

## Recognition of Islamic Urbanism and Architecture with Chaos Theory and Fuzzy Rule Case Study: Yazd, Meybod, Tabriz

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### Abstract

By viewing Islamic cities in different time periods from the birth of Islam to the Qajar era in Iran, a dynamism<sup>1</sup> could be realized in the traditional Islamic cities. There have been a significant difference between the urban spaces of the pre-Islamic and contemporary periods in Iran, which is resulted from organized complexity. This complexity has occurred in an open system and its components (fractals) have been formed with a logic over time resulting in an internal development in an urban system with a hidden order in the urban chaotic<sup>2</sup> space. In the traditional urban areas, a hidden order in the urban space organized urban development within a defined boundaries. People's participation in achieving this important issue has played a crucial role, which is among the most important issues in urban sustainability. The present research, with documented and comparative studies applying chaos theory (fractal geometry, fuzzy logic and chaos space) as a systematic theory, aims to analyze the factors of dynamism, complexity<sup>3</sup>, nonlinearity, hidden order, space self-organization, which is among the characteristics of a chaos space and living system, in urban structure and traditional Islamic architecture such as privatization laws, public laws and Islamic inheritance laws in order to recognize the hidden order in ancient cities, inconsistency of contemporary cities developed in unspecified bounds by achieving a definite definition of consistency and integration. Finally, the paper introduces endogenous growth and people's participation, which are resulted from Iranian-Islamic culture and world view in urban life aspects in a living system instead of specialization in the direction of urban stability and architecture.

### Keywords

Chaos, Dynamism, Fuzzy Logic<sup>4</sup>, Fractal<sup>5</sup>, Traditional Islamic Urbanism.

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## Introduction

Islamic cities presents an integrated and diverse structures that by deep grow in the living urban systems<sup>6</sup> have provided the city growth and development. Beside taking into account the visual or aesthetic aspects , this stable and strong bond can be observed in the interaction between the people and space, contrary to what exists in the contemporary architectural and urban spaces. Cities, which their structures are the victim of scattered suburbs and skyscrapers place identity does not exist in the sense of belonging to architectural and urban spaces and consequently cultural instability and lack of unity will not be dominant in such a system. The objective of this research is to extract the dynamic factors of urban spaces by using complex systems, because dynamics is considered as the main factor of the stability of chaos theory leading to chaotic, but organized structures. Therefore, this method is suitable to analyze the complex structure of traditional urban spaces in order to obtain the main factors for creating the dynamic spaces, rooted in people's participation and the Islamic world view, forming more stable and integrated contemporary urban spaces.

## Background

Few decades ago, scientists regarded the world as a set of systems that moves clearly and predictably in compliance with the algebraic rules of nature, but with the advancement of science, many of natural events were not justifiable by algebraic views. Scientists' efforts to describe such events led to the quantum theory and relativity in physics as well as chaos theory in mathematics. Chaos theory is regarded as a mathematical concept, which perhaps could not be defined precisely, but it can be considered as a type of causality along with certainty. The certainty is due to the fact that chaos internal reasons and does not occur due to external disturbances. It is owing to the fact chaotic behavior is irregular and unpredictable. This theory, which is entered in the empirical science, mathematics, ethology, management and sociology

has changed man's perspective to solve unpredictable problems. The main and key idea of chaos theory is that a kind of disorder lies in each type of order. In other words, order should not be searched in one scale. A phenomenon at a regional scale, which seems completely random and unpredictable, may be completely stable and predictable at a larger scale (Eftekharzadeh, 2014).

In order to discuss the urban development and architecture from the chaos theory lens , a brief review of the world developments in the post-modern period is required. In the field of urban development, cities and their parts from the outset are complex and therefore require high fractal order (Batty, 2005). The chaos theory was introduced to the world of architecture in Europe by Charles Jenkins's iconoclastic theories (Trachtenberg & Heyman, 1986). Jenkins has founded his new suggested paradigm on what he imagines as the theoretical basis for buildings that defends. He claims that these buildings are created with the applications of new science and they can be understood by considering the theory of complexity, self-organizing systems, fractals, nonlinear dynamics, emergence and self-similarity (Eftekharzadeh, 2014).

The complex and contradictory relationship between architecture and the sciences of complexity have been for more than two decades. In 1970, a mathematician named Mandel Burt, in the introduction to his famous book "Fractal Geometry of Nature" states:

"Euclidean geometry cannot analyze natural forms. No mountain, no cloud or no walnut is triangle, oval or spherical, respectively. However, in nature, harmony, coordination and surprise attraction exist between the components of natural landscapes that are attractive in the human eyes contrary to Euclidean geometry" (Nesbitt, 1996).

Peter Eisenman is among the other theorists and architects that can be considered as a pioneer in the application and analysis of this theory. Eisenman believes that in design scale, the aspects of temporal and marginal changes are proposed. Therefore, murmurs occur in both scale and time that its result is self-

resemblance not self-likeness. (Banimasoud, 2007). The entrance of chaos theory, fractal geometry and fuzzy logic in Iran goes back to the past decade. Researchers such as Tufan Haqqani investigated the relations between this theory and urban development in the paper “the Fractal Map: a new tool in the analysis of city complexity” in the seventeenth international conference on urban formation (ISUF) in Hamburg in Germany, which is mostly in the realm of morphology and geometry (Haqqani, 2010). In addition, Zabihi in the book “An investigation in theories and practices of urban development and fuzzy urban planning” evaluated the properties of time and its impact on urban development and focus of fuzzy logic on urban planning and considered morphology and geometry issues less.

Panahi et al. (2006) examined the three themes of chaos theory, fractal geometry and fuzzy logic in architecture and urbanism. The research result using content analysis concluded that “urban carpet” can represent folding urban development formed based on fractal geometry, fuzzy logic and chaos space (Panahi, et al, 2006).

This study seeks to examine the fuzzy theory in the traditional Islamic architecture and urbanism of Iran that rarely have been addressed in the literature. Despite the emergence of chaos theory, fractal geometry and fuzzy logic in the recent decades, there is an evidence of this theory in urban planning of ancient Iranian architecture that makes its recognition indispensable according to the principles of the theory that are proposed in today’s world.

### Methodology

The current study is qualitative in nature and has been reviewed the relevant literature on the city and architecture as well as new and related theories of science and philosophical views. In addition a comparative analysis method has been applied to extract the intended principles. Accordingly, the structure of three cities of Meybod, Yazd and Tabriz using adaption method with the suggested principles in the chaos theory tested urban elements and the

logic between the components as fractals and fuzzy logic in order to extract the reason of the dynamism and stability of traditional cities.

### Theoretical framework

#### • Chaos Theory

The word “complexity” originally means trivial including higgledy-piggledy, but the word in the early 1960s with the development of information theory, and systems and self-organizing released from the sense to bond order, disorder, and organization and within the organization, concept of unity in diversity to each other so that the concepts function in the complementary way to interact with each other and form a group (Mohajeri, 2006: 122).

Chaos or complexity is a system that its dynamics against the change of the initial values, shows an extremely sensitive behavior so that their future behaviors cannot be predicted. In this type of system, variables are not related to each other. Lawrence (atmospheric scientist) introduced a theory known as “butterfly effect” that the flapping of a butterfly in Singapore can change the direction of a tornado (a kind of whirlwind and storm) in the U.S. A. (Zabihi, 2011: 152).

#### • Fractal

The components that are inside the chaos space are fractals, which are growing with a kind of logic (fuzzy logic). Fractal and chaos are used to describe the complexity of forms and behaviors, respectively and what regulates this behavior is called “fuzzy logic”. Fractals geometry could be found vastly in the nature. As linear systems are only a special case of nonlinear systems, Euclidean geometry is only an extremely small subset of the actual and natural geometry, which the very natural geometry is fractal (Mohajeri, 2006: 123).

#### • Fuzzy Logic

Lotfi Asgarizadeh suggested fuzzy logic for the first time in 1965. Fuzzy logic with gray look into the world of reality seeks to depict external facts fully and

refers to the in-between space between, it means the crossing of zero world and one and drowning in the sea of fractions (Zadeh, L. A., 1997). In fuzzy logic, for each variable, we have a different output that a set of the outputs creates chaos space (Kartalopus, 2002: 53). It is also noteworthy that fuzzy is not chaos thinking, but a descriptive method to explain chaotic events (Casco, 2001: 164). Everything is relatively right or wrong. Regarding the accuracy of real phenomena always some degree of uncertainty applies, in the other words, real phenomena are always somewhat fuzzy, vague and imprecise (Zabihi, 2011: 158).

### Discussion and Results

Analysis of Islamic Urban Structures with the Approach of Chaos Theory

With view to urban texture of the Islamic era, irregularities in the structure spaces are formed so that the texture is not only disruptive, but also the hidden order in this chaos has created a kind of cohesion.

#### From Irregularity to Hidden Order

Due to the different performance of early Islamic cities, the form of the cities vary by type of operation (Hamouch, 2007: 220). For example, cities where the place of the rule of the caliphs, are more disciplined in terms of form are people-centered cities.

According to Table 1, the early Islamic cities are classified into 4 groups:

#### • Holy Cities

Holy cities, those that are formed with the holy sites and other monuments are usually formed around this site so that the orientations of the monuments are not predetermined, but they are rather organic.

#### • Royal Cities

Royal cities have a regular structural model, which are based on the defense strategies and over time lose their discipline and their form become irregular.

#### • Heritage Cities

These cities are the ones that with Muslim control, their regular and predetermined model due to an irregular geometry have become a disordered geometry.

#### • Auto-Made or Organic Cities

These cities lack the characteristics described above and merely are formed by a gathering of people over time, which are endogenous or organic (Table 1).

The irregular and complex geometry of cities could be resulted from three main factors namely variety of the details of buildings, irregular model of arteries and interfere of urban structure. It is noteworthy that existing irregularities in the mentioned cities is possible through the analysis and consistency with chaos theory and fractal geometry since the classical Euclidean geometry and classical mathematics cannot analyze this confusion of form.

Damascus and Aleppo in the early pre-Islamic period had Hellenistic network (City design based on two axes perpendicular to each other) (Habibi, 2011) that in the post-Islamic periods, wide arteries became narrow and sometimes became impasse spaces due to the interweaving of urban buildings.

The initial regular geometry of these two cities was applied by Roman power with a strong military and political policy. People changed this model in the Islamic periods and thus a complex geometry was formed in the texture that the effects of the evolution and the geometry are evident today in the texture of cities. Regular and network geometry in the initial texture of cities that in terms of military and defense considerations did not meet the policies of the Islamic state. Therefore, restructuring over the centuries and due to the security measures in the Islamic state, induced complexity to the context of these cities. In another example, Meybod in the Sassanid era was built with checkered texture with four gates around the city that over time and in the Islamic period, an irregular and complex model became dominant over it as shown in Fig. 1.

#### Time and Fractal in Chaos Space

Time is an important factor in the maturity and complexity of cities. As a result, older cities were more prone to accidents and structural changes. On the other hand, new cities maintained their integrity. For example, two of Manama and Almareq (1780) are much younger than cities such as Cairo, Tunis and

Table 1. Examples of classification of cities. Source: author.

City	City Performance	Pre-development city geometry	Post-development city geometry
Mecca, Medina, Jerusalem	Religious	Organic (irregular )	Irregular
Baghdad, Al-Zahra	Royal	Regular	Irregular
Damascus, Aleppo, Algeria cities	Heritage	Regular	Irregular
Yazd, Isfahan	---	Organic (irregular )	Irregular

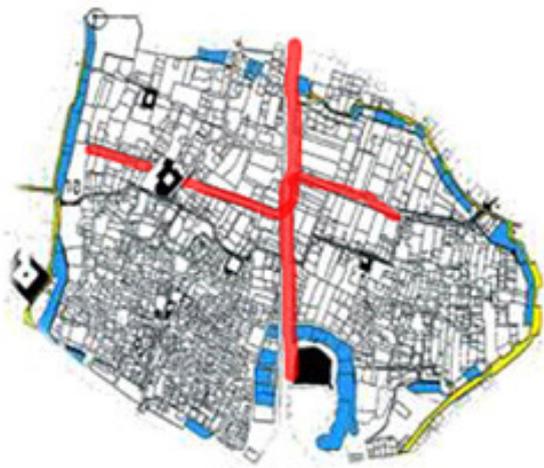


Fig. 1. Meybod in the early period of Islam.  
Source: author and Google Earth.

Mecca, but the texture of the cities have a complex model with less consistency than the old ones (Ben hamouch, 2007: 220). Here, the dimension of fractals even without mathematical calculations can analyze the evolution of their chaos with the age and time of cities. By comparing the two old textures of Yazd in the Seljuk and Qajar periods (Fig. 2), the difference between complexity and texture integration can be identified.

It is noteworthy that culture and freedom-centered politics from the Islamic world view are the roots of this complex tissue that can be analyzed using

fuzzy logic (Diagram 1). In fuzzy logic, per data, we will have varied outputs that are unpredictable. In the urban texture of the cities, politics and culture affected the variable of regular city and produced out of irregular city that at different times, the rate of irregularity cannot be calculated.

### Division of Arteries

As mentioned above, the reason of irregularity of urban texture is the interweaving of urban buildings and consequently the narrowing of urban arteries. The hierarchy of arteries (main, secondary, alleys and dead-end) is an effective definition of the growth of fractals. The main arteries are considered active lines, which become inactive in dividing into sub-arteries. Following it, sub-arteries become activated. In the hierarchy of the division, the very sub-arteries become inactive and this will continue without any end. In urban areas after 6 to 7 stages of division and smallness when the branching comes to the threshold of houses and rooms, the process ends. The process of creating arteries occurs simultaneously with changing or making surrounding textures that this factor has furthered the houses into the streets or alleys and the arteries have not a distinctive geometry (Fig. 3).



Fig. 2. The right image: Texture of Yazd in Seljuk period and the left image: Texture of Yazd in Qajar period. Source: author and Google Earth.

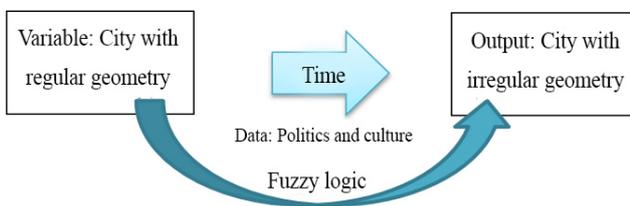


Diagram 1. Diagram of city geometry and fuzzy logic. Source: author.

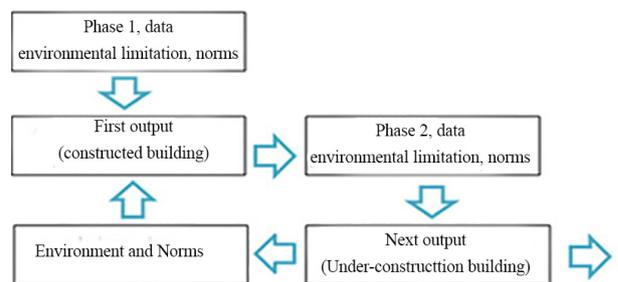


Diagram 2. Construction process of buildings and their influence of surroundings. Source: author.

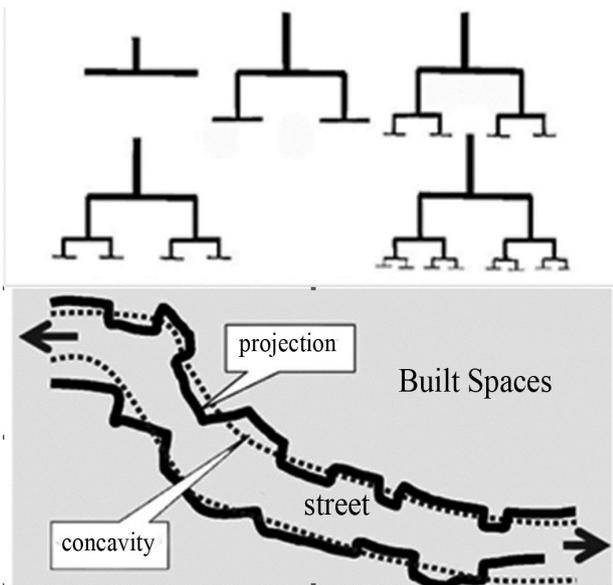


Fig. 3. Geometry of streets (irregular). Source: author.

### Hidden Order and Endogenous Process

Evolutionary processes in Islamic cities were conducted by endogenous processes with popular participation that the behaviors are rooted in religion

and environment coexistence. The interesting point is that different behaviors have created a variety of complex and irregular spaces so that the hidden order in the complex spaces, are the fact of the stability and integrity of texture. The stability and integrity are formed using the feedback obtained from standard cultural norms and behaviors over time. Fuzzy logic leads the feedback so that each output (constructed building) affects the next variable as the data and the creation of a next output (under-construction building) depends on how the first output perform (constructed building) and cannot be studied alone and, over time, the first output also would be influenced by the next output (Diagram 2).

### Growth and Self-Similarity Principle in Islamic Urbanism

According to chaos theory, growth does not mean an increase in the size or largeness of the volume or surface, but it means reproduction and reduced volume in a system and taking a successive and

purposeful path of one complex structure to another complex structure. For example, the growth and reproduction of human sperm is not only a matter of increasing the number of cells, but while this increase, some changes are made bringing the complex structure of human to the fullest perfection and unity (Khakzand, et al, 2007). The growth usually is begun from a simple root and base and changes into chaotic structures. The first model that was used to understand growth in the complex structure was the precision measurements over the coastline of the beach of Great Britain by Mendel Brute in 1967. He showed that as measuring scale becomes smaller, the measuring length of coastlines indefinitely increases and in fact, each curved level of the lines included multi-corner lines that were of infinite length.

In traditional Islamic houses, this principle is clearly visible. For example, in Algeria, during three centuries Ottoman Government fixed surface area of 45 hectares with a city wall that determined its privacy. The city over the years had fluctuated population from 50,000 to 100,000 and then increased to 150,000. At the beginning of the 19th century due to the spread of disease and economic poverty and wars, the population was 30,000 people. The remarkable point is that despite the volatility of the urban population, the increase of the area and urban privacy did not exceed from a few centuries ago. Certainly, it made it possible for the city urban space to have endogenous growth that lead it to the development and optimum use of spaces. This is the integration factor of urban texture that lacks this integration in the contemporary cities (Whealy, 2007). Another characteristic of chaos theory is self-similarity that means each component of the combination is similar to the whole combination. Self-similarity is different from objectivity. What is suggested in objectivity is an exact duplication of components.

The principle of self-similarity in two urban structures and Islamic architecture can be observed. For example, a variety of open spaces in urban scale, neighborhood and building are among the same

principle which is as follows:

Houses that are formed around an urban open space, usually this open space is the gathering place for people and trading such as Naghshe Jahan Square in Isfahan that today is considered as a public space for urban meetings and commerce.

The open spaces that exist at neighborhood scale for a total of houses that are as a public space for the neighborhood despite the fact that these spaces did not have certain standard and form, but were identifiable by the people of each neighborhood. This is the very principle of continuity.

Open spaces that exist as a central courtyard in most houses of Muslim-resident cities and are smaller than urban open spaces (Fig. 4).

### Unpredictability and Randomness

The unpredictability and randomness of the growth and development of buildings in traditional and Islamic cities is a main issue in the development of the urban textures, and this lack of assurance is due to the changing needs of people in different periods of time. This change of forms affects the form and performance of the future buildings and after a few years, complexity will be dominant over the structure of the city. The unpredictability of the development in old textures due to the informal growth of buildings is based on personal needs and freedom that its result becomes manifested in the texture of architecture, the in the neighborhood and in the city. Uncertainty has existed in not only texture but also social behavior as different people in response to different structures, show different behaviors. The dissimilarity of textures for people has created a sense of belonging to their own life site so that consider the property belong to themselves and refuse to leave it. This is the factor of stability in urban texture (Christopher et al., 1994).

In Fig. 5 the North Garden Neighborhood of Tabriz (the old texture in Tabriz) is shown. The left figure shows the current situation of the texture. The middle figure shows the initial model of the texture design. The right figure shows the computer analysis of

dark and bright spaces of the texture indicating the change and type compared to the original state. In this context of development that has occurred over time, has transformed it into a complex system so that in this system uncertainty exists.

### **Dynamic and Nonlinear Features**

Mobility is a source of complexity. Dynamic systems can be regular, irregular, natural or man-made there. Social systems are the largest dynamic systems, since the greatest uncertainty and complexity can be found in these systems.

In the system, if the relationship between cause and effect and consequently their evolution is predicted, this is linear system and if this relationship is unpredictable, this is nonlinear system.

Architecture and urbanism has a nonlinear complexity, because the houses are not built by a definite reason, but different people and different conditions at different times affect the structures of buildings and cities and here architecture is a process not a product or in other words, it is a verb not a noun. Disorder and randomness in the dynamism are the true picture of sophistication (Mohajeri, 2006).

### **Analysis of cellular automata behaviors**

Cellular automata theory was first proposed in the 1970s. The performance of two cellular systems in Fig. 6 is shown as two-dimensional form. Automatic automata include a series of cells that these cells are located in a network, each cell is either active or inactive on the network. Active and inactive cells are displayed in black and white, respectively. In this network, specific law and logic direct cells and activities occur in a hierarchy. Diversity of law exists in the conduct of system leading cells in Fig. 7 as follows: Cells are active that around them exist at least five active cells, and on the other hand, cells are inactive or die that stay alone there or less than five active cells exist around them. The arrangement of initial cells is shown in left figure that in the next stage is converted into the right figure.

This simple game has some interesting results. To

understand the issue better, another example will be discussed. In Fig. 6, results from a cellular automata with 10,000 cells in a grid of 100×100 are achieved, which are remarkable. The first phase involves the arrangement of cells amorphyously so that between them there are nine empty rectangular spaces. The law guiding this system is that the living cells have minimally 3 and maximally 8 cells and the rest become inactive. In the next phase, with the continuity of the same trend, blank squares also change and after 45 phases, the original order completely disappears. With the study on the cellular automata, the initial geometric order is converted to chaos so that cells as fractal components in chaos with fuzzy logic change (Rubinowicz, 2000).

Similarities exist between the cellular automata, urban space and architecture. In urban space, houses are the same cells that change over time based on the behavior of proximities, neighborhoods, social norms and different needs and create complex structures. In other words, present urban space affects the future and the future is not independent of the present behavior and somehow the future of a city is dependent on the present changes. Precisely, this is the main rule of the game of cellular automata that can be studied in the city.

In traditional Islamic cities due to participation and attendance of people in the construction, each house (cell) shows a different behavior according to the behavior of cellular automata that affects other houses. However, in contemporary cities all cells (houses), there is a law and standard, and also some people are less involved in creating their living space and this causes instability in the living spaces that means urban growth will be more urban development.

### **Analysis of Architectural Structures with Approach of Chaos Theory**

#### **Geometric Order and Chaos in Architecture**

From the beginning of human history, geometric order and complexity have been existed in architectural structures. In architecture, the balance between order and complexity is necessary, because architecture

space is created by a design process, but at different times, this space undergoes a series of changes due to climatic, social, political and cultural factors so that the changes and their development are unpredictable (Lynn, 2004).

Geometric order is defined by pure mathematic forms (2-dimensional like line and 3-dimensional like circle and cube) and favorable relations (perpendicularity, parallelism, similarity and rhythm). Chaos is the conflict of geometric order and is defined by complex forms and relationships so that classical mathematical cannot meet this complexity. Additional definitions can be studied from the point of view of spatial perception:

In Fig. 7, a graphical composition can be observed that each of the two forms has 1600 points and the average density of the all surface of the two combinations is fixed. In the left combination, the circle-form surface with a set of regular points is visible in the background with irregular points. The right figure is the reverse of this state. The circle-form surface includes irregular points is visible in the regular background. Based on this example, chaos is definable indirectly with the involvement of geometric order and geometric order is identifiable with chaos. In general, geometric order can be a special case of chaos geometry.

### **Desirable and Undesirable Structures (ideal and non-ideal)**

The pure logical and geometric forms of architecture in the complex nature background become indicator. In other words, monumental architecture as a regular structure has imposed itself on nature. However, throughout history, parallel with desirable and pure structures, non-ideal structures are also have been created and move from pure forms to impure ones has been owing to compromise with the complex nature on the one hand, and different functional needs, on the other hand (Eynifar, 2003).

Creating an architectural space is not an isolated event, but a continuous process produces it over time. Comparing the pre-Islamic and post-Islamic

monuments testifies this issue. If the spatial relationships of mosques and the spatial relationships of temples are compared, it is obtained that various factors (cultural, religious, economic, political and social) have been effective in the creation of mosques. In addition, what has been involved in the creation of the pre-Islamic temples spaces such as temples and fire-temples is the factor of religion. Therefore, the involvement of various in creating a work makes it complex that in a complex space system can maintain its integrity.

### **Comparison of Modern and Post-modern Architecture Thinking**

The famous modernist architect "Mies van der Rohe" applied the motto "Less is more" to the architecture of modern times. The word refers to pure and simple forms so that the architect should conduct spacing and minimalism with the least elements (Yazdanju, 2002). In 1957, another architect named "Robert Venturi" proposed a theory in contradiction with that of Mies van der Rohe and expressed that "Less is bore". In this theory, he prefers the complex forms over pure ones and introduces it as the basis of post-modern architecture. With passing from modern to the post-modern era, complexity and variety enter architecture spaces and consequently spatial boredom is created. On the other hand, eliminating geometric order makes the combination eligible. Therefore, the balance between order and disorder in chaos theory, which is dependent on post-modern, can be a suitable solution to the stability of architectural spaces, something which is clearly visible in the traditional Islamic house in Iran (Fig. 8).

### **Design and Self-organization**

As mentioned, architectural spaces are created by a design process and are developed and changed by external and internal factors. By comparing different periods, we realize an endogenous system in the architectural spaces that the system is affected by external (climatic factors) and internal (man's change of needs) factors. For example, if we consider



Fig. 4. Principle of growth and self-similarity of central courtyard in the historical texture of Yazd. Source: author and Google Earth.

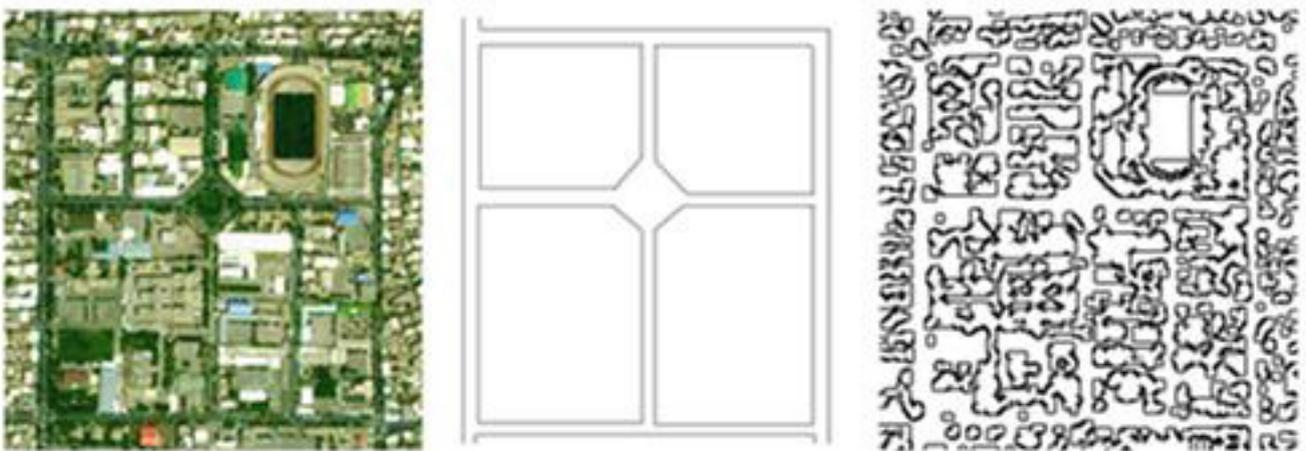


Fig. 5. Analysis of unpredictability in the development process of the structure of North Garden Neighborhood of Tabriz. Source: author.

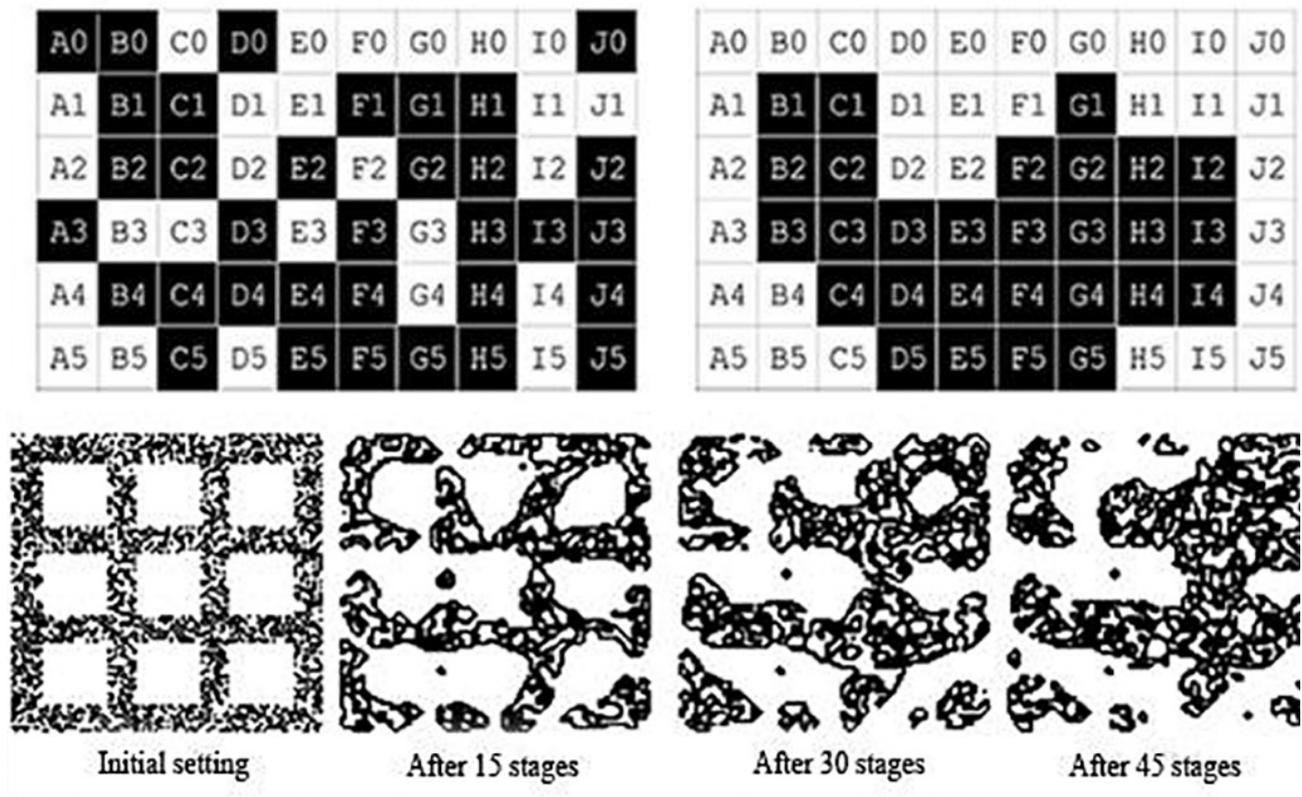


Fig. 6. Behavior of cellular automata. Source: Rubinowicz, 2000.

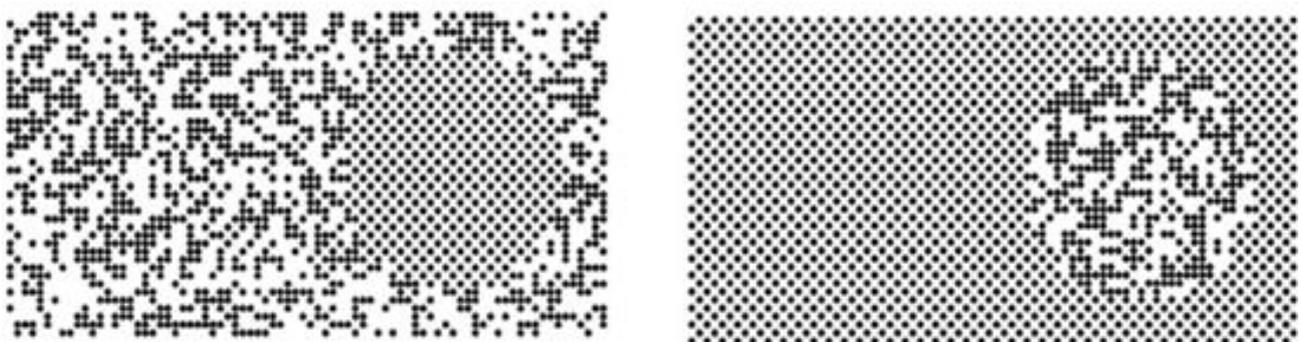


Fig. 7. Order and disorder. Source: Rubinowicz, 2000.

the façade of an old house as shown in Figure 9, we realize that the original model of the façade is something different from its facade built in different periods. The left image is the current facade and the right image is the computer analysis of the façade based on dark and light surfaces. This comparison shows the complexity and chaos at the surface of the building façade, which is the result of internal and external processes. In fact, it can be claimed

that architectural façade is unpredictable in a long process (Rubinowicz, 2000). In traditional Islamic architecture, uncertainty is multiplied, because some cultural norms affect the main model and change the structure of the building in addition to climatic factors. Among the norms arisen from Islamic world view, inheritance laws, right of preemption, privatization law and pious legacy can be named, which have been effective on

the building forms in different periods of time. Some of them are mentioned below:

### Privatization Law

According to this principle, the Muslim person is free to design his house spaces including doors and windows based on his/her preferences. Furthermore, equal standards did not exist for all, individuals made houses according to their need and as a result, complexity became dominant in structures, certainly, it should be mentioned that observing a series of principles, which are adopted from people's world view and climatic factors made the whole texture integrated and interwoven.

### Inheritance Law

According to inheritance law, dividing landed property has a fractional relation. For instance, in Islam, for wife 1.8, and the remaining 7.8 in relation 2 to 1 were respectively assigned to male and female

children. Thus, over time and property division, the complexity in textures increased and the structure of buildings undergoes changes.

### Algorithm Public and Private Construction

A series of factors such as climatic factors and social norms have been effective in the construction of architectural spaces. In addition to the mentioned issues, specialization and performance of spaces (public or private) in the process of designing buildings are not ineffective.

In the past, large urban spaces such as waterways, mosques, city gates, malls and palaces were made by the city leaders, which had fixed rules and standards. An algorithm can be used to process this process, which is the linear algorithm. However, the algorithm of designing private spaces in comparison to the public ones has large nonlinear rings that there are many causal relationship within it (Fig.11).

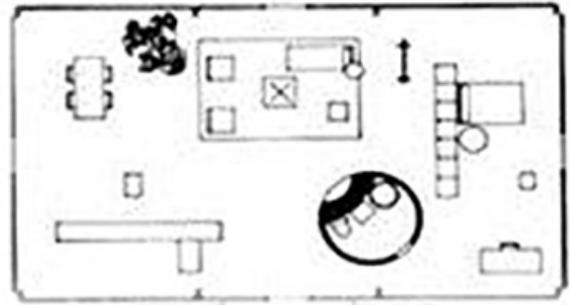
### Conclusion

As described, chaos theory and its stability factors were investigated and then urban structures and Islamic architecture with the approach of the studied theory were analyzed and concluded. Now, after analyzing spaces with the view of chaos theory, the following results can be presented as follows:

What makes urban spaces and traditional Islamic architecture coherent and sustainable is the principle of self-organization and its evolution so that the relationship between the urban the surround environment and interactions of urban elements and their flexibility resulted in the endogenous growth in the complex urban system. Houses as fractal elements in the urban chaos atmosphere of urban with fuzzy behavior affected and directed future neighboring. In other words, they created integration in the urban texture and participation. Inheritance laws, privatization and people's participation in this indigenous trend created living spaces. The factors that are less highlighted in the contemporary architecture and urban development. Therefore, modern urban principles have not had much success in linking culture and environment and consequently, the incoherence of urban texture is resulted. This incoherence in the texture will have social problems and abnormalities. Thus, if the rules and principles of Islamic architecture and urbanism, based on a perspective, are so targeted according to fuzzy logic and with flexibility and people's participation could be responsible against adverse changes of urban system in the distant future, rehabilitating and vivifying dead cities or urban areas around them will be achieved. Otherwise, with specialized interests and superficial views, solving the problem and providing solutions for the near future will not work so that leads to lack of integrity and extension of urban closed and linear system (Diagram 3).



Traditional house in Yazd



Glass house of Philip Johnson

Fig. 9. Analysis of the complexity in the facade of house. Source: Rubinowicz, 2000



Fig. 10. Division of property based on the law of inheritance. Source: Ben Hamouch, 2007.

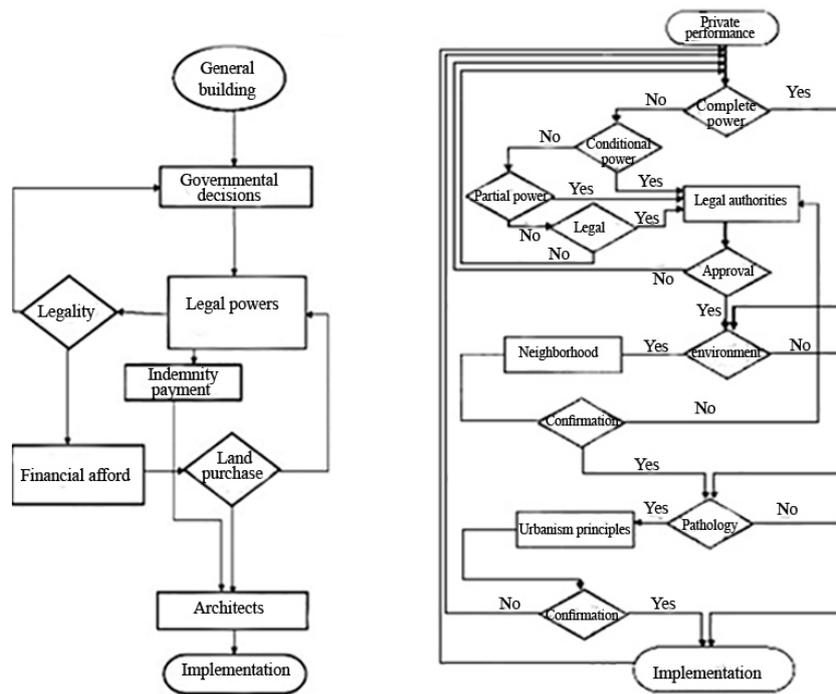


Fig. 11. Public performance algorithm (left) and private performance algorithms (right). Source: author.

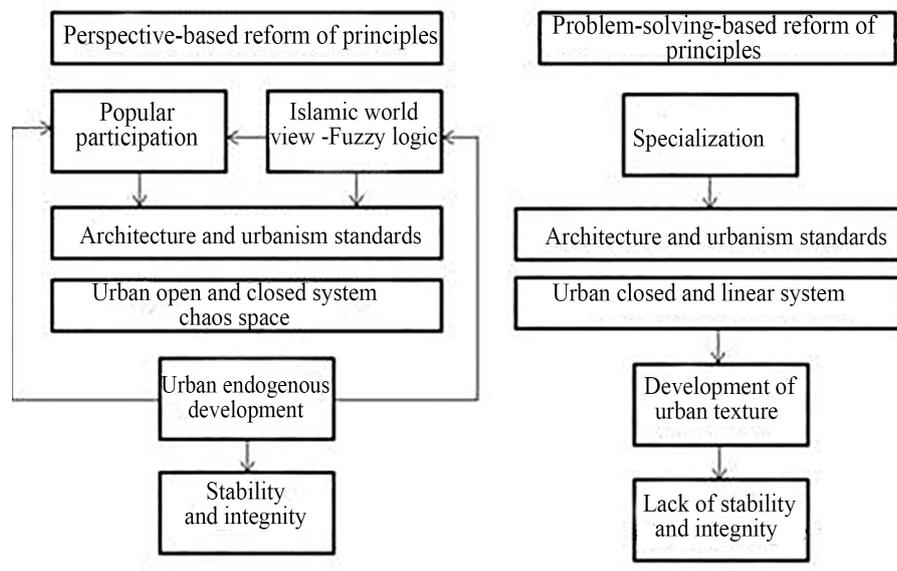


Diagram 3. Causes and recognition of urban unsustainability. Source: authors.

**Endnote**

- 1.Space that induces a sense of movement in individuals is called “dynamic space” such as what is seen in Iranian gardens.
- 2.Butterfly effect is the name of a phenomenon that due to the sensitive nature of chaotic systems to primary conditions is created. This phenomenon refers to this a small change in a chaotic system such as the atmosphere of the Earth planet (e.g. flapping of butterfly) can cause intense changes (hurricanes in other countries) become in the future. This phenomenon was first proposed in 1952 in a short story called “The Voice of Thunder” by Rey Bradbury. The term “butterfly effect” in 1961 was born in an article by Edward Lorentz. He, in the 139th AAAS seminar in 1972 presented a paper

entitled “Can butterfly’s flapping in Brazil lead to the creation of storm in Texas?” Lorentz, in research on the extremely simple mathematical model of the Earth atmosphere, reached an unsolvable differential equation. To solve this equation, he used computer-aided numerical methods. To be able to do the work in subsequent days, he entered the last output of one as the primary conditions of the next day. Lorentz finally observed that the result of different stimulations with the same primary conditions are quite different. The computer printed out an analysis has shown that Royal McBee, the computer that Lorentz used, rounds the output up to 4 decimal places. Since the internal calculations of the computer was with 6 decimal places, the loss of the last two digits caused such an effect. The changes in rounding are close to the effects of a butterfly’s flapping. This fact showed the impossibility of weather forecast in the long run. Lorentz’s observations created chaos theory. The expression of “butterfly effect” the specialized language of chaos theory is translated as “sensitive dependence to primary conditions”.

3. Complexity in architecture is one of dynamism and movement factors.

4. The knowledge for most of the study issues will appear in two distinctive forms:

Objective knowledge such as models, equations and mathematical formulas, are pre-determined to solve physics, chemistry or engineering problems.

Personal knowledge such as knowledge that is describable in linguistic terms, but cannot be quantified by traditional mathematics. The knowledge is called “Tacit Knowledge”.

Since both types of knowledge are needed in practice, fuzzy logic attempts to form them orderly, logical, mathematical and coordinated with each other.

5. Fractals is a structure that any of its part is similar to its whole.

6. Living system is a system that its components are active with each other regularly with domestic law without imposing the law on them. They are active endogenously. In this paper, our purpose of system is urban system.

7. Linear systems are systems that show linear behaviors. In the linear analysis of phenomena, it is assumed that any effect will be referred to its past and its cause can be clearly found.

8. Cellular automata model are phenomena that their development law is external. In other words, development in the situation of a point depends on the other points in the neighborhood of that point.

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