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Comparative Study of Ecological City Criteria in Traditional Iranian Cities

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***Abstract*—**Many urban designers and planners have been involved in the design of environmentally friendly or nature adaptable urban development models due to increase in urban populations in the recent century, limitation on natural resources, climate change, and lack of enough water and food. Ecological city is one of the latest models proposed to accomplish the latter goal. In this work, the existing establishing indicators of the ecological city are used regarding energy, water, land use and transportation issues. The model is used to compare the function of traditional settlements of Iran. The result of investigation shows that the specifications and functions of the traditional settlements of Iran fit well into the ecological city model. It is found that the inhabitants of the old cities and villages in Iran had founded ecological cities based on their knowledge of the environment and its natural opportunities and limitations.

***Keywords*—**Ecological city, traditional city, urban design, environment.

I. Introduction

THE increase of population has had basic and mostly catastrophic effects on the habitats of the earth. Unlimited use of renewable energy resources, increased use of water and reduction of its quality, deforestation and extinction of plant and animal species are some examples of the mentioned effects [1].

Climate change and the water crisis are of the most prominent threats ahead of human life. They are extensively increased by urban ecosystems [2].

The cities have occupied 3% of the land on the earth, but their ecological impacts extend over areas much more immensely than their district. Our urbanizing is based on the classical and the cliché models of urban development which ignore the local properties and regional conditions; hence, not only it provides unsustainable conditions in the cities, it also makes unsustainable the around areas [1].

The mentioned challenges propose that we need a historical approach in urban design and management. To understand the latter approach, the city is considered as an ecosystem and ecological system. To implement this approach and to provide sustainable urban development, different models have been introduced. The ecological city model is among the latter category.

Ecological city is something more than a metaphor since it describes the important goal of the human [2]. This goal is to provide balance between urban development and the environment around the cities. Investigation of the proposed historical approach reveals the following hypothesis for a research in this regard.

The aim of this investigation is to find out the basics and methods of ecological planning in traditional Iranian cities to use them in the planning of modern cities.

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II. Materials and Methods

To achieve the mentioned goal, an analytical comparison between the indicators of the ecological city and the functions of the traditional settlements of Iran seems to be necessary. Due to the lack of quantitative data in the resources related to the associated traditional habitats, this investigation is based on the qualitative and descriptive indicators. The indicators of energy, water, land use and transportation are used in this comparison.

A. The City as a System

One of the ways to improve the urban environment management is to analyze the city as an ecological system. As a resuscitative environmental system, the city must provide energy and the essential resources and have methods for garbage disposal. These functions of the city ecosystem are realized by relation with the environment around. The city is not an independent system; it depends on other cities and rural regions [3] and exchanges materials, energy and waste with them.

B. History of the Mentioned Models

One of the first models which proposed an eco-systemic view point on the city was introduced by Howard [2] with the idea of garden-cities. In this model, the cities have a symbiotic relationship with the farmlands around which absorbed residuals in a beneficial way [4].

Wolman introduced the concept of urban metabolism which focused on the physical input and output flows of the city [2]. Similar concepts such as healthy city, green city, eco-city and eco-community were explained also. All of these approaches were based on the physical dependence of the urban environment on the natural environmental services and sought a bigger concept – sustainable urban development [2].

The sustainable urban development theory deals with issues such as prevention of urban and regional environment pollution, reduction of local, regional and national production capacity, supporting the recycling, rejecting harmful developments and eliminating the gap between the rich and the poor. Sustainable urban development can be known as the sort of development which improves the long term social and ecological health of the cities. The sustainable development

theory was introduced in the beginning of 90s. In recent years, architects and urban planners have used this concept in urban development models, one of which is the ecological city.

C. Ecological City

Ecological city is a kind of sustainable city which is explained as "the city which provides the acceptable living standards for its inhabitants in a way that its related ecosystems and bio-geo-chemical cycles are not destroyed". The main characteristics of the ecological cities are

- They are constructed by people's activity in local scale and not by the government and the planners.
- Decreasing of the ecological footprint by applying changes in the market structure and deciding councils?
- Life development compatible with natural resources limitations.
- Using the brown fields instead of the green fields considering the standards agreed by the urbanites, government and the society.
- Establishing indicators to control the city health [2].

D. Indicators

Indicators are the most fundamental measurement factors and represent the status of a society. Indicators are indeed brief data which present important of phenomena such as cities [1]. The indicators can be used in any spatial scale; they can differ from national average to the average of the city or its subsets, e.g. the families [2]. The most critical indicators are those which influence the great eco-systemic flows, e.g. energy management, land use, transportation and water [5].

1. Energy Indicator

Energy is a key point to understand the interactions between the cities and the environment that they depend on. The cities are the centers of localized energy usage. They are also huge sources of the waste. The high energy and fossil fuels usage and consequently, change of the environment and the weather qualities are the most destructive damages in the energy section [2].

To compensate the mentioned damages, one should

- Define the energy performance as the main goal at home or in the office use renewable and non-pollutant types of energy, e.g. solar energy or wind energy,
- Forestation
- Reducing the energy usage by increasing the efficiency.

In fact, strategies to support the hierarchy to reduce usage reuse and recycle [2].

2. Water Indicators

The city affects its surrounding hydrological cycle directly as a manmade ecosystem. The main challenges of the rural water management are the following ones.

- Increasing flood risk, impermeable area and preventing rain water from penetrating the ground,
- Supplying the water required for the inhabitants' usage, and
- Controlling the water contamination caused by human activity [2].

To avoid the mentioned damages, one should apply the following options.

- Reduction of flood risk by internment and letting water penetrate the ground and be injected to the aquifer.
- Increase of land porosity by increasing the green spaces and producing porous infrastructure.
- Recycling and reusing of consumed water.
- Reduction of usage of the other watersheds.
- Having integrated approach to watersheds.

3. Land Use and Transportation

The main concerns of nowadays are the problems of traffic and roads, tremendous energy usage and environmental and climate change. These damages can be mitigated through the following ways.

- Hierarchical connection of roads and increasing the number of highways in the cities,
- Increasing the easy and free access,
- Localization of the land use and termination one-functional zone.

III. Discussion

Settlement of the residential area, the formation of urban and rural patterns, and their interactions and adaptation with the natural and ecological elements In Iran has always been of interest for researchers. One of the main advantages of the traditional habitats of Iran is being compatible to the dry and desert environment. Indicators which are investigated in this research approve this claim. In the following, the characteristics of the cities are classified into three categories by considering their direct impact. It is worth mentioning that besides the direct influence on a special aspect, these functions have indirect effects on the other investigated issues too. Table I shows the accordance of these characteristics with the indicators of ecological city (direct and indirect).

A. Energy

Some of the general characteristics of rural and urban patterns are listed below.

- Compact rural and urban pattern
- Completely surrounded urban spaces
- Narrow, disordered and sometimes covered with arches
- Buildings which are connected together
- The way of the establishment of the residential area based on the orientation of the sunlight and wind

In most parts of Iran, the residential area is dense and the constructions are connected to provide a protection against the heat in the long days and the winds which carry dust. The narrow alleys together with the relatively high walls have an important role in providing shelters protected from sunlight. The bending of the alleys is a relative advantage of these habitats since wind can flow heavily in straight and wide routes and disturb everyday life [6], [7].

Orientation of the passages and the different constructions prevent the dust from entering the city. The form of the roof and the outer surfaces and also the utilized materials minimize thermal exchange [6] (Fig. 1).

TABLE I
THE ACCORDANCE OF TRADITIONAL CITIES CHARACTERISTICS WITH THE INDICATORS OF ECOLOGICAL CITY. ✓= ACCORDANCE

Ecologic models in planning, design and architecture		1. Energy							
		Using renewable energy	Covering roof, have an appropriate height and permeable and residential spaces	Establishment based on wind and son orientation	Sardabs and shuvadans	Dense residential pattern	Walls and covered roof corridors	Green belt around the city	Narrow alleys
1. Energy	use renewable and non-pollutant types of energy	✓		✓	✓				
	forestation							✓	
	reducing the energy usage by increasing the efficiency	✓	✓	✓	✓	✓			✓
2. Water	Reduction of flood risk		✓					✓	
	Increase of land porosity by increasing the green spaces							✓	
	Recycling and reusing of consumed water	✓						✓	
	Reduction of usage of the other watersheds								
	Having integrated approach to watersheds								
3. Land use and transportation	Compact rural and urban pattern								
	Hierarchical connection of roads								
	Localization of land use								
	Increasing easy accessibility								

Ecologic models in planning, design and architecture	2. Land use			
	Existence of map and comprehensive plan	Emphasizing on neighborhood and localisation	Establishment of each important key in each neighborhood	Heiarchical connection between neighborhoods and bazzar
1. Energy				
		✓	✓	
2. Water				
	✓			✓
3. Land use and transportation	✓	✓	✓	✓
		✓	✓	✓

Ecologic models in planning, design and architecture	3. Water					
	Available enough water in establishing a habitat	Build a high level for flood risk	Streams and creeks and green spaces in city	Building dams and bridges on rivers	Control and supervising center of using water	Qanat an reserving water in water depots
1. Energy					✓	
						✓
		✓	✓		✓	
			✓			
2. Water					✓	
	✓		✓	✓	✓	
	✓			✓	✓	
	✓			✓		✓
3. Land use and transportation						

The skillful method of designation of halls in Persepolis (Takht-e-Jamshid), which is also used in the other cities-, the proportion of the unit's surface and height to each other, and the consideration of the sunlight-filled and empty surfaces, which has been caused energy usage minimization-, has added to the credit of this construction. Also, urban planners of the Sassanid era have taken into account the geographical situation and the summer-time high temperature of Bishapour city while its construction; axes of all buildings are 35° deviated from north direction. [8].

Use of renewable energies such as wind and solar energies is another characteristic of the mentioned regions. Buildings are designed for four seasons; they benefit from the maximum temperature in the winter and the minimum temperature in summer. Furthermore, the basement (Sardab) and Shuvadan were built normally in the summer-living part and had several flours underground to reduce the temperature around 15 to 20 °C. In some of the houses, a branch of the aqueduct passed through the cellar and provided easy access to the water [9], [7].

Fig. 1 A view of a traditional pattern in Yazd (city in center of plateau of Iran). Domical roofs minimized possibility of heat exchange in dry and hot regions [10]

Fig. 2 Windward is one of the key elements of Iranian architecture. This is the Dolat Abad wind ward and the highest one in the world [11]

Windward is another masterpiece of the Iranian architecture which is created to match the ecological cities environment (Fig. 2). Windward is the main natural method of ventilation in the buildings which has been designed regarding the speed and direction of the wind. After passing the upper surfaces, wind is directed into channels which are connected to the water in the Qantas or the aqueduct water in the cellar. In this method, it can reduce the temperature inside the building. In humid regions, wind is directed through dry channels only. Besides the cooling, windward avoids putrefaction of water. To reach this goal, windward is built over the water depot; otherwise, the water taste and smell will degrade.

Almost all of the compact residential areas in Iran are surrounded by agricultural lands which have been used as farms or gardens. The green spaces around them play the two main following roles.

- As a source of income and production for the inhabitants, and
- As a green belt which protects them from undesired natural elements, e.g. high temperature and warm and dry winds which carry sand. It also increases the humidity [12].

B. Land Use and Transportation

The existence of the map and comprehensive plan in the formation and the management of the city is one of most advantageous and most prominent characteristics of urban development in Iran both before and after Islam. Such comprehensive plans have been developed for villages, cities, and defense towers. The location of the main city buildings and their connection with each other, the bared spaces between them, e.g. squares, major and minor connection networks, water supply and sewage networks and the slopes of the designation, all show that their position had been considered in the city map to respond the needs of inhabitants of the city [8] (Fig. 3).

The construction of the city as a set of different neighborhoods and creating centers in each neighborhood by building squares and the required public places such as bazaar, public bathroom, mosques and water depot around it diminished the need to go to the city center (Fig. 4). Furthermore, it lets the inhabitants of each neighborhood become more acquainted, and their social relations become stronger [8], [6]. The neighborhoods of the city accessed to the Grand Bazaar, which was located in downtown, were accessed to other places of the city by that [6].

The major accesses were connected to both the neighborhood center and the market or city center. The ways were mainly surrounded by an edge of residential blocks or high commercial constructions. The commercial buildings were made high to provide shadow. The general form of the access networks was like a spider net and its structure is an indicator of the education, life and culture of the people in where they lived [5]. Using their special form, i.e. being centralized, having proper size, appropriate view and a minimum of urban facility, the neighborhoods provided a desirable compatibility between the type and the form of activities and the density of the buildings [6].

C. Water

One of the main traditional characteristics of the Iranian cities which have accordance with the indicators of the ecologic city is accessibility to water resources. Also, in many cases, it was desirable to place the city in regions higher than

the neighboring areas to provide a better view and protect the city from floods. In some cases, it is observed that, in order to construct the city, firstly, vast stages are built; one of the oldest examples of this can be found in Shoush city which is built on a natural and man-made hill (Fig. 5). In Hyrcanian region which is located in Gorgan, some of cities are located on areas which are 20 to 50 meters higher than the neighboring lands [8].

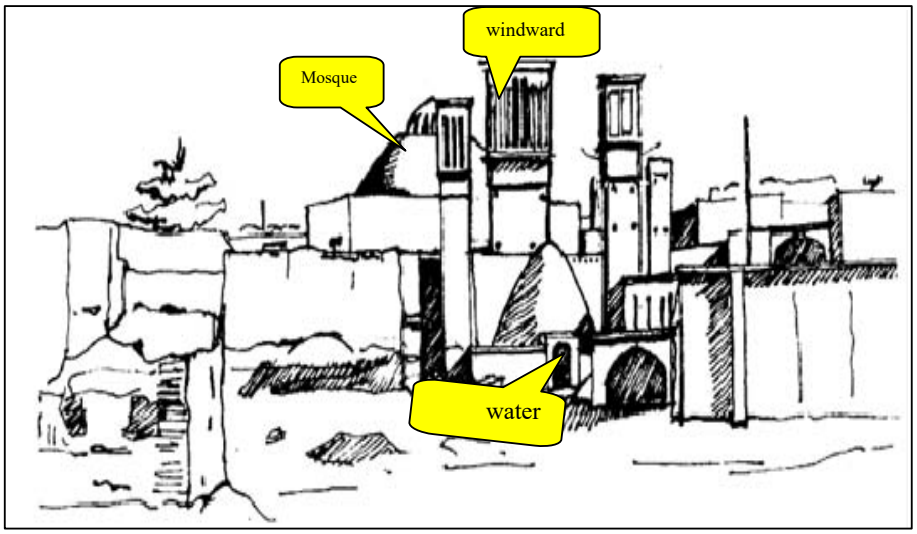

Fig. 3 Key elements of a traditional neighborhood (windward, water depot, masque, etc.) which located as a set close to each other [5]

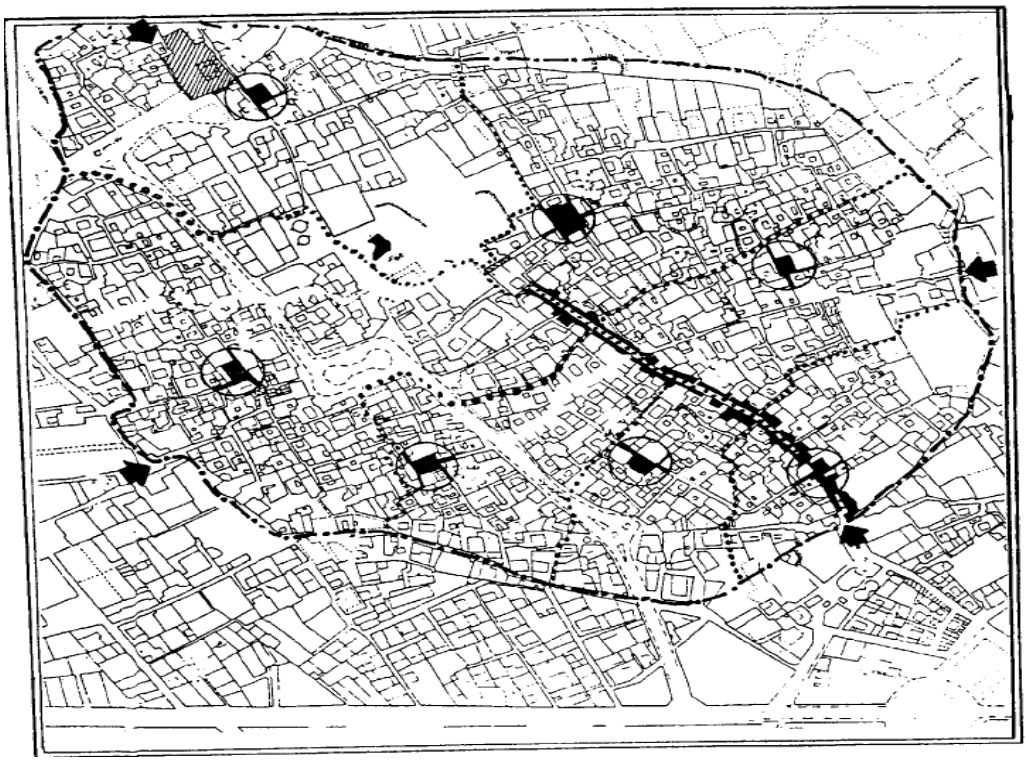

Fig. 4 Traditional pattern of Old Region of Naiin and seven neighborhoods of it represented in this picture [6]

Construction of streams, creeks, shallow water bodies, spacious and wide pools and ponds in urban spaces related to green spaces (more porosity of land and distribution of torrential rains runoff) are of the main elements traditionally used to complete the green spaces, to form and decorate the pattern and networking of the neighborhoods and to circulate water [8], [9].

Fig. 5 Shoush city in Iran with its bridges and dams is one of the most important centers in water management

By building dams, bridges and stone walls on the rivers around the city or by construction of handmade canals and collection of runoffs and water of creeks and small and seasonal lakes in water depots, the running water was used optimally. After building the dam, the amount of water behind the dams was controlled by a building called "Kolah Farangi" and a person called "Mirab" supervised the usage of the water bodies [9]. In dry lands with low rain, underground water has a very important role in the formation of the habitats and the continuation of life of the people. Extraction of the underground water was performed through the very innovative technique of digging Qantas [12].

In general, there was coordination in population, activities and dimension of settlements with amount of available water and existence watersheds, amount of rainfall, amount of highlands as a resource of water reservoir, depth of underground water and permeability and slope of land and possibility of water extraction by Qantas.

IV. Conclusion

Some common problems in the modern urbanism in Iran are neglecting the natural properties of the environment, unlimited and overcapacity urban development and waste of the natural resources. In this research, after the definition of a sustainable city, describing its identifying elements and comparing it with the elements and the cities function of the plateau of Iran, it is concluded that the traditional habitats of Iran served well as ecological cities. The Old Iranian cities were ecological from three different aspects: finding location and settling, design of the urban elements and architecture of the buildings and their details. Also, they resolved the basic needs of the people and showed organic order noticing the culture, life and technology in their corresponding era. The people of Iran have managed their natural settlement in an environmental-friendly way. They have tried to establish the balance between their needs and the sustainability of the environment.

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