Investigating the changes of ecological network and its role in the ecological resilience of Mashhad city

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Extended abstract

Introduction

Today, the urban ecological network is considered as an approach to enhance the ecological values of urbanizing areas. Indeed, the concept of urban ecological network in relation to overcoming the natural environment and its fragmentation due to the human environment development is appeared. This concept as a suggestion to protect the ecological elements of the urban structure in response to the disruption and destruction of its components was proposed. Ecological network structure based on the principles of landscape ecology includes a combination of the landscape basic elements such as patches, corridors, and matrix. These elements in urban areas consist of natural and artificial ecological layers so that the adjustment and how these layers adopt with each other are very important. Supporting the urban ecological networks is a factor to protect natural processes and biophysical functions in the cities, and promotes the system capability to cope with environmental pressures by balancing human and ecosystem services. However, ecological networks are destroyed, damaged or fragmented in many urban development plans instead of using them as natural potentials. This issue leads to serious negative consequences in urban areas.

In addition, maintaining the natural context and biodiversity in cities in order to create a connection with nature due to the environmental degradation and disruption of the urban ecological foundation, requires integration of ecology knowledge with the process of urban planning and design. The emergence of ecology as a distinct discipline has occurred in the late nineteenth and early twentieth century in Europe and North America. The introduction of different paradigms over a time led to the ecology development and provided the context for changes of the urban ecology approaches. Thus, according to the evolution of urban ecological science and based on recent approaches, cities are presented as social-ecological systems that the resilience of these systems are affected by both socio-economic and biophysical patterns and functions. In fact, the relationship between natural and human functions is the most important determinant of urban ecological resilience. So, creation and restoration of the ecological network in the cities are considered as the practical application of urban ecology science in urban planning and design. This action is an important step toward achieving the goals such as maintaining natural context in urbanizing area, consolidating the relation between city and nature, providing the better utilization of natural ecosystem services and increasing urban ecological resilience.

Side effects of unplanned urban developments are visible in Mashhad as a second most populous city in Iran. The elimination of greenways, fragmentation of gardens and green areas, burial of the natural streams and urban air pollution increment have all led to cripple natural systems, descend the quality of life and consequently decreased the ecological resilience of this city. With regard to the above issues, illustrating the position and importance of attention to urban ecological networks in urban development plans towards achieving ecological resilience is the main purpose of this research. Other objectives that pursue the main purpose, are explained as follows:

- Identifying the ecological structure of the Mashhad city and its forgotten and burial ecological values in the current situation, and determining the relationship between natural and man-made elements in Mashhad.
- Illustrating the qualitative and quantitative changes of the ecological networks in the processes of Mashhad development over the past half-century, and analyzing the impacts of these changes on the ecological resilience of the city.
- Suggesting the strategies to improve the structure and function of the Mashhad ecological network and similar urbanizing areas.

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Materials & Methods

The research method of this paper is a mixed method and both qualitative and quantitative methods to gathering and analyzing data are used according to different parts of the paper. Output data like qualitative maps and quantitative tables are created using ArcGIS 10.2 software. Period 1956 (the time of the first aerial photographs of Mashhad) up to 2015 is selected in order to investigate the evolution of ecological structure components of Mashhad city in its development processes and analyzes the impact of these changes on the ecological resilience of the city. Based on Forman mosaic model, the ecological structure of the Mashhad city according to the spatial distribution of patches, corridors and matrix in 60 years period and times of 1956, 1987 and 2015 is analyzed and its quantitative and qualitative changes are studied. In order to extract the structural elements of the ecological network in the three listed times, the satellite images of Landsat OLI/8 (15 August 2015), Landsat TM/5 (20 July 1987), historical aerial photos of the years 1956 and 1987 for the study area of Mashhad and historical documents are used. Data of the past and current situation of the Mashhad city for a mentioned period which were gathered by studying historical and pictorial documents are interpreted through content analysis and comparative methods.

The pre-processing of the satellite image to extract data mainly includes radiance calibration and atmospheric correction is done. In addition, pan-sharpening is applied in order to increase the resolution of the 2015 image from 30 m of multispectral bands to 15 m of panchromatic on. The aerial photos of the years 1956 and 1987 are georeferenced and image mosaics are integrated using ArcGIS. Natural and man-made layers including hydrological maps, green space, and accessibility network as the components of the ecological structure are identified by using aerial and satellite images and also historical documents. These layers along with other land cover classes such as arid lands, highlands, and built areas are mapped in ArcGIS as classified shapefiles. Finally, the GIS maps of the Mashhad city in the three mentioned times are created, and qualitative and quantitative comparing of the components of the ecological structure through maps, statistic data and attribute tables are provided. Comparing these components in the three times of 1956, 1987 and 2015 indicates the changes and evolution of them in the processes of Mashhad urban development and growth.

Discussion of Results

The components of ecological networks based on the patch-corridor-matrix model as classified layers are extracted to determine the situation of ecological networks in Mashhad city. These layers are overlaid to analysis the ecological structure and urban function.

- Natural and built green patches layer has an important role in an urban ecological structure which effects directly on the ecological activities of the city.
- Hydrological network layer as the most important natural and built ecological corridors of urban landscape includes surface and subsurface streams.
- Accessibility network layer as built ecological corridors in urban fabric includes main roads which connect the ecological patches in dense urban areas.

Finally, the ecological structure of the Mashhad city in each considered period are created as union map by integration of natural and man-made layers above-mentioned.

The survey of the aerial photos and satellite images of the Mashhad city in the three periods and comparison of the quantities data obtained from the shapefiles of land cover layers as well as analysis the overlaying maps of these layers with GIS software techniques show that about 1743 hectares of agricultural lands and about 630 hectares of green spaces in the year 1956 have been changed to build areas in the processes of urban development. Moreover, 2478 hectare of agricultural lands and about 513 hectares of green spaces in the year 1987 have been destroyed. The investigation of the water corridors during the 60 years of evolution shows their structural and functional changes. Mashhad city physical development was led to enclosure, blockage, redirection or removal of some of the corridors. The enclosure of Naderi and Gharekhan streams as two of the most important western-eastern water corridors of Mashhad, the disappearance of the end section of the Gonabad stream as a vital transporter of the Gilas fountains' water into the city, and burial of many northwest streams are the main impacts of unplanned urban development. In fact, these corridors must be preserved as the ecological elements which have main roles such as linking the city and nature, conveying water and air flow throughout the city and as respiratory organs of the city.

Conclusion

In this paper, based on landscape ecology principles, the position and importance of urban ecological networks in urban development plans towards enhancing urban ecological resilience are discussed. Investigation the evolution and changes of the ecological networks during the 60 years period in the Mashhad city indicates that about 2373 hectares of green and agricultural lands in the year 1956, as well as 2991 hectares of these lands in

the year 1987 were destroyed in the processes of urban development. So that there is no trace of them in the ecological network in the year 2015. Thus, more than 5300 hectares of green patches were destroyed while these areas should be preserved for main reasons such as preventing the formation of urban heat islands, contributing to the penetration of runoff into underground aquifers in order to maintain natural water cycle, prevention of climate change and natural air filtration. As a result, the ecological resilience of Mashhad city has been decreased in the face of environmental hazards like climate change, air pollution, drought and flood. Today, in this city the most important ecological elements of the past are streams and water corridors which are considered as a key factor to preserve nature in the Mashhad urban landscape. By recognizing and revitalizing these corridors that strengthen the ecological values of the city and link the open and green spaces to each other, the ecological structure of the city can be increased. The loss of network integrity, disruption of the network elements connection, negligence in maintaining the ecological corridors, unbalance distribution of natural elements and low ecological quality of patches and corridors are the main problems related to Mashhad ecological network.

Finally, the corresponding strategies to these important problems are proposed by considering the different methods of intervention. Some of these strategies include maintaining buffers among the green patches and water corridors, increasing the diversity of green spaces by using indigenous plant species, increasing the number of green patches and corridors in the network, paying attention to proximity principles of ecological land use, improving the pattern of man-made elements in accordance with natural pattern, keeping balance between natural and artificial elements and considering ecological elements as a key factor in the process of urban planning and design. Generally, the ecological structure of Mashhad city can be improved through strategies in protection, reclamation, restoration, rehabilitation, and creation phases.

Keywords: ecological network, landscape ecology, resilience, urban landscape.