ISSN: 2008-5079 / EISSN: 2538-2365
DOI: 10.22034/AAUD.2020.218993.2120

Feasibility Study of Development of Vertical Green Spaces (Green Roof) to Achieve an Ecological City; Case Study: District 5 of Isfahan*

Elaheh Taheri Mirqaed[a]- Hamid Saberi[b]**

[a] M.A. of Urban Planning, Najafabad Branch, Islamic Azad University, Najafabad, Iran.

[b] Assistant Professor, Department of Tourism Research Center, Najafabad Branch, Islamic Azad University, Najafabad, Iran (Corresponding Author).

Received 07 February 2020; Revised 10 March 2020; Accepted 12 December 2020; Available Online 22 September 2021

ABSTRACT

In recent years, through the development of international awareness regarding the scale and severity of the environmental change, the phenomenon of ecological cities has toturn out to be a global event. Instead, the development of green roofs as vertical green spaces and due to problems, such as lack of land and water resources can be really important to increase green space per capita, improve environmental quality, optimize climatic conditions, reduce pollution and achieve the goals of ecological cities. District 5 of Isfahan, regarding issues such as improper distribution of green spaces, lack of barren lands, air pollution, noise pollution, etc., and, due to its potential, can use green roofs to attain ecological city goals. This study aims to assess the feasibility of green roof development to achieve an ecological city in the study sample. The research method is applied in terms of purpose, descriptive-analytical interms of nature, and quantitative in terms of paradigm. The data collection method was documentary and field study through a questionnaire. The statistical population of the study is citizens over 15 years old. In 2016, their number was 126,530, out of which 375 were selected by cluster sampling. Based on the purpose of the research, 55 items were designed in the form of 11 ecological city indicators and according to the research hypotheses. The validity of the questionnaire was confirmed as face validity from the perspective of academic experts and its reliability was confirmed by Cronbach's alpha (more than 0.7). Regarding the results attained from the citizens' point of view, there is the necessary preparation for the construction of green roofs to achieve an ecological city in this region. Also, there is a significant relationship between raising the level of culture and awareness of citizens living in the region and participation in the development of green roofs in the region (0.364) and there is a significant relationship between the application of incentive criteria and the desire to develop green roofs (0.232).

Keywords: Green Roof, Ecological City, District 5 of Isfahan.

* This article is taken from a part of the first author's master's thesis entitled "Feasibility study of developing vertical green spaces (green roof) in order to achieve an ecological city, a case study: the fifth district of Isfahan" with the guidance of the second author in the Department of Urban Planning, Islamic Azad University Najafabad is in the year 2019.

** E_mail: hamidsaberi2000@gmail.com

1. INTRODUCTION

Thus far, in the urban planning system of Iran, the qualitative dimensions of the urban environment have been less considered, so that every day the traces of nature and its beauties become less and less and lifeless and inanimate developments replace it. Consequently, widespread and traditional plans that limit urban planning to physical planning are no longer responsive, and the country's urban planning and management necessitatesnovelmethods that reinforce the city's connection with nature and make the city more vibrant and livelier. Other aspects of city development, such as the environment, should be considered (Abbaszadeh & Hosseinpour, 2011, p. 78). Due to this fact, projects such as the Ecological City have become very important in contemporary urban research and several studies can be done in line with this topic. One of the ecological solutions to build cities is to pay attention to the development of green roofs, which whenever these spaces are appropriately planned and implemented, will unquestionably help increase ecological potential and diversity (Rahnama, Kharazmi, & Karimi, 2013, p. 39). Though, in recent years, the physical growth of cities and unprincipled constructions have reduced green spaces, created an unstable urban environment, destroyed natural environments and agricultural lands of the city, and, increased demand for housing, land shortages, high price and horizontal expansion of cities necessitate place owners to provide a minimum of green space (Warsi & Karimi, 2017, p. 107) and have adverse physical and environmental effects, so projects such as green roof as a green space in a kind of space are very important to promote the principles of ecological city and sustainable environment.

District five of Isfahan city is located in the south of Zayandeh Rud and has been noticed by citizens due to its very convenient location and important uses. Despite its potentials and capabilities, this region is always associated with environmental challenges such as air pollution and noise pollution, reducing the capacity to absorb pollution, aggravation of pollution, weakness of the environmental system, severe destruction of ecological foundations, and daily increase in temperature. In addition, residents of the center, west, and south of the region, including Bahar Azadi, Sichan, Hosseinabad, Vahid, Farahabad, Sepahan, and Sepahan Shahr neighborhoods do not enjoy much green space. And the accumulation of green spaces along the Zayandeh Rud area, hence, the inappropriate distribution of green space is obvious. Factors such as lack of barren lands, lack of financial credits for land acquisition, the high added value of lands in the region, and very limited water resources for the development of green spaces in the region, are the problems of District5, which doubles the importance of paying attention to the development of green roofs to achieve an ecological city in the mentioned area, and since so far, numerous and coherent studies have not been done to present the optimal model of an ecological city and its feasibility by using green roofs for the city of Isfahan; this issue is unique for Isfahan's District 5 due to the mentioned issues, especially the issue of severe water shortage.

In the present study, three hypotheses are proposed:

Hypothesis 1: There is a great possibility of developing green roofs to achieve an ecological city in District five of Isfahan.

Hypothesis 2: Improving the level of culture and awareness of citizens living in the region can play an effective role in citizen participation in the development of green roofs in District 5 of Isfahan.

Hypothesis 3: In terms of urban management, incentive criteria have an effective role in the development of green roofs in District 5 of Isfahan.

2. THEORETICAL FOUNDATIONS

Theoretical foundations are the basis on which all study plans and projects are placed and include concepts, theories, frameworks, and models are considered.In this part, appropriate to the subject, the following items have been considered:

2.1. Ecological City

An ecological city is a sustainable city, in which physical and economic structures have been formed with the observance of environmental considerations or in other words compatible with the conditions of the natural environment (Kokhaei & Masnavi, 2014, p. 557). In the ecological city, which is a meta-organic city, any kind of planning must be done based on natural principles to maximize productivity and minimize environmental damage (Feyzabadi, 2014, p. 3). The turning point in the ecological city concept came when the ecosystem concept was first introduced by the United Nations in 1971 and was later defined by Richard Regiserat Berkeley in 1987 in his book. The most dominant theorists in the field of the ecological city who have a holistic and a wider view and have provided a precise and clear definition of the criteria of ecological city and its feasibility are as follows, Richard Regiser, Paul Downton, Ken Yeang, Philine Gaffron, Gé Huismans, Franz Scala andColin Fournier. Regiser was the founder of the idea of an ecological city, and the term ecological city is taken from his book, Building Cities for Healthy Futures in 1987. In a general definition, Regiserdefines the ecological city as follows: "The ecological city feeds itself through the minimum need of the natural environment around it and uses renewable energy sources" (Mosaedi, Hejazi, & Zaeimdar, 2015, p. 52).

Downton defines idealistic ecological cities as modern-day urban planners who must look at modern cities as cancer cells with lung cancer and devise a plan before the disease spreads throughout the biosphere. He considers his theory to be complementary to Regiser'stheory (Downton, 2009, p. 508).

As a pragmatic theorist, Ken Yeang has used the concepts of ecological cities in various projects. He proposes inclusive ecological planning as the method of future planning and emphasizes science and technology that are in complete agreement with the natural environment (Yeang, 2006, p. 128).
Philine Gaffron, Gé Huismans,and Franz Scala are theorists who have redefined the concept of the ecological city in the context of the European Union and have put their theories into practice by carrying out executive projects.
Generally,Colin Fournier considers an ecosystem to be an urban city that is built in balance and harmony with the natural environment and has clear boundaries and an optimal ratio between density and network of public open spaces and is defined by urban blocks with mixed-use (Head, 2008, p. 38). To provide a comprehensive view, all the indicators considered by the above-mentioned experts for having an ecological city are presented in Table 1.

Table 1. Ecological City Indicators from the Theorists' Perspective

Researcher	Indicators	Reference
Regiser	Mixed-use, compact and center-oriented texture, locating transportation routes and buildings according to the biological system, the significance of pedestrian transport networks, bicycle, rail, and public transportation networks in all parts of the city, the presence of diverse animal and plant species, use of planting methods and native plant species, organic gardening, clear vision and clear colors on a sunny day, recycling and repair and reuse of materials, the existence of urban gardens, urban farms, urban planting paths and green roof, existence local markets and self-employment in the field of art, sale of books, music, handicrafts and local theaters in the city and sale of agricultural products, sense of belonging and the presence of urban symbols and features in the minds of citizens, protection of biodiversity networks, the presence of vibrant symbols and signs,revitalization of indigenous customs and traditions, impenetrable flooring.	(Regiser, 1987, p. 98)
Downton	Use of native and diverse plant species and recognition of all living organisms in the city and evident biodiversity in its surface, planting trees and increasing the green area in the floor, walls, and roof of building masses, minimal use of resources and energy, avoiding expanse of city size, public transportation network with full access to all parts of the city, the existence of walkable paths within urban centers, the evident use of renewable energy and ecological technologies and recycling of resources, materials, and waste, encouraging urban agriculture and reclamation of damaged land by human construction, location of urban services with easy access for all citizens, organization of surface water and rainwater and its reuse, the city in harmony with the collective spirit of citizens and their beliefs, multiple urban centers.	(Downton, 2009, p. 508)
Yeang	Continuity of green space in the urban landscape and design of integrated green networks in the city, use of green roof and green skyline and vertical green space, use of plant species and various native plants, city design based on reducing the need to use motor vehicles and strengthening bicycle and pedestrian routes, city design according to existing local and cultural patterns, avoiding urban growth, the health of water resources and streams, waste reduction and recycling, manifestations of using any type of renewable energy, promoting a sense of belonging in citizens, protection of biodiversity networks carriers.	(Yeang, 2006, p. 128)
Gaffron et al.	Protection of landscape, natural heritage, and biodiversity in the city, revitalization, and strengthening of urban green space in horizontal and vertical levels, dense multicenter urban structure, land use mixing, attractive public space suitable for daily life, protection and strengthening of rivers and waterways, prioritizing the bicycle and pedestrian network and public transportation, renewable energy in the city, create a market for local products, display advertisements to raise citizens'awareness of environmental issues, citizens' sense of belonging to their environment	(Gaffron, Huismans, & Franz, 2005, p. 105)
Fournier	A city with integrated horizontal and vertical green areas, mixed-use, creation of public spaces for daily life, reduction, and recycling of waste, priority given to pedestrians, cyclists, and public transportation, minimum land use, a city with short distances, use of renewable energy creating a strong local economy, cultural identity, and social diversity, creating a closed water cycle, an integrated city in the global communication network.	(Head, 2008, p. 38; Hashemi, 2014, p. 36)

Since one of the dimensions of achieving the ecological city is the green roof, this issue and its related dimensions will be studied as follows.

2.2. Green Roof

A green roof is a category of vertical green space and one of the new approaches to architecture and urban

planning and arises from the concepts of sustainable development. A green roof is a roof that is partially or completely covered with vegetation and soil or with a growing medium, and consists of an interconnected set of vegetation with proportionate growth, a drainage layer suitable for draining water, and waterproof insulation that supports the roof (Razavian, Ghafouripour, & Razavian, 2010, p. 138).

Green roofs have been created in different periods and civilizations with diversemotivations. The first examples of green roofs have been found in Mesopotamian ziggurats built between the fourth millennium and 600 BC (Magill, Midden, Groninger, & Therrell, 2011, p. 3). Between 1600 and 1800, the Norwegians covered the roofs of buildings with soil to insulate them from the cold and then planted herbaceous plants to stabilize the soil. This technique was also used in parts of the United States in the late 1800s (Razavian, Ghafouripour, & Razavian, 2010, p. 141). In the modern West, the use of dead space as a public space that can be used in dense urban contexts, the practical and social dimensions of the roof garden more colorful and also made its construction popular. But after the environmental movement of the 60s, the green roof was considered in a different sense and spread extensively in European countries (Poursafavi, Eskandari, & Zahedi, 2015, p. 31). Germany is known as the origin of today's green roofs so that by 2006 about 14% of all flat roofs in Germany were green (Magill et al., 2011, p. 78). In Iran, according to the historical background of the use of clay and mud in Iranian architecture, moss and lichen cover and a variety of herbaceous plants have been used on the roofs of buildings in different parts of the country such as Azerbaijan, Gilan, and Mazandaran, the roofs of mountain houses and villages. It is the houses of Masouleh village in which the roofs of the lower houses act as the courtyards of the upper houses (Ansari & Keshtkar, 2006, p. 60).

Green roofs are divided into three groups based on the type of plants, the depth of the planting layer, and the amount of installation required:

A. Wide green roof: This roof is also known as a low cross-section or a low thickness section (Razavian, Ghafouripour, & Razavian, 2010, p. 144). The planting layer, from 5 to 15 cm, usually does not need to modify the structure of the building, it is suitable for being on the roof of existing buildings, and it uses plants with short roots and this type of roof is not used for special functions (Poursafavi, Eskandari, & Zahedi, 20115, p. 32).

B. Concentrated or compact green roof: This system is also known as a deep section or roof garden (Razavian, Ghafouripour, & Razavian, 2010, p. 145). The planting layer of this type of roof varies from 20 to 60 cm. The best option for this type of green roof is to build it on new buildings and one can use a variety of plants, shrubs, and trees that can be planted on the ground or even a waterfall in its design and create beautiful and diverse spaces (Akhavan Tabatabai, 2008, p. 69).

C. A modular green roof or plant box (semi-wide): In recent years, prefabricated models have entered the green roof technology market that does not require infrastructure and can be implemented on any roof, which is a combination of two wide and concentrated roofs. The medium depth in this type of roof is between 12 and 20 cm, and this type of roof creates an outdoor living space.

Generally, according to Table 2, the benefits and advantages of green roofs can be divided into three categories: environmental, economic, and social.

Table 2. Advantages of Green Roofs in Three Dimensions: Environmental, Economic, and Social

Dimension	The Benefits of a Green Roof
Environmental	Management of rainwater, reducing the effects of heat islands, improving air quality, environmental diversity of urban life and return of animal life to the city, providing humidity, reducing dust and smoke particles, reducing air pollution and creating air conditioning in the city, reduce noise pollution, save on heating and cooling energy, reduce the effects of greenhouse gases, reduce carbon dioxide, prevent ultraviolet radiation to the building, moderating hot air, reduce the penetration of electromagnetic radiation and reduce the load on sewer systems.
Economic	Reduce the cost of repair and renovation, protect the roof shell, generate energy and reduce fuel consumption, control floods, use the place, create job opportunities.
Social	Creating space for social interaction of residents, the possibility of exchanging culture and information between the residents of the building, creating entertainment such as: walking, reading, spending time, increasing the sense of belonging to the place.

(Taghavi, 2014; Nahrli, Abdollahi, & Vali Beigi, 2011; Keshtkar Qalati, Ansari, & Nazi, 2009; Mahmoudi, Pakari, & Bahrami, 2012)

2.3. Summary of Ecological City Indicators from the Viewpoint of Theorists

To extract the final indicators of the ecological city according to the conditions of the region and using the method of overlap and comparative comparison, the indicators in which there is consensus are considered, consequently, those indicators that at least three theorists have mentioned them, as the final indicator, are the basis of this research. In this study, the index of creating and strengthening urban green spaces,

urban gardens, urban farms, urban planting paths and increasing the green area on the floor, walls, and roof of buildings (green roof) and the index of prioritizing the bicycle and pedestrian network and public transportation, were agreed by all five researchers and are of great importance. The final indicators are presented in Table 3.

Table 3. Final Indicators of the Ecological City

Dimension	Index	Researchers
Environmental	Creation and consolidation of urban green spaces, urban gardens, urban farms, urban planting paths and increasing the green area in the floor, walls, and roof of buildings (green roof)	Regiser, Downton, Yeang, Fournier, Gaffron et al.
	Prioritize the bicycle and pedestrian network and public transportation	Regiser, Downton, Yeang, Fournier, Gaffron et al.
	Use of planting methods and native plant species, organic gardening, and biodiversity	Regiser, Downton, Yeang, Fournier, Gaffron et al.
	Mixing public and private housing, avoiding the size of the city, and emphasizing compression	Regiser, Downton, Yeang, and Fournier
	Recycling, repairing, and reusing materials or waste	Regiser, Downton, Yeang, and Fournier
	Use of renewable energy in the city	Downton, Yeang, Fournier, Gaffron et al.
	Land use mixing	Regiser, Fournier, Gaffron et al.
	Conservation of biodiversity networks (green spaces, landscapes, natural heritage, species, rivers, etc.)	Regiser, Yeang, Gaffron, et al.
Economic	Local and self-employment markets (local economy)	Regiser, Fournier, Gaffron et al.
Socio-cultural	Sense of belonging to a place	Regiser, Yeang, Gaffron, et al.
	The city is in harmony with the collective spirit of citizens and their beliefs and the existence of clear and unique symbols and signs	Downton, Yeang, and Fournier

3. METHOD

The research method in the current study was quantitative in terms of paradigm, applied in terms of research objective, and descriptive-analytical in terms of nature of research,and the method of data collection was documentary and field through a questionnaire. The statistical population of this study is the total number of citizens (individuals) over 15 years old living in the area, which according to the latest available statistics (2016), from the population of 105865 people in the 5th district of Isfahan, the population over 15 years old is 126530 people. The statistical sample is estimated at 375 people based on Cochran's formula. Regarding the size of District5 and having 14 neighborhoods with different structures, five neighborhoods were selected by cluster sampling. In this method, first neighborhoods with heterogeneous characteristics are identified, then some of them are randomly selected and then the citizens of each neighborhood that were randomly selected are studied. Thus, five selected neighborhoods that have heterogeneous conditions (relatively different geographical, social and physical characteristics) include Bagh Zereshk neighborhood in the northeast of the region, Bagh Daryacheh neighborhood located in the northwest of the region, Bahar Azadi neighborhood located in the center of the region and Imam Jafar Sadegh and Sepahanshahr neighborhoods in the southernmost point of the region.

After selecting the neighborhoods, 75 questionnaires were distributed in each neighborhood. The selection of individuals for distribution of the questionnaire includes citizens who are 15 years old and have lived in selected neighborhoods and they were randomly sampled on holidays and non-holidays. To increase the sampling accuracy, all dwellings in each neighborhood were coded, and then, using a table of random numbers, the citizens living in the dwelling units were selected and completed a questionnaire. To compile the questionnaire, five-pointLikert has been used for categorizing. The validity of the questionnaire was formally confirmed by five academic experts and the SPSS tool and Cronbach's alpha coefficient were used to measure the reliability of the questionnaire. The values obtained for each index are presented distinctly in Table 5. It should be noted that in the previous section, the final indicators of the ecological city were selected for the study. In this section, items appropriate to each of the indicators were developed, which were approved by experts. For those indicators in which the current situation and the citizens' willingness to implement the index (to examine the future situation) have been evaluated, Cronbach's alpha coefficient has been calculated separately for both situations.

Regarding the table, Cronbach's alpha for each index is more than 0.7, which indicates the relationship and internal consistency of the indicators and the reliability of the items to measure the concept. It must

be mentioned that in the following table (Table 5) and other analyzes performed in subsequent sections of the research, based on the objectives and hypotheses of the research, the green roof is separated from the first index and examined as an independent variable. Figure 1 also presents the conceptual model of research (research variables).

Table 4. Assessing the Reliability of the Studied Indicators

Index	Items	Cronbach's Alpha	
Creating and strengthening urban green spaces, urban gardens, urban farms, urban planting paths, and increasing the green area in the floor and walls	-Existence of suitable urban gardens and city parks around the living area -Existence of green paths in the neighborhood -The extent to which individuals and family members have access to green space	Current situation	0.778
	-The tendency to create suitable city gardens or city parks in the neighborhood -The tendency to keep the paths leading to the residence green	Tendency to index	0.742
Increasing the green area on the roofs of buildings (green roof)	-The number of green roofs in the neighborhood -The tendency to have a calm and green environment on the roof of the building -The tendency to create vegetation on the roof of the building for benefits such as reducing energy consumption and improving climate quality -The desire to have an appointment in a green and perfect environment on the roof of the building	0.729	
Prioritize the bicycle and pedestrian network and public transportation	-Satisfaction with bus access to different parts of the neighborhood -Suitable walking paths in the neighborhood -Sidewalk for the disabled or the elderly -The number of proper bike paths in the neighborhood -The tendency to use sidewalksand bicycles -The tendency to use public transport	Current situation	0.712
	- The tendency to use Sidewalksand bicycles - The tendency to use public transport	Tendency to index	0.717
Use of planting methods and native plant species, organic gardening, and biodiversity	-Planting rate of native and scarce plant species in the neighborhood -The degree of diversity of plant species in the habitat -Familiarity with the principles of houseplant care	Current situation	0.706
	-The tendency to use native and waterlogged plant species -The tendency to use a variety of plants to beautify the home -Acceptance of keeping houseplants as a good behavior	Tendency to index	0.708
Mixing public and private housing	-Satisfaction with living in an apartment (if living) - The level of interest in living in an apartment in the coming years	0.853	
Recycling, repairing, and reusing materials or waste	- The amount of separation of their waste - The level of satisfaction with the separation of municipal waste by the municipality in the neighborhood	0.700	
Use of renewable energy in the city	- The tendency to use solar energy to improve the environment	0.706	
Land use mixing	- The amount of sports space in the vicinity of the residence - The amount of recreational space or a suitable shopping center in the vicinity of the residence	Current situation	0.719
	- The degree of desire to have a shopping or entertainment center in the vicinity of the residence - The tendency to have a sports space in the vicinity of the residence	Tendency to index	0.789
Protecting biodiversity networks	- The level of satisfaction with the preservation of historical trees, materials, rivers and green spaces, etc. - The rate of dealing with neighbors in case of damage to natural heritage	0.709	
Local and self-employment markets (local economy)	- The amount of local market for handicrafts	Current situation	0706
	- Willingness to present a product or art in a local exhibition or gallery around the residence	Tendency to index	0.732

Index		Items	Cronbach's Alpha
Sense of belonging to a place		- Interest in the place of residence - Impact of distance from home and place of residence (in case of relocation) - Willingness to spend time - financially to improve the neighborhood	0.749
The city is in harmony with the collective spirit of the citizens and the existence of clear symbols and signs		- The degree of compatibility of neighborhood constructions with the morale of citizens - The degree of coordination of neighborhood constructions with traditional construction in Isfahan - The number of buildings or unique signs in the neighborhood	0.711
Culture, awareness, and citizen participation in the field of green roof	Culture and citizens' awareness about green roofs	- The importance of environmental issues and the environment - The importance of reducing air pollution - Awareness of a green roof - The tendency to design the roof of the building as a green roof - Increasing the quality of the residence by creating a green roof (personal opinion of the person)	0.738
	Citizens' participation in the development of green roofs in the region	- The amount of participation in public meetings held with neighbors in the neighborhood - The desire to put a suitable idea in the field of creating a green roof at the disposal of the municipality - The tendency to spend on green roofs - The tendency to convince neighbors to create a green roof - The tendency to pursue matters related to the green roof of themselves and their neighbors, through the municipality and government institutions - The rate of participation in awareness-raising workshops to create a green roof	0.787
Urban management	Incentive criteria	- The tendency to use low-interest bank loans to create a green roof - Tendency to create a green roof in exchange for increasing the density of the building (for reconstruction and building permits in the future) - The desire to create a green roof by giving financial credits to the government and the municipality - Tendency to create a green roof in exchange for paying fewer tolls to the municipality	0.723

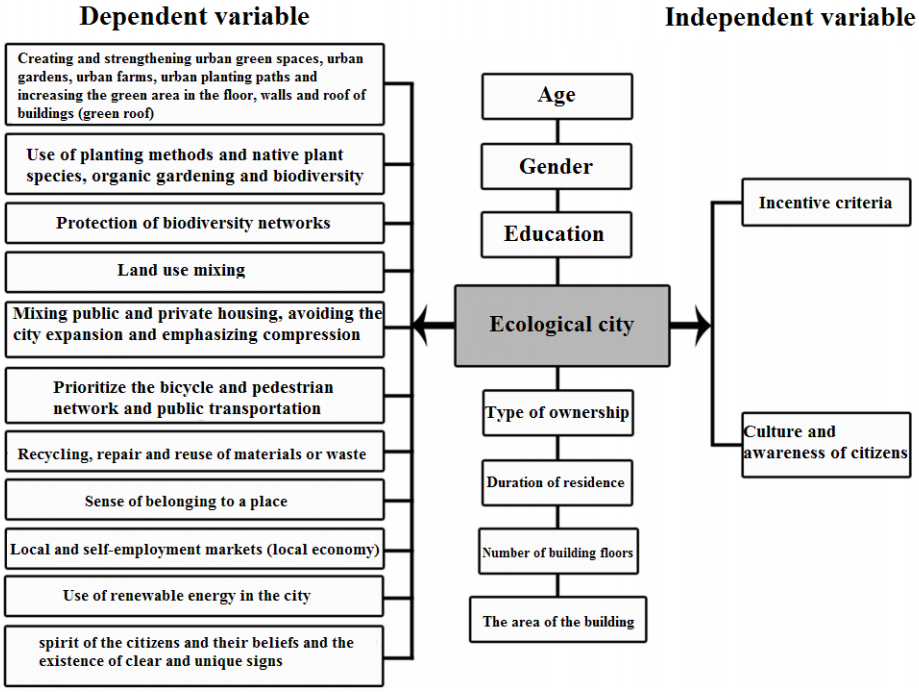

Fig. 1. Conceptual Model of Research

4. INTRODUCING THE STUDY AREA

The spatial territory of the present study is District five in the south of Isfahan and south of Zayandeh Rud, which has an area ofabout 6002 hectares (Atlas of Isfahan metropolis, 2015, p. 35). Figure 2 shows the location of the area and its neighborhoods.

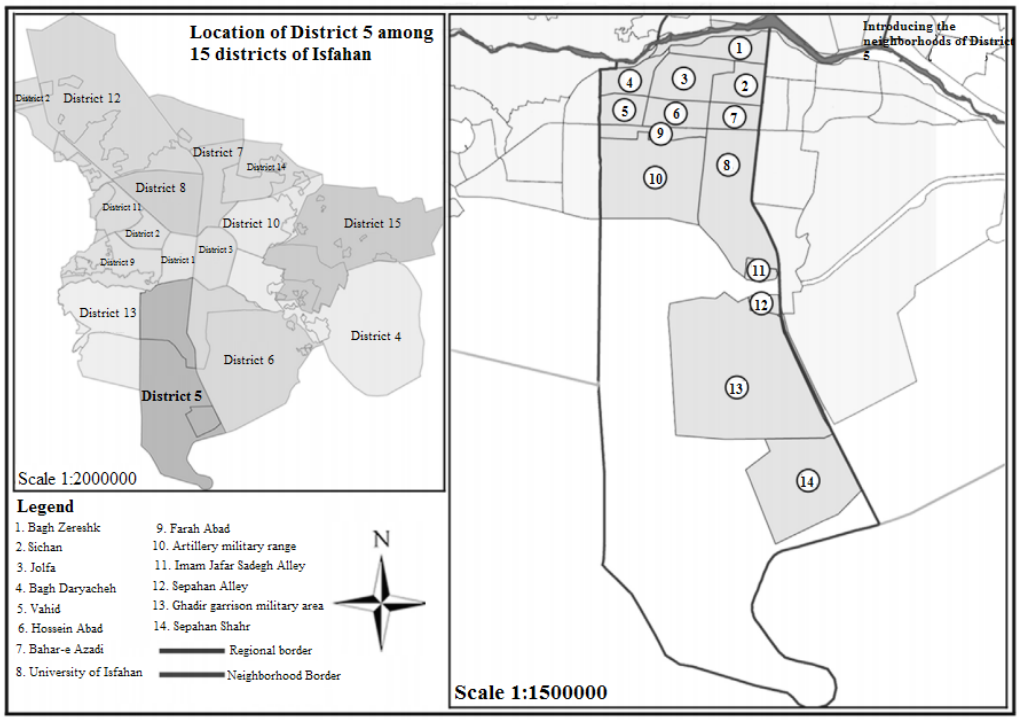

Fig. 2. Location of the Study Area

5. FINDINGS

After collecting information and data from the questionnaires, the analysis of the collected data including demographic findings of the research, descriptive findings of the research, and finally inferential analysis of the findings are considered.

5.1. Examining the Demographic Characteristics of the Respondents

Based on the results obtained from 375 samples, 52.7% of the citizens were female and 47.3% were male. Likewise, the education degree of 16.5% participantswas diploma and less, 60.6% master's degree and Associate Degree, 21.3% master's degree and 1.3% doctorate. length of residence of 3.2% participants was under one year, 28.5% 1 to 5 years, 36.7% 6 to 10 years and 31.6% over 10 years, the area of the property of 2.9% citizens wasunder 100 square meters, 41.5% 100 to 200 square meters, 37.5 percent 201 to 300 square meters, 15.7 percent 301 to 400 square meters and 2.4 percent more than 400 square meters.

5.2. Review of Descriptive Statistics

In this section, the indicators of the ecological city and the desire of citizens to create a green roof are examined. Table 6 shows the frequency of responses and the mean of each indicator.

Examination of the index of urban green spaces, urban gardens, urban farms, urban planting paths, and green space in the floor and walls, shows that this index is not very favorable in the current situation with an average of 2.60 in the fifth district of Isfahan, but citizens' tendency to this index with an average 4.22 is too much. Based on the studies, there is no green roof in District 5, but the willingness of people to build it has been evaluated at a high level with an average of 3.81. Regarding the surveys, the current state of the bicycle, pedestrian, and public transport network is at an average level with an average of 2.91, but the willingness of people to use the sidewalks, bicycles, or public transport with an average of 3.67 is highly assessed and has a good position. The current situation of the index of the use of planting methods and native plant species, organic gardening, and biodiversity with an average of 2.55 is not in a good condition, but the tendency of people to this index with an average of 3.58 is high.

Satisfaction and desire for the index of mixing of public and private housing with an average of 2.43 are low and do not have a suitable position. According to studies, the index of recycling and reuse of materials or waste with an average of 3.31 is in good condition. In the study of renewable energy in the city, none of the people chose a very small option and the average is significantly higher than 3 (4.10), so it is quite clear that citizens are very interested in this indicator. The

current situation of the number of sports, recreational or shopping center in the vicinity of the place of residence of respondents with an average of 2.95 is average, also according to the average of 3.98, respondents have a strong desire to have a sports space near their place of residence. The biodiversity conservation index with an average of 3.26 is in good condition. The current situation of local and self-employment markets, with an average of 1.95, is in a very unfavorable situation and the rate of this index is very low, but the tendency of citizens to present a product, art, or work in a local exhibition or gallery around their place of residence with the average of 3.46 is high. Investigation of the sense of belonging index shows that this index has a relatively good position with an average of 3.35. The city index is not very suitable in harmony with the collective spirit of the citizens and the presence of symbols and signs with an average of 2.50. The results of the study of the level of awareness and culture of citizens in the field of green roofs show that with an average of 3.03, this rate is at an average level, the index of citizen participation in the development of green roofs in the region, with an average of 3.01 is at an average level. The study of the citizens' willingness to use various incentive criteria to create a green roof with an average of 3.63 shows that this rate is high.

Table 5. Average and the Average Percentage of Citizens' Responses to Examine Each Indicator

Index		Mean		Frequency				
				Very Low	Low	Moderate	High	Very High
Creating and strengthening urban green spaces, urban gardens, urban farms, urban planting paths, and increasing the green area on the floor and walls of buildings		Current Situation	2.60	14.0	33.0	42.3	6.9	3.8
		People's Tendency	4.22	0	0	4.0	33.3	62.7
Increasing the green area on the roofs of buildings (green roof)		3.81		0	0.6	15.5	85.4	25.6
Prioritize the bicycle and pedestrian network and public transportation		Current Situation	2.91	9.8	19.7	61.2	9.3	0
		People's Tendency	3.67	6.6	12.5	30.6	30.8	12.2
Use of planting methods and native plant species, organic gardening, and biodiversity		Current Situation	2.55	14.9	39.0	31.4	13.3	1.3
		People's Tendency	3.58	0	1.6	33.0	85.5	11.9
Mixing public and private housing, avoiding the size of the city, and emphasizing compression		2.43		10.1	29.0	31.6	26.6	2.7
Recycling, repairing and reusing materials or waste		3.31		1.1	18.6	20.7	53.9	5.8
Use of renewable energy in the city		4.10		0	3.2	11.4	57.2	28.2
Land use mixing		Current Situation	2.95	9.0	19.4	42.6	25.0	4.0
		People's Tendency	3.98	1.3	2.2	16.8	43.4	36.3
Protecting biodiversity networks		3.26		0.5	21.1	28.2	45.7	4.5
Local and self-employment markets (local economy)		Current Situation	1.95	38.3	37.5	16.8	5.6	1.9
		People's Tendency	3.46	1.6	13.8	39.1	27.1	18.4
Sense of belonging to a place		3.35		1.3	10.6	30.9	45.2	11.9
The city is in harmony with the collective spirit of citizens and their beliefs and the existence of clear and unique symbols and signs		2.50		17.8	27.6	51.0	2.4	1.1
The second Hypothesis	Citizens' culture and awareness	3.03		7.3	5.6	53.5	30.5	3.1
	Citizens' participation in the development of green roofs in the region	3.01		2.7	10.0	55.1	27.4	4.9
The third hypothesis	Incentive criteria	3.63		0.6	5.1	30.4	46.0	18.1

5.3. Inferential Statistics and Testing of Research Hypotheses

To test the main hypothesis of this research, a one-sample t-test was used to show the possibility of developing green roofs to achieve an ecological city. Since the mean and median are 3, the means of this test were compared with Test Value = 3. The one-

sample t-test aims to investigate the difference between the mean of the research findings and the mean or hypothetical mean of 3. If the mean of the obtained data is below 3 or above 3, there may be a significant difference with the assumed mean of 3. According to Table 7, the results show that the possibility of developing green roofs to achieve an ecological city is very high because the green roof composite index has an average of 3.81 and more than 3. Therefore, the validity of this hypothesis is confirmed. As shown in the table below, the average of the green roof composite index is 3.81 and the highest average is related to having a calm and green environment in the building with an average of 4.40 and the lowest average is related to familiarity with keeping houseplants with an average of 2.68. Likewise, according to the significance level of the studied items (dig. (2-tailed), which is less than 0.05, there is a significant difference between the mean obtained and the assumed mean of 3.

Table 6. Test of the First Hypothesis Using a Single-Sample T-Test and the Assumed Mean 3

	Test Value=3						
	Mean	t	df	Significance Level-2-Tailed	Mean Difference	Mean Difference in 95% Confidence Interval	
						Low Limit	Upper Limit
Tendency to have a calm and green environment on the roof of your building	4.40	35.398	375	0.000	1.40691	1.3288	1.4851
Tendency to create vegetation on the roof of your building to reduce energy consumption and improve climate quality	3.94	20.056	375	0.000	0.94149	0.8492	1.0338
The desire to meet in a green place on the roof of your building	4.02	25.107	375	0.000	1.02660	0.9462	1.1070
Familiarity with the maintenance of houseplants	2.68	-6.216	375	0.000	-0.31915	-0.4201	-0.2182
Welcoming the maintenance of plants	3.66	15.562	375	0.000	0.66755	0.5832	0.7519
Tendency to create a green roof	3.89	19.355	375	0.000	0.89894	0.8076	0.9903
Approval of green roof as an enhancer of residential quality	4.05	25.003	375	0.000	1.05851	0.9753	1.1418
Composite Index of Green Roof Development	3.81	34.734	375	0.000	0.81155	0.7656	0.8575

To test the second research hypothesis, to examine the relationship between the two variables and considering that the research data is more than 30 and according to statistical methods, the distribution is balanced, Pearson correlation test is used to determine whether the promotion of citizens'culture and awareness will increase their participation in the development of green roofs in the fifth district of Isfahan? The results reveal that there is a significant relationship between raising the level of culture and awareness of citizens living in District 5 and participation in the development of green roofs in District 5 of Isfahan 0.364 or 36.4% with a 95% confidence level. This direct relationship indicates that the higher the level of culture and awareness of citizens in the field of green roof development, the greater their participation in the development of green roofs. Therefore, the second hypothesis is also confirmed.

Table 7. Investigating the Relationship between Raising the Level of Culture and Awareness of Citizens Living in District 5 and Participation in the Development of Green Roofs

Variable		Culture and Citizens' Awareness about Green Roofs	Citizens' Participation in the Development of Green Roofs
Culture and Citizens' Awareness About Green Roofs	Pearson Correlation	1	** 0.364
	Significance Level	-	0.000
	Frequency (Number)	375	375
Citizens' Participation in the Development of Green Roofs	Pearson Correlation	**0.364	1
	Significance Level	0.000	-
	Frequency (Number)	375	375

**. Correlation is Significant at the 0.01 Level (1-Tailed).

To test the third hypothesis, the relationship between incentive criteria and green roof development must be weighed. Pearson correlation test was used to investigate this relationship. As shown in the table below, there is a significant relationship (Sig. (2-tailed) less than 0.05) between the incentive criteria and the development of green roofs 0.232 or 23.2%. This direct relationship means that incentive criteria play an important role in the development of green roofs. Therefore, the third hypothesis is confirmed.

Table 8. Investigating the Relationship between Incentive Criteria and Green Roof Development (Third Hypothesis Test)

Variable		Incentive Criteria	Green Roof
Incentive Criteria	Pearson Correlation	1	**0.232
	Significance Level	-	0.000
	Frequency (Number)	375	375
Green Roof	Pearson Correlation	**0.232	1
	Significance Level	0.000	-
	Frequency (Number)	375	375

**. Correlation is Significant at the 0.01 Level (1-Tailed).

6. CONCLUSION

In the current study, the feasibility of green roof development to achieve an ecological city in region 5 of Isfahan was investigated and the results disclose that the composite index of green roof with an average of 3.81 is more than the hypothetical average of 3, which indicates that the citizens of the region 5 cities of Isfahan tend to create a green roof to reach an ecological city. These findings are consistent with the findings of the theoretical foundations and research background. Regarding the importance of culture and citizens'awareness in green roof development, the results reveal that there is a noteworthy relationship between these two variables (0.364), this means that the higher the level of citizens' awareness about the green roof, the higher their participation in green roof development. There is also a significant relationship between incentive criteria and the development of green roofs (0.232), which means that as the incentive criteria in the field of green roofs increase, green roofs also develop. Lastly, the main research proposals for the development of green roofs in the 5th district of Isfahan are presented.According to the research hypotheses, the suggestions of this research can be classified into three categories: feasibility study of green roof development, increasing culture and awareness of citizens, and use of incentive policies:

A. Feasibility study of green roof development includes the creation and expansion of the necessary infrastructure, including scientific, technical, and educational infrastructure, which can be mentioned as examples of executive policies in these three areas:

1. Evaluate projects and educational activities and specialized research in the field of green roof and get help from universities in the fifth region, such as the University of Isfahan;

2. Forming specific groups of specialists and technical experts to identify the stability and instability of buildings in the region in terms of structures and prepare a list of them for faster development of green roofs and

3. Laying a suitable platform for establishing interactions with leading and successful countries in the field of green roofs such as Germany to access the latest technology in the world and launch educational trips to areas with successful experiences to train developers, builders, city staff, and green roof consultants.

B) Raising citizens' awareness, including the development of media and virtual advertisements in the field of green roofs in the region, distribution of brochures among citizens of the region, and gathering places in the region such as Azadi Square, Nazar Street, Hakim Nezami Street and holding conferences and free seminars on green roof in the University of Isfahan and other universities in the region;

C) Use of incentive policies including forgiveness of construction fines and granting density in exchange for the creation of green roofs (which is very important due to the value of land and buildings in this area) and providing free consulting services to create green roofs and offering free services for maintenance and monitoring costs of green roofs.

REFERENCES

- Abbaszade, GH., & Hosseinpour, A. (2011). Residential Cities: Benefits of Urban Environmental Planning. Tehran: publication of Tahan.
- Akhavan Tabatabayi, M. (2008). Environmental Management of Green Spac:Center of Studies & Urban Planning of Tehran.
- Ansari, M., & Koshtkar, A. (2006). Investigating the Challenges and Effective Factors in Lack of Expansion and Development of Green Roofs in Iran. *International Journal of Roads and Buildings*, 62, 55-62. https://www.sid.ir/fa/journal/ViewPaper.aspx?ID=251676
- Downton, P.F. (2009). Ecopolis: Architecture and Cities for a Changing Climate. Austrailia: Springer.
- Feizabadi, M. (2014). Undeniably Indispensable Ecosystem. *Specialized Journal of Ecosystems*, 1, 1-9.
- Gaffron, Ph., Huismans, G., & Franz, S. (2005). Ecocity: A Better Place to Live. Vienna: Facultas Verlags- und Buchhandels AG. https://www.scirp.org/(S(i43dyn45teexjx455qlt3d2q))/reference/ReferencesPapers.aspx?ReferenceID=1768757
- Head, P. (2008). Entering an Ecological Age. *Journal of Arup*, 67, 23-39. https://www.arup.com/perspectives/publications/speeches-and-lectures/section/entering-the-ecological-age-the-engineers-role
- Koshtkar, A., Ansari, M., & Nazi, S. (2010). Development of Green Roof System Based on Sustainable Development Criteria in Iran. *City Identity*, 6, 15-28. https://hoviatshahr.srbiau.ac.ir/article_1119.html
- Koukhaei, T,. & Masnavi, M. (2014). Environmental Design of Urban Landscape Ecological Infrastructures Using the Principle of Branch Linkage to Improve Urban Quality of Life. *Ecology*, 3, 559-572. https://jes.ut.ac.ir/article_52205.html
- Magill, J.D., Midden, K., Groninger, J., & Therrell, M. (2011). A History and Definition of Green Roof Technology with Recommendations for Future Research. Southern Illinois University Carbondale, [online] http://opensiuc. lib. siu.
- Mahmoodi, M., Pakari, N., & Bahrami, H. (2012). Evaluation of how Green Roof Effect in Reducing Ambient Temperature. *Bagh-e-Nazar*,20, 73-81. http://www.bagh-sj.com/article_1178.html
- Mosaedi, M., Hejazi, R., & Zaeimdar, M. (2015). Educational Needs Assessment of Selected Indices of Eushehr. *Environmental Education and Sustainable Development*, 3, 51-63. https://www.sid.ir/fa/Journal/SearchPaper.aspx?writer=308945
- Nahrali, D., Abdollahi, M., & Vali beigi, M. (2011). Investigation of Restricting Factors on Green Roofs Development in Iran Based on Hierarchical Analysis. *Ecology*, 60, 89-98. https://www.sid.ir/fa/journal/ViewPaper.aspx?id=152145
- Poor Safavi, M., Eskandari, S., & Zahedi, M. (2015). Green Roof or Roof Garden?. *Journal of Manzar*, 31,30-37. https://www.magiran.com/paper/1493636
- Rahnama, M., KHarazmi,O., & Karimi, E. (2013). Feasibility Study of Ecological City Theory with Emphasis on Green Space Dimension in Mashhad. First National Conference on Urban Services and Environment. https://civilica.com/doc/238228/
- Razavian, M., Ghafooripour, A., & Razavian, M. (2010). Green Roofs. *Environmental Treatment*, 10, 138-160. https://www.sid.ir/fa/journal/ViewPaper.aspx?id=143194
- Regiser, R. (1987). Ecocity Berkeley: Building Cities for a Healthy Future, Cabriola Island: New Society Publishers.
- Taghavi, L. (2014). The Role of the Roof and Green Wall in Sustainable Urban Development: Case Study: Tehran. *Sustainability, Development and the Environment*, 93, 20-36. https://www.magiran.com/paper/1691203
- Varesi, M., & Karimi, L. (2017). Geographical Analysis of High-rise Buildings: Case Study: South of Zayandehrood River in Isfahan. *Geographical Arrangement of Space*, 24, 2-14. https://www.sid.ir/fa/journal/ViewPaper.aspx?id=319331
- Yeang, K. (2006). Ecodesign: A Manual for Ecological Design. London: Wiley-Academy, London.

HOW TO CITE THIS ARTICLE

Taheri Mirqaed, E., & Saberi, H. (2021). Feasibility Study of Development of Vertical Green Spaces (Green Roof) to Achieve an Ecological City; Case Study: District 5 of Isfahan. *Armanshahr Architecture & Urban Development Journal*. 14(35), 267-278.

DOI: 10.22034/AAUD.2020.218993.2120
URL: http://www.armanshahrjournal.com/article_135953.html