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# Integrated Analysis of Urban Landscape Fragmentation (Case Study: Historical-Religious City of Ray)

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**ABSTRACT:** Landscape fragmentation has threatened the landscape continuity of Ray which was maintained from prehistoric times until recent decades. From 19th century that Tehran sprawl growth affected Ray's landscape as a satellite city of Tehran, Ray experienced rapid landscape fragmentation and underwent many changes. In order to cope with the threat, the process of changes from landscape fragmentation should be studied. For this purpose, integrated approach was applied to assess landscape fragmentation. Landscape fragmentation is analyzed based on physical and quantitative evaluation using landscape metrics and perceptual and quantitative evaluation through an in-depth interview with natives. The results have cleared an image of the structural changes and also great change of people's perception during the time. Based on the results, Ray's landscape is structurally fragmented, but native do not perceive it. This is while people perceive landscape functional fragmentation. This inconsistent perception of landscape has caused the native's dissatisfaction about their living place. With the prepared image of landscape fragmentation in the City of Ray, city managers, designers, and planners will be able to deal with rapid changes and preserve landscape continuity of Ray.

**Key words:** Integrity, Fragmentation, Landscape assessment, Perception, Mental map

## INTRODUCTION

Landscape is dynamic and extremely complex (Antrop, 1998; Antrop, 2000; Levinthal and Warglien, 1999; Southworth *et al*., 2002). Human and nature interactions lay at the core of complexity and dynamism(Given *et al*., 2013), which create inimitable landscapes (Marc Antrop, 2000). The dynamic interactions lead to continuous changes (Antrop, 1998; Forman and Godron, 1981). Patterns, pace, and magnitude of changes are different especially in the countryside near major cities and metropolitan areas (Antrop, 2004). Landscape fragmentation is the result of such changes that is mainly defined as the breaking of a habitat, ecosystem or landscape into smaller pieces which is usually caused by human activity (Forman, 1995). The definition has emphasized on structural change (landscape units breakage), that lead to functional changes (Gulinck and Wagendorp, 2002; Cook, 2002; Dibari,2007; Ecke *et al*., 2013). This definition focuses on the physical and ecological aspects of landscape, while based on the landscape definition provided by the European Landscape Convention, the perceptual and sociocultural aspects are also important (Council of Europe, 2000; Fry *et al*., 2009; Antrop, 2000; Nüsser, 2001; Stobbelaar and Pedroli, 2011). Landscape fragmentation as a multi-dimensional nature should be studied based on all mentioned aspects. The main dimensions of landscape fragmentation are physical and perceptual. In the physical dimension, changes in landscape structures and functions are important. Functional changes include ecological and sociocultural dimensions. People's perception about fragmentation consider in the perceptual dimension (Fig. 1).

Landscape dimensions, as mentioned above, have been studied in different disciplines such as ecology, urban science, environmental science, and landscape architecture. Generally, all studies have defined fragmentation from three perspectives. The first one is the physical view that is addressed mostly by biologists, landscape ecologists and landscape architects. In this view, fragmentation is purely a physical process that changes the structure and functions of the landscape (Monavari and Momen Bellah Fard, 2010; Salehi *et al*., 2011; Ceccarelli *et al*., 2013; Pedroli *et al*., 2006 ; Wu and Hobbs, 2002). In the second view, landscape is studied as a perceptual reality whose features result from economic activities,

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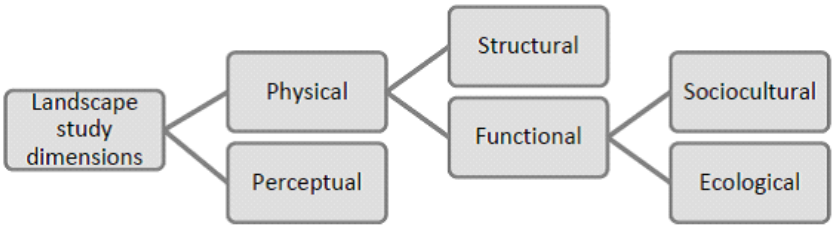


**Fig. 1. Dimensions of landscape fragmentation studies**

social interactions, and personal experiences and preferences (Kolahi *et al*. 2014; Spanou *et al*. 2012; Taylor, 2002). According to the third and hybrid view, fragmentation should be examined in terms of both physical and perceptual aspects. That is because a physically fragmented landscape might be perceived to be integrated by users due to popular preferences. Therefore, both human perception and evaluation of landscape and ecological studies are essential for comprehension of landscape fragmentation.

There are also disagreements over evaluating fragmentation as a positive or negative process. Based on the presented perspectives, some researchers believe that fragmentation is a disruptive process with just negative effects on humans and the environment (Llausàs and Nogué, 2012; Girvetz *et al*., 2008; Sun *et al*., 2012). The second group believes that fragmentation is a natural positive process that must be preserved in landscape (Taylor, 2002). Based on the third group's theory, fragmentation is considered as a part of the dynamic nature of landscape. Hence, like any disturbance of natural or human origin, fragmentation is not merely destructive and is a process that can have positive or negative effects on landscape (Leitão *et al*., 2006; Fahrig, 2003; Bowman *et al*., 2002; Law and Dickman, 1998; Gulinck and Wagendorp, 2002).

Also, landscape fragmentation is less understood in urban fringes due to landscape complexity and dynamism (Antrop and Eetvelde, 2000). Fragmentation leads to spatial reorganization of landscape in which different socio-economic driving forces play a vital role. Landscape configures according to the needs and values of local society and economic forces simultaneously. Normally, a new landscape component is imposed on landscape which alters the natural resources, historical and cultural values in an irreversible manner (Antrop, 2004; Nüsser, 2001).

Landscape fragmentation understanding requires a holistic approach to account for the chaotic situation. As a result, analysis of landscape transformation needs to analyze the landscape changes and human driving forces (Nüsser, 2001). On the other hand, "the new state of landscape forms the reference base for future changes," (Antrop, 1998). Consequently, analysis of changes, process, trends, and pattern is essential in all dimensions. The explanation of landscape continuous transition needs first, focusing on people's perception (Antrop and Eetvelde, 2000) and second, assessment of ecological fragmentation. Complexity, interconnectedness, and uncertainty are intrinsic characters of landscape changes (Lein, 2008) that should be realize in landscape problem solving based on integrated approach. The integrated approach includes perception and evolution that allowing the landscape ecology and perception linkage to be investigated (Antrop, 2000). Also environmental conditions governed by human driving forces in an economic and cultural context (Nüsser, 2001) should be consider in integrated approach. On the other hand, lack of integrated approach in landscape studies will lead to injustice, especially when human law and social practice ignore natural processes and when those who plan, design, and build the city focus on a neighborhood's problems and fail to recognize its resources (Spirn, 2005).

Studying the dynamics and continuum of landscape change is necessary to meet the challenge of understanding the complexity of landscape transformation, reveal dimension, pace, magnitude, and impacts of changes, and obtain reliable data in order for proper decision-making (Antrop, 2004). Future is the continuum of the past and present; hence, identifying this process can be referred to as the main step for planning the future to meet human needs while maintaining ecological processes and biodiversity which are important for the future of human being. In this paper, two questions are discussed: what is the nature of changes in landscape? How do people perceive landscape changes?

## MATERIALS & METHODS

The current study has been done in the historical and religious City of Ray. Ray is a particularly important place because of the unique historical-cultural background. Ray has its origin in prehistoric times. The first settlement dates back to the fifth millennium BC in the plains of Ray (Ghirshman, 1957). The formation of the initial core of the city dates back to

the Medes dynasty period in the sixth century BC (Diakonov, 1959). The city has faced many changes over time. In the Parthian period (second century BC), it was chosen as the capital for the first time (Kariman, 1966) and it received much attention due to being located on Silk Road, the commercial and military pathway (Pirnia, 1952). This caused a lot of looting and invasion in the course of time. After the Mongol invasion, nothing remained except the ruins of the city in the thirteenth century AD, (Sykes, 1991; Benjamin and Greene, 1984). The last major change occurred in the Islamic era. During this period, the city was rebuilt around the holy shrine of Shah Abdul Azim and an Islamic city was shaped (Bird and Weston, 1997). The city of Ray attained features of Islamic cities and integrated structure and functions caused the maintenance and durability of the city. These features in the Islamic city of Rey comprise: 1- Shah Abdul Azim's Shrine: the initial formation core of the city and the center of all religious, socio-economic and cultural activities, 2- Bazaar: a framework linking urban spaces from the shrine to the suburbs of agricultural lands and also, a linkage for religious, agricultural and economic activities. 3– Residential neighborhood: as the main living space, 4- Agricultural lands: as the main working space (Fig. 2).

All these linkages among structures and functions were tightened by waqf. Waqf had made a system of functions in the city of Ray in which each function causes sustainability for the other functions. All farm lands around the holy shrine were endowments. They were rented to the residents at a very low price, they were thus a source of income for them and also for the government to spend on shrine maintenance and pilgrims services. The Bazaar's shops and Caravanserais were also endowments which while offering service to pilgrims, were a source of income for many households.

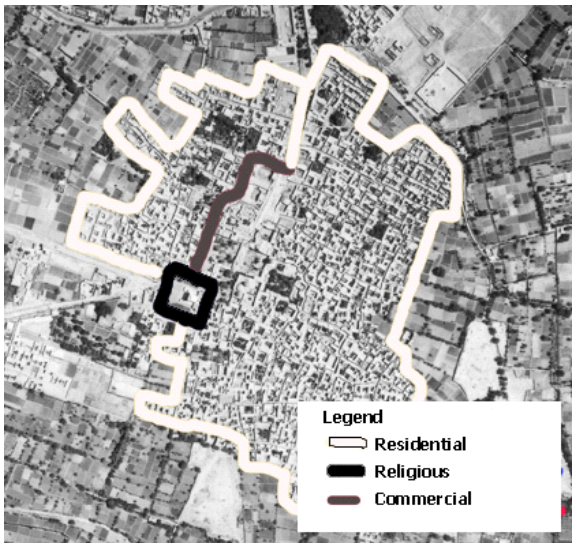


**Fig. 2. The location of the Bazaar and the residential neighborhoods near Shah Abdul Azim's Shrine**
(Adopted from: national mapping agency, 1956)

Hence, in the Islamic era, a combination of history, religion, and agriculture created a special unique landscape over time. The unique urban landscape had experienced continuity over centuries because of the coherence among landscape religious, agricultural, commercial, and residential functions. This continuity existed in Ray until the Qajar dynasty, when Tehran, which was one of Ray's villages, was chosen as the capital of Iran. From then, Tehran has experienced rapid growth (especially in the last decades) and Ray became a satellite city of Tehran and faced too many changes.

The linkage in the urban structure and functions retained until the Qajar dynasty and peak changes have occurred during the second king of the Pahlavi regime up to now. Thus, in terms of time, two distinct periods can be identified in contemporary Ray. The first period is from the early formation of the current Ray (in the Islamic era) to the beginning of the peak of urban landscape structural changes during the second king of the Pahlavi regime. The second period is from the second king of the Pahlavi regime up to now. Accordingly, assessing landscape fragmentation in the city of Ray has been done in these two periods.

The area of study is the main historic- religious core of the city of Ray with its surrounding agricultural landscape area. The area is located on a 270-hectares site around Shah Abdul Azim's Shrine (Fig. 3).

The importance of the site is that in this area, all of the city functions (Fig. 4) which were coherent in the past are located together. So it will be possible to study their structural and functional changes. Current heterogeneity has shaped a new landscape facing crucial challenges from natural structure and function up to the identity problem which create a suitable place to study landscape fragmentation.

Three different methods are presented to assess landscape fragmentation. The first group is quantitative methods based on a physical view that uses landscape metrics (Burel and Baudry, 2003; Farina, 2006; Lausch and Herzog, 2000). The second group is quantitative methods used for measuring human perception and landscape preferences. These methods are based on the idea that a certain degree of fragmentation should not be considered as a threat or against the cultural and aesthetic principles without taking preferences into account (Appelton, 1975; Kaplan and Kaplan, 1989; Zube and pitt, 1981; Antrop, 2005). The third group is the integrated approach that

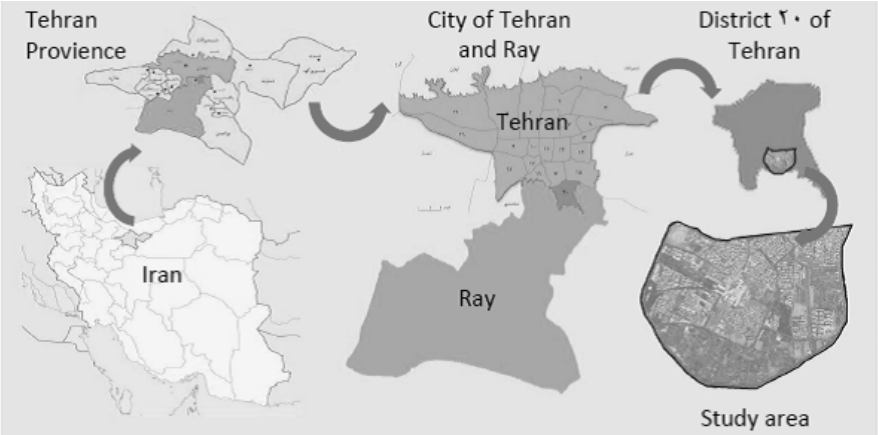


**Fig. 3. The location of the study area in relation to Tehran and Iran**

**Fig. 4. The study area and its context**

mixes the two mentioned methods (Dramstad *et al*., 2006; Farina, 2006; Gulinck and Wagendorp, 2002; Jongman, 2002; Fry *et al*., 2009; Purcell and Lamb, 1998) based on the European Commission of Landscape (ELC) definition of landscape. The efficient methods are those that can identify the relationship between landscape structure, functions, and perception.

This study combines quantitative and qualitative methods to assess landscape fragmentation. The method consists of three steps (Fig. 5).

The first step involves the application of quantitative methods in order to unfold the fragmentation in study area based on landscape metrics. Landscape metrics display structural changes and were used by many researchers (Antrop and Eetvelde, 2000; Williams *et al*., 2012; Zeng and Wu, 2005; Mas *et al*., 2010; Jongman, 2004; Fernandes *et al*., 2011 ;Li *et al*., 2005; Uuemaa *et al*, 2013). However, efficient and widely used indicators to measure landscape fragmentation used in this study are number of patches (PN), mean patch perimeter (PP-MN), mean patch area (AREA-MN) and compared patch area (CAP). Using this method, landscape structural changes resulting from fragmentation are studied and it is brought into light whether the landscape is physically fragmented or integrated. In the second step, a qualitative method was used. User's perception of their surrounding environment will be examined in order to understand whether people perceive their landscape to be fragmented or integrated and measure people's satisfaction of the landscape current state. In order to qualitatively assess landscape fragmentation, since the perception is connected with a set of personal senses (sight, hearing, smell, touch and even taste), the debate is complicated. Hence, in-depth interview seems to be appropriate among a variety of methods to assess people's preferences. Efforts were made to obtain information regarding people's thoughts about the environment and their mentality. Sampling for this study combines classified and snowball sampling. Since the target population is

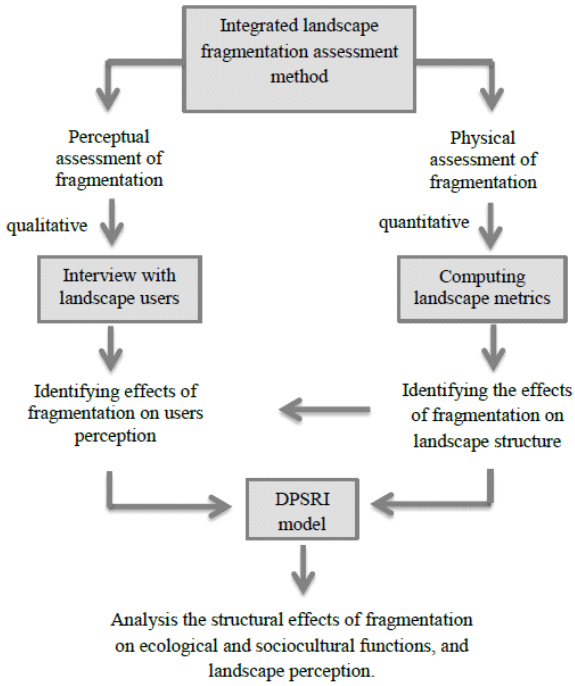


**Fig. 5. Integrated method to measure and assess landscape fragmentation**

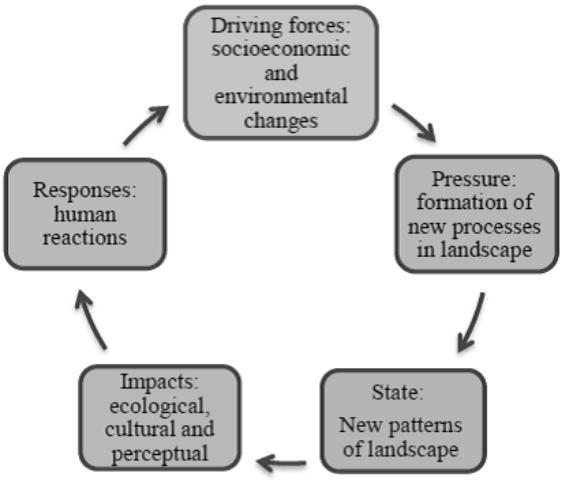


**Fig. 6. DPSIR framework for integrated landscape analysis**

composed of distinct groups, the classified method is applied and three groups including 1-farmers, 2-residents and 3- Bazaar traders are specified. Then, in order to perform sampling in each group, snowball sampling is carried out because the target group is people who have had long term experiences of living or working in the study area. Through this method, people's perception of their living place is examined and results will determine whether they perceive landscape fragmentation or not. In addition, comparing people's perception of the current landscape with what is in their memories of the past landscape will be possible.

In the last step, the results of the first and second steps will be analyzed in DPSRI model. (Fig. 6). (Through DPSRI model, results will be summarized and effects of structural changes on ecological and socio-cultural functions and landscape perception can be analyzed.)

DPSIR model is a causal framework for organizing information about the state of the environment and describes the interactions between society (development) and the environment (Kristensen, 2004) for integrated environmental assessment and reporting which was proposed in1999 by the European Environmental Agency (EEA) (Carr *et al*., 2007). Based on the figure, driving forces (D) including social, economic, and environmental changes create new human and ecological processes in the landscape. The processes put pressure (P) on the landscape and create new patterns and states (S). This leads to the appearance of the ecological, social, and cognitive impacts (I) which create human reactions (R).

## RESULTS & DISCUSSION

One of the dimensions of landscape fragmentation is structural fragmentation which is measured by different quantitative metrics. Four metrics have been used in this study including mean patch area, mean patch perimeter, mean patch area**,** compared patch area and patch number. These metrics have been calculated based on Ray's land use maps of years 1956 and 2013 (Fig. 7). In the map of year 1956, three main patch groups have been detected including: residential - service patches, brown fields and farms. An additional patch group has been identified in the year 2013. This patch group contains parks and urban green spaces. Table 1 shows the calculation results of the above metrics for the defined patches of the years 1956 and 2013. Physical assessment results will show whether landscape is structurally fragmented or not. Perceptual assessment will show if structural and functional fragmentation is perceived by landscape users or not. Hence, in-depth interview has been done with local people and the results are reflected in Table 2-4 and Fig. 8. Three target groups have been selected for in-depth interviews: residents, farmers and Bazaar traders. In each group, interviewees were chosen by the snowball method. The interviewees should be native and settled in the area more than fifteen years in order to have a continuum perception from landscape and its changes.

The main interview topics have focused on landscape subsystems connections. The amount of

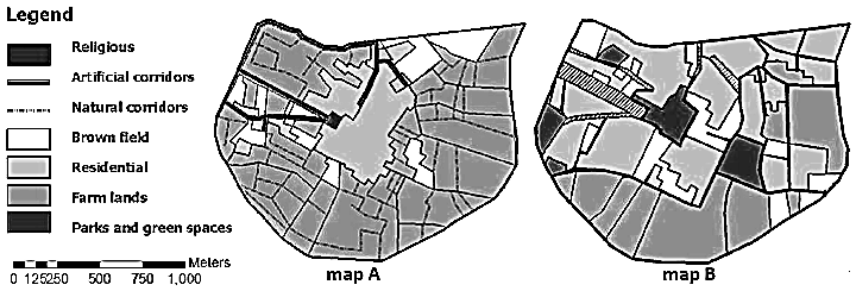


**Fig. 7. Maps of land uses of the site in years 1956 (map A) and 2013 (map B)**

**Table 1. Comparison of landscape metrics for the years 1956 and 2013**

| Metrics / Patch type | Mean patch perimeter (m) | | Mean patch area ($m^2$) | | Compared patch area (%) | | Patch number | |
|---|---|---|---|---|---|---|---|---|
| | 1956 | 2013 | 1956 | 2013 | 1956 | 2013 | 1956 | 2013 |
| Residential - Services | 47034.95 | 56379.35 | 914.95 | 990.57 | 15.07 | 37.58 | 9 | 18 |
| Brown fields | 22534 | 37950.31 | 696.23 | 1251.75 | 10.01 | 11.25 | 12 | 8 |
| Agriculture lands | 101397.2 | 69624.53 | 1381.32 | 1070.13 | 71.33 | 28.36 | 19 | 11 |
| Parks& green spaces | 0 | 32040.98 | 0 | 720.32 | 0 | 4.75 | 0 | 4 |

**Table 2. Results of interviews with residents of Ray (%)**

| main interview topics | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Shrine impact on people's lives | | | Users connection with Bazar | | | Tended to farming in the city | | Current users' participation in agriculture | | Users connection with agriculture | | |
| + and _ impacts | None impact | + impact | Half connected | Not connected | Connected | Not tended | Tended | Not Partnership | Partnership | Half connected | Not connected | Connected |
| 15 | 15 | 70 | 25 | 10 | 65 | 15 | 85 | 90 | 10 | 40 | 25 | 35 |

**Table 3. Results of interviews with local farmers of Ray's farmlands (%)**

| topics of interview questions | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bazar relationship with agriculture | | | | Ownership of stores | | Current residents participation in agriculture | | | customer Groups | | |
| Half connected | Not connected | Connected | Both | Waqf | Personal property | Both | Foreign workers | Residents | Both | Pilgrims | Residents |
| 26.6 | 33.3 | 40 | 27 | 30.6 | 46.3 | 26.6 | 13.3 | 60 | 26.6 | 46.6 | 26.6 |

connections will show whether users perceive landscape functional fragmentation or not. If the users perceive lack of connection and coherence among functions, it means they perceive fragmentation. People were also asked to compare their memories of the Ray's past features with the current landscape, in order to compare the people's perception of current and former landscape. Mental maps of former and current Ray are prepared based on people's descriptions. These maps will show if structural changes are perceived by users

**Table 4. Results of interviews with Bazaar traders of the shrine od Shah Abdul Azim's Bazzar(%)**

| main interview topics | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Shrine economic relationship with agriculture | | | Ownership of lands | | Current residents participation in agriculture | | | Product sales place | | | customer Groups | |
| Half connected | Not connected | Connected | Waqf | Personal property | Half Partnership | Not Partnership | Partnership | Surrounding areas | Ray | Both | Pilgrims | Residents |
| 80 | 10 | 10 | 0 | 100 | 40 | 50 | 10 | 10 | 90 | 40 | 0 | 60 |

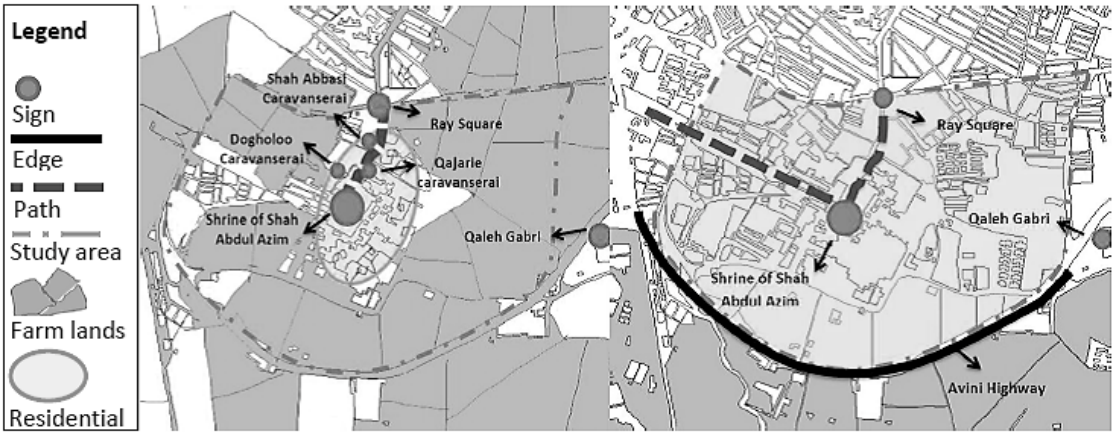


**Fig. 8. Natives' mental maps based on their memories of the old Ray (map A), and their descriptions of the current Ray (map B)**

or not. The results of interviews will also show how structural changes have affected people's perception (Fig. 8).

The results of the physical assessment revealed a decrease in the number and area of agricultural patches to less than half from 1956 to 2013. Vice versa, the number and areas of residential and services patches have increased to more than double. These changes are due to the changes in land ownerships and growth in the residential area. Changing in land ownership from the Waqf system to personal property means that people have to pay for farming costs that farming is no longer profitable. On the other hand, land use change from agricultural to residential and services is economical and could bring more outcomes for owners in short term and there was an extensive demand for land due to urban growth. Therefore, agricultural lands have been converted into residential land use more than ever. Moreover, the natural corridors have greatly been destroyed from 1956 to 2013, in such a manner that no significant natural corridors remained in 2013. Conversely, artificial corridors have increased as is evident in Fig. 3. But artificial corridors prepared for urban services more than ecological or agricultural purposes. The growth of the city led to structural fragmentation which is the result of the transportation infrastructure development and expansion of residential patches among farm lands. The structural changes resulting from the landscape fragmentation in Ray can be determined as follows: 1. decrease in farmland's patch number and area, 2. increase in the artificial corridors, 3. increase in brown fields patch number and area, 4. increase in disturbance patch number and area as residential- service and commercial land uses, 5. decrease in and destruction of natural corridors and 6. introduce new land uses such as parks to the landscape.

The results presented in tables 2-4 reveal that landscape subsystem connections are too limited. Reduction of active farm lands, and decrease in agricultural products have caused little connection between the Bazaar's and farmlands' functions. There is no more farm products to be sold in the Bazaar. Moreover, fewer pilgrims are associated with

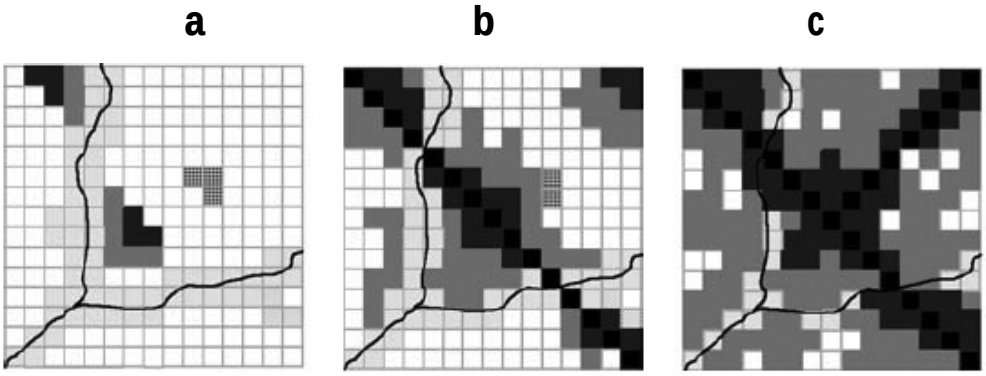


**Fig. 9. Fragmentation of agricultural landscape has led to the integration of the urban landscape.**
Residential and artificial corridors: black and dark gray, farmlands and natural corridors: white and light gray. (Adapted from: Leitão *et al*., 2006)

agricultural lands because of the distance between farmlands and Shah Abdul Azim's Shrine which is the result of structural changes and the growth of residential patches that decrease accessibility to farm lands. Also, residents are no longer involved in agricultural activities, despite the fact that most farmlands are owned by residents.

They prefer to rent their lands because irrigation corridors are destroyed and there is a lack of irrigation water. Residents' and pilgrims' relations with the Bazaar are also restricted. That is again because of the change in the ownership system of stores from Waqf to personal property. So, high rent prices have caused the commodity prices to rise, which has led to less purchases (Also, other factors are influenced on a subject that is out of the scope of this article). These results which reveal few linkages between users and landscape subsystems show that landscape functions are fragmented and this reality is perceived by natives.

The native's mental map of the city before fragmentation (Fig. 8 - map A) demonstrates an integrated matrix of agricultural lands which surround religious and residential areas. Although there is another residential area on the west side of the Shrine (Fig. 7 – map A), natives did not mention it in their description of the past. This description suggests that the expansion of agricultural land in the past had made an integrated matrix that caused the small residential neighborhoods to be ignored. On the contrary, in the mental map of the current Ray (Fig. 8 - map B), the largest space is devoted to the residential area. This is because of the reduction of agricultural patch numbers and areas and increased residential- service and commercial patch numbers and areas in addition to increased artificial corridors. Residents in their descriptions considered the area in the north of Highway (shown as edge in Fig. 8 - map B) as residential area while they are all farmlands (Fig. 7 – map B). This shows that the highway has evoked an edge in mind which separates the farmlands of north and south of the highway and since most of the area in the north of highway is residential, they ignore farmlands. Thus, any structural change resulting from fragmentation causes a change in the way people perceive the landscape.

These results show that structural fragmentation has affected the natives' perception of their surrounding environment. Some parts of reality are omitted in their mental image of the current Ray because of the structural changes. This has led to the perception of structural integrity, while they perceive functional fragmentation. In fact, their mental map of the current Ray has shown a new integration which is the result of urban patches (residential, service and commercial) growth and connection (Fig. 9). Their mental map of the old Ray also shows integrity, but that is because of the connection between farmlands and also urban patches. So, the main difference between these perceptions is that their mental map of the past Ray complies with the reality of the old Ray (Fig. 7 - map A), and all parts of the landscape are perceived. That is because of the functional integrity of the old Ray's landscape. Conversely, their mental map of the current Ray does not comply with the reality and an important part of the landscape is omitted in their mental image of Ray. These results suggest that people have an inconsistent perception of landscape fragmentation. They do not perceive landscape structural fragmentation. While they perceive landscape functional fragmentation, they think landscape is structurally integrated. This leads to dissatisfaction with their living place.

Structural changes resulting from fragmentation in addition to change in landscape perception, lead to changes in ecological and socio-cultural functions.

**Table 5. Results analysis of physical and conceptual assessments by applying DPSRI model**

| | |
|---|---|
| Driving forces (changes) | - Urban sprawl and urban population drift from large population centers (Tehran).<br>-Concentration of population in suburbs. |
| Pressure (processes) | - Increasing the construction and housing prices caused by increased demands.<br>- Development of urban infrastructure and services.<br>- Increasing population density.<br>- Increasing Traffic. |
| State (patterns) | -More residential- services and commercial land uses patch number.<br>-More artificial corridors and less natural corridors.<br>-Emergence of new land uses such as parks.<br>- More brown fields. |
| Impacts (ecological, cultural and perceptual) | **Ecological:** Increasing the land form diversity. Destruction of ecological habitats. Fragmenting animals' habitats and interrupting the communication between the two sides of the corridor fauna and flora. Reducing biodiversity. Increasing pollution of water, soil, and air.<br>**Socio - cultural**: Increasing communication and cultural exchanges. Forgetting the traditional knowledge. Reducing social interactions because of cultural heterogeneity. Changing recreational space forms. Changing the nature of human-environment relations. Buried historical landscape under the urban landscape.<br>**Perceptual**: Reduction of perceiving the place as integrated. Increasing readability of space because of more pathways and roads. Replacing natural symbols with urban symbols. Losing collective memory. Alienation from the natural environment. Alternating natural environment with urban green spaces. |
| Responses (human reactions) | **Natives' reactions:** Trends to the past and willingness to find traces of the past. Increasing concerns about anonymity and speed changes. Lack of tendency to stay in the place. Changing behavioral models based on changing in the economic conditions. Resistance to rapid change. |

Thus, they cause a wide range of changes. In order to analyze and summarize them, DPSRI model is used and the results are shown in Table 5.. The following table describes the effects of fragmentation on landscape dimensions from the city structure to user's perception. The table provides an explicit description of landscape fragmentation process in the City of Ray.

Based on Table5, the beginning of the Rey's landscape fragmentation coincides with the urban sprawl of Tehran, expansion of Tehran towards Ray and population drift from Tehran to Ray. These changes have led to population growth, more housing demand and rising land price. These socio-economic and environmental changes have caused new processes in landscape such as increased the construction and population density (See Table 5 for more details). These processes have led to structural fragmentation and creating new patterns of landscape. New patterns include more residential-service and commercial patch number and more artificial corridors (See Table 5 for more details) have also affected socio–cultural and ecological functions and perceptions of landscape.

Structural fragmentation has affected ecological functions by increasing the land form diversity and destruction of ecological habitats. In terms of the socio-cultural functions, increased communication and cultural exchanges are impacts of structural fragmentation. In addition, structural fragmentation has also affected the perception of landscape by losing collective memory, and alienation from the natural environment (See Table 5 for more details). Changes in ecological and socio-cultural functions and perceived landscape of Ray have given rise to certain responses among the natives including trends to the past memories, and resistance to rapid changes. In the provided description of the landscape changes resulting from fragmentation in the city of Ray in addition to the agreement between the physical and perceptual assessment results, positive and negative effects of this process can be simply identified and discussed by planners, city managers, and landscape architects and designers.

## CONCLUSIONS

The city of Ray is an important historical city that conserved its landscape integrity through history, now it has faced many challenges due to landscape fragmentation especially in recent decades. The city had retained its continuity until fragmentation happened. Hence, discovering the process of fragmentation and

the resulting changes is extremely important for future. For this reason, integrated landscape fragmentation assessment is investigated. The results showed that Ray's current landscape is physically fragmented in comparison to the past. Structural changes in addition to sociocultural and economic changes have affected many functions and led to functional fragmentation. Structural and functional fragmentations have changed the user's perception of their living place. Natives perceive that landscape is functionally fragmented, but they do not perceive landscape structural fragmentation. This inconsistent perception of landscape has caused the native's dissatisfaction with their living place. With the created awareness of the landscape fragmentation process and its impacts on the city structures and functions and the native's perception and satisfaction of their living place, the city managers and designers will be able to make changes to improve the situation.

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