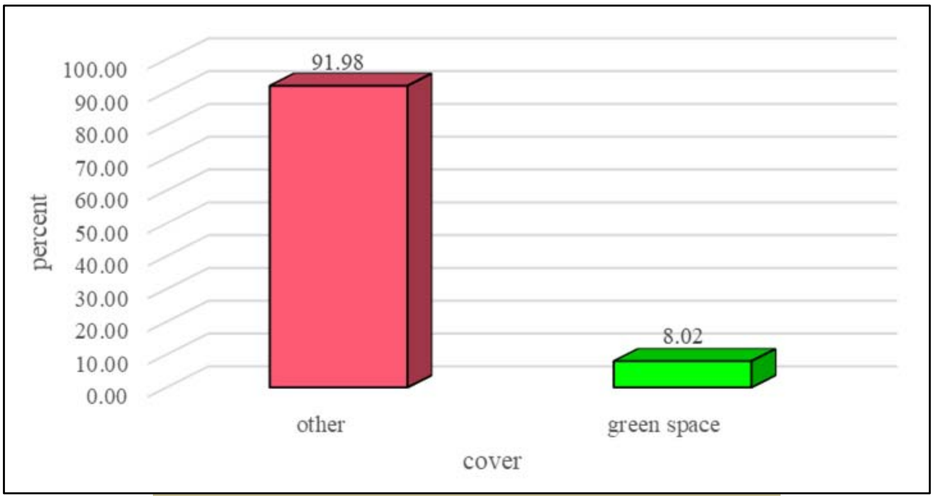

Figure (10): Diagram of percentage area of green cover

3.4. Biophilic governance and institutions

The prioritization of budget and investment reflects the governance structure and style of a municipality. In the case of Yazd Municipality, the allocation of funds towards the protection of nature and recreation is notably low, comprising only 0.01% of the total municipal budget. This falls below the standard expected of a biophilic city. Additionally, Yazd lacks significant botanical gardens and museums of natural history, further indicating its deficiency in biophilic governance.

3.5. Biophilic knowledge and attitude

Teaching environmental knowledge is a fundamental requirement for enhancing the quality of environmentalism in cities. Environmental education fosters creativity and instills a sense of commitment among urban dwellers, encouraging them to engage with nature and embrace environmental ethics. The findings of a survey conducted to assess the general environmental knowledge of citizens, using a questionnaire, revealed that over 49.25% were unfamiliar with common plant and animal species in the city, while 65.88% expressed concern about the urban environment (see Figure 11). Consequently, Yazd falls below the average benchmark for biophilic cities in this aspect.

B1. Citizens are familiar with unique plant and animal species such as *Zygophyllum* and *Otididae*.

B2. Citizens' concern is the increasing spread of drought, reducing the level of gardens, and the instability and inflexibility of Yazd city.

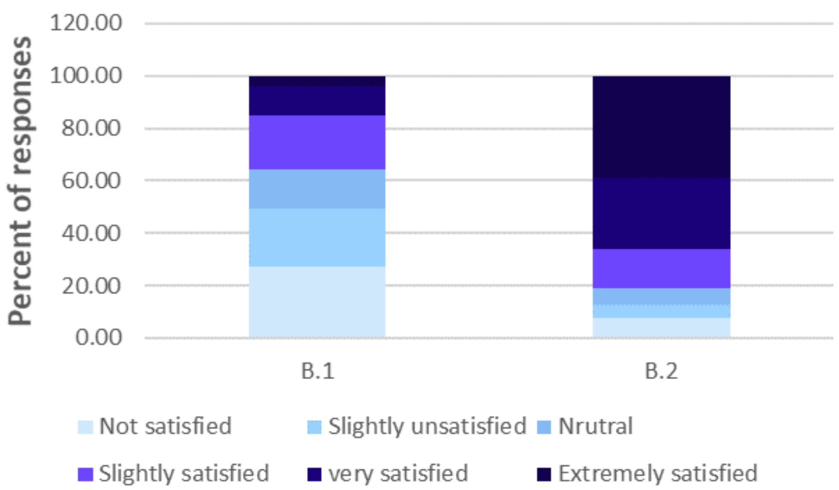

Figure (11): Results of the questionnaire related to Biophilic knowledge and attitude

3.6. Biophilic activities

The concept of biophilic cities emphasizes the connection of citizens with the nature around them. The existence of nature-tourism clubs in cities, as well as organizations and activities that are active in the field of environmental education in cities, are characteristics of ecological cities. According to the questionnaire, 49.46 percent of the urban population did not exercise outdoors and in open spaces during the day, only 22.52 percent went for walks in the daytime, and 61.10% did not use urban parks in the daytime. Moreover, 36.51% of the residents said that climatic conditions prevented their presence in the city, 14.99% had active gardens (on the balconies, rooftops, or community gardens), and 72.71% believed that there was not enough time and space for their children in city schools (Figure 12). As a result, the indicators fall short of the biophilic city average, indicating Yazd does not meet this standard.

D1: The presence of green and open spaces in the city provides citizens with the opportunity to walk.

D2: Easy access to green spaces and parks enables daily visits to urban parks.

D3: Weather conditions and air pollution reduce the time citizens spend outside the home.

D4: The possibility of cultivating flowers and plants within citizens' houses (balconies and roofs) is provided.

D5: There is enough space and time for children's social games in city schools.

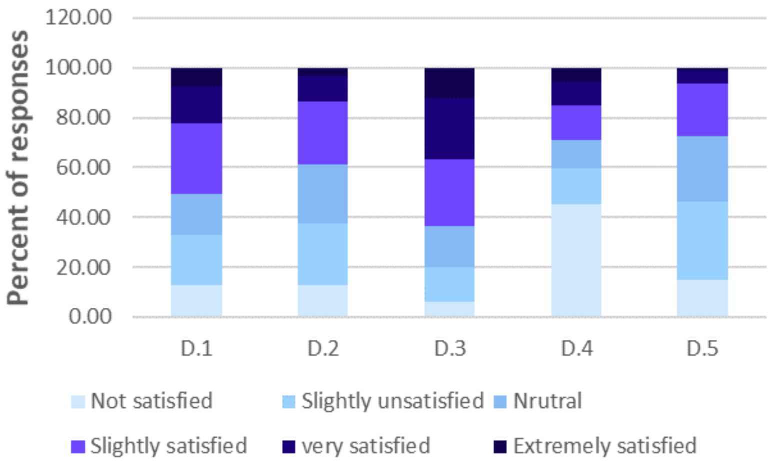

Figure (12): Results of the questionnaire related to Biophilic activities

3.7. Health

Cities, due to their disconnection from nature, exert harmful effects on the health and well-being of their residents. Research indicates numerous positive physical and mental health benefits associated with incorporating plants and green elements into urban living and working environments. Green neighborhoods and natural living environments have been shown to reduce stress and enhance both physical and mental health among citizens. However, a significant portion of the urban population lacks access to such green spaces. Statistics reveal that a considerable majority of the city's residents (72.6%) do not have access to urban green spaces, with 64.3% not engaging in outdoor exercise and 75.7% expressing concerns about their children's limited exposure to nature and green spaces within the city's schools. These findings underscore the inadequacy of urban populations' access to nature, with the situation being particularly dire for children. Alarmingly, only approximately 4% of the urban populace can access nature within a five-minute walk, as depicted in Figure 13. Consequently, it is evident that Yazd fails to meet the criteria for being designated a biophilic city based on this indicator.

C1. I utilize the city green space for at least 30 minutes during the day.

C2. I exercise outdoors for at least 30 minutes during the day.

C3. In our city schools, children have daily access to nature and green space.

C4. In most parts of the city, you can reach the green space with a 5-minute walk.

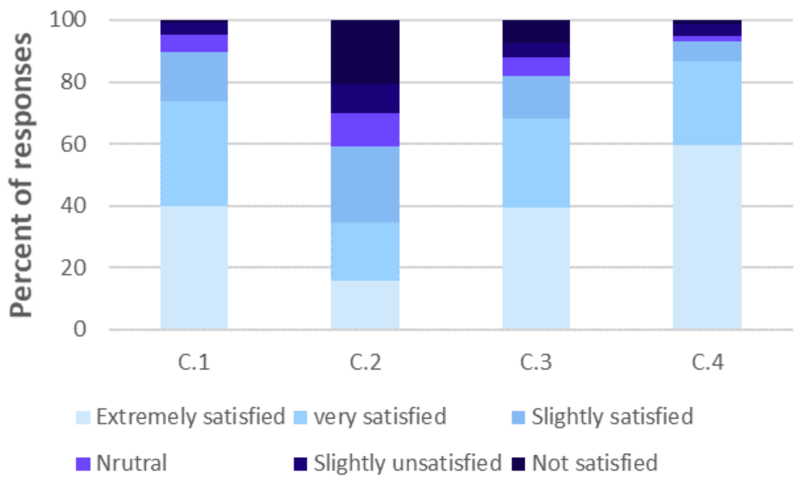

Figure (13): Results of the questionnaire related to Health

3.8. General evaluation of Yazd as a biophilic city

The city of Yazd exhibits significant deficiencies in meeting the indicators of a biophilic city, thereby falling short of being categorized as one. The key indicators of biophilic cities were established through expert opinions and measurements, and were subsequently identified and assessed in previous stages. A hierarchical process was employed to determine the importance of each contributing factor to the biophilic city concept. The implementation of this hierarchical analysis involved two main stages:

Hierarchical structure: The first step in the hierarchical analysis process is to establish an appropriate hierarchical structure for the given problem. This entails breaking down the problem into smaller components and different levels based on necessary and effective criteria. In accordance with the primary issue, the hierarchical structure was developed with one overarching goal, two main components, seven criteria, and 21 sub-criteria.

Calculation of weights: To assign weights to the criteria in the hierarchical analysis process, expert opinions from individuals knowledgeable about the subject matter are solicited. At this stage, pair matrices are formed for each criterion based on the relevant factors. Within these matrices, comparisons are made using a specialized matrix that ranges from preference for one option to infinitely preferring another. These judgments are then quantified on a scale from 1 to 9. To gather expert opinions, 20 questionnaires were distributed and completed (refer to Table 4).

In the final stage, to assess the overall biophilic conditions of Yazd city, the biophilic score for each index was determined based on the results obtained from the biophilic city indicators in preceding stages (reflecting the current state of Yazd city) using a Likert scale (refer to Table 5). Subsequently, the rank of each index was multiplied by its relative importance to ascertain the biophilic score for each component. Under ideal conditions, where all sub-criteria (21) exhibit the highest level of biophilic attributes (corresponding to a Likert scale rating of 5), the overall biophilic score would be 5. Conversely, under conditions of non-biophilic city, where all sub-criteria (21) demonstrate the lowest level of biophilic attributes (corresponding to a Likert scale rating of 1), the overall biophilic score would be 1. The biophilic rating of Yazd is determined to be 1.72.

Table (4): Relative Importance and Biophilic Degree of Criteria

Components	Criteria	Subcriteria	The relative Importance of subcriteria	Biophilic degree	Relative Importance * Biophilic degree
Natural Parameters	Water	Surface water quantity	0.111	2	0.222
		Groundwater quantity	0.119	1	0.119
		Surface water quality	0.124	2	0.248
	Weather & Climate	The concentration of natural pollutants	0.060	1	0.06
		The severity of the drought	0.068	2	0.136
		Atmospheric changes	0.037	1	0
		Ultraviolet beam index	0.023	2	0.037
		Landscape connectivity	0.028	3	0.046
Human parameter	Health	Urban population's access to nature	0.056	2	0.084
		Children's access to nature in schools	0.024	2	0.112
	Institutions and Biophilic governance	Design and planning regulations	0.029	1	0.048
		Supporting organizations	0.026	2	0.029
	Biophilic activities	Recreation	0.024	2	0.052
		Environmental NGOs	0.018	1	0.048
		Communication with nature	0.039	1	0.018
	Biophilic knowledge and attitude	General knowledge level	0.060	3	0.039
	Urban infrastructure design	Green-corridors	0.026	1	0.18
		Urban agriculture	0.023	1	0.026
		Urban parks	0.055	2	0.023
		accessibility	0.020	1	0.11
		Landcover	0.030	2	0.02

Table (5): Relative Importance and Biophilic Degree of Criteria

Score	State of being biophilic	Characteristic
1	Very critical	The current situation is critical
2	Critical	The current risky situation will become critical if this process continues without planning.
3	Medium	The current status is low-risk and has limited biophilic conditions.
4	Fairly acceptable	The current status of this criterion is low-risk and relatively stable.
5	Acceptable	Biophilic conditions prevail in the city.

4. Conclusions and Discussion

The increasing population in cities and the disproportion between population growth and urban infrastructure and facilities have led to various pollution problems and disturbances in urban areas. Growing cities in arid climates experience many environmental challenges. Among these challenges, we can mention the reduction of green and open urban spaces, climate change, desertification and destruction of habitats, water shortages, air pollution, and urban heat islands. These conditions have undermined the quality of urban life in different dimensions and prompted thinkers and urban designers to search for solutions to these issues and problems. Biophilic cities are one of the new ideas for sustainable and smart cities. Cities with extensive tree cover and green and open spaces have many ecological benefits that make them more resilient. The goal of the biophilic city is to reduce the adverse effects of urban development and improve the mental health of its citizens. Considering the environmental, economic, and social benefits of these cities, it is necessary for city planners and officials to incorporate this idea into their urban design and planning.

The purpose of this research is to evaluate and rank the environmental condition of Yazd using biophilic city indicators. In this regard, in the first step, the indicators of the biophilic city (7 indicators and 33 metrics) were determined and quantified, and in the next step, the most important indicators and dimensions of the biophilic city were determined with the help of experts.

The results of measuring the status of criteria related to the natural conditions of Yazd show unstable and stressful conditions. Due to the lack of surface water resources, indiscriminate withdrawal of underground water, and the transfer of water between basins, the situation of water resources in this region is critical. With the increase in industrialization, the number of polluted days and dust storms in this region is on the rise, resulting in unfavorable air quality. With the increase of impervious surfaces and unplanned construction, the continuity of green and open spots has been lost and turned into small enclosed areas. The results regarding the assessment of the health indicator show that citizens and their children in schools do not have adequate access to nature, leading to a poor situation in this indicator. Based on the indicator of biophilic governance institutions, Yazd Municipality allocates very little budget and takes very few measures to preserve and improve the environment, thus resulting in an undesirable situation. Evaluation of the indicator related to biophilic activities reveals low rates of visits to parks and walks, a low number of active gardens, and inadequate playing space for children in schools. Assessment of the indicator related to biophilic knowledge and attitude in the city demonstrates that people have little knowledge of their surroundings but are concerned about the environmental conditions, resulting in a relatively good situation in this indicator. Evaluation of the indicator related to biophilic urban infrastructure design in Yazd showed an undesirable situation due to the reduction in urban agriculture and the very low per capita urban green space.

Yazd's sustainability score, based on the weighting of 16 evaluated criteria, was determined to be 1.27 out of 5. This score indicates that Yazd is not a biophilic city, and the current situation is far from biophilic. According to the existing conditions in the city, planning and measures should be taken to maintain and improve the quality of the urban environment and, as a result, the state of the urban environment. The criterion that received the most weight in this study was the water index. Due to the vital role of water in the continuation of human life, it is at the center of development. Due to the increasing demand for water consumption and the lack of water resources and reserves, it is considered a great threat to human societies, especially in dry and water-scarce areas. Therefore, planning for water supply in cities located in dry areas has high priority. Based on this, cities in dry areas can implement water-saving strategies to reduce water consumption and ensure efficient use of water. This can include the use of drought-tolerant plants, low-water landscaping, water recycling, and rainwater harvesting systems.

To create biophilic conditions in Yazd by relying on the existing potential and capabilities, it is suggested that:

At least five percent of the municipal budget should be allocated to the conservation of nature in the city.

Creative projects and plans should be approved to support biophilic indicators in Yazd.

The Municipality should support local organizations that advocate the concept of biophilic cities, such as botanical gardens and natural history museums.

Priority should be given to teaching environmental subjects in schools.

Active clubs should be established or tourism infrastructure should be built so that at least one-quarter of the city's population becomes a member of these clubs.

Parks and green spaces in neighborhoods must be correctly located and designed.

Elements such as plants, fountains, urban green public spaces, and features of green cities such as green roofs, green walls, and trees should be included in designs for urban public green spaces.

The number of pedestrian routes should be increased (about one mile per 1000 people).

Urban agriculture should be preserved and expanded (one garden for every 2,500 people).

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