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Application of Graph and Least-Cost Theory to Urban Green Space Network Development and Enhancing Landscape Ecological Connectivity (Case Study: Tabriz city)

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Abstract

One of the challenges facing cities as the most complex landscapes is population growth and land use, followed by land use changes and fragmentation of urban lands, especially green and ecological spaces. The purpose of this study was to evaluate and enhance the ecological continuity of Tabriz city using modelling of urban ecological networks. At first, the ecological continuity status of the city was evaluated using connectivity indicators (Cohesion and IIC) and Fragstats and Conefor software. Both indicators prioritized the most important green spots in Tabriz metropolitan area while measuring the ecological continuity of landscape. Finally, with the most important green spots and land use maps, the optimal corridors were prepared based on the layer of land cover and graph techniques with minimum cost using Linkage Mapper software. The results of this study show that by applying the principles of land landscape ecology and concepts in graph theories and minimum cost together to simulate and analyse ecological networks and thus the optimal development of urban green networks.

Keywords: Ecological network, Graph theory, Landscape connectivity, Landscape fragmentation, Least-cost theory.

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Expanded Abstract

Introduction

Urban areas, including the most sophisticated landscapes and mosaics, consist of natural and artificial elements that accommodate different types of land use and are the main attraction of the human population due to the numerous services provided. Population growth and the need to meet human needs have led to the expansion of the use of natural resources and the conversion of ecosystems to urban areas, and by increasing urban construction, the demand for land has intensified in many countries, especially developing countries. The need for land and housing, which is constantly increasing today, leads to land use change and land fragmentation. Landscape disruption is a human process and a dynamic process over time involving changes in the type of land cover and the breakdown of a single habitat or ecosystem into discrete parts. Green spaces are recognized as part of urban landscape and remnants of natural habitats in the city that have numerous social, economic and environmental functions and benefits and play an important role in sustainable development and ecological integration in landscape. However, in recent decades, the expansion of cities and rapid urbanization have destroyed and transformed these spaces into smaller parts, which not only endangers the health of ecosystems, but also impacts the quality of life of citizens and residents of these areas. In this regard, various studies have found the most effective way to deal with the problems of urbanization and ecological cohesion is to strengthen the rational and sustainable relationship between human, city and nature resulting in the emergence of concepts such as ecological networks. The concept of ecological networks is used as a sustainable and appropriate approach to improve the ecological values of urban green spaces and generally through protecting existing green spaces, creating new spatial forms, repairing and maintaining existing connections between green patches, and constructing corridors or corridors. A new ecology is developing. Tabriz as the largest city in the northwest of the country, is the most important center of population attraction in this region of the country and is constantly expanding its physical reach. In recent decades, the city has witnessed many changes in the amount and type of urban uses, especially in the ecological arena, due to rapid population growth and urbanization. So, many of the city's gardens and landscapes have become over time demolished, fragmented, and reused. In this regard, this research has been designed with the aim of ecological analysis of landscape of Tabriz city and presenting solutions to improve its condition.

Materials and Methods

Tabriz city is located in the center of East Azarbaijan province in the northwest of Iran and is the largest city in the region with an area of 131 km² and a population of over 1.7 million people. The present study is applied in terms of purpose and descriptive-analytical in nature. In order to achieve the aims of the research, library studies were carried out and then based on the studies, the research framework and the required data were prepared and finally, the results and findings of the research were obtained. The conceptual model of research, based on the research background and the authors' studies, consists of two main steps: First, the ecological continuity assessment of Tabriz metropolitan landscape based on the continuity indices and identifying the most important urban green spots. Then, design the optimal corridors and build an ecological network based on the findings of previous steps using graph theories and minimum cost were done.

To evaluate the ecological continuity of Tabriz, two of the most important indices (Cohesion and IIC) at grade level and stain were measured and analyzed using Fragstats 4.2 and Conefor 2.6 software. The Cohesion Stability Index (Cohesion) calculates the degree of consistency and consistency of patches on the landscape based on measurements of the area and environment of the patches, which can be measured in Fragstats software. The Integrity Integrity Index (IIC) measures the functional consistency of the landscape using the concept of graph theory using Conefor software. Finally, by analyzing the results of the correlation indices, the most important green spots (core or core spots) of

Tabriz were identified. These spots play an important role in the creation of continuous green networks and consequently increase the connectivity of urban ecological spaces and promote the quality of urban environment.

In the second stage of research, using the most important green spots, using Linkage Mapper tool, based on graph and minimum cost concepts, the ecological continuity of Tabriz city and continuous network of corridors and ecological spots were improved. This requires three input data (patches or core habitats in vector format, resistance or cost layer, and Euclidean patches text file), obtained by various tools in ArcMap software. By calling all of the Linkage Mapper software input files and applying the appropriate settings, the lowest cost corridors are plotted, passing mainly the areas where the coverage is less resistant.

Discussion of Results and Conclusions

The results of Cohesion index measurement in Fragstats software, based on the type and nature of land use in the landscape of Tabriz metropolitan area indicate that the lands constructed in Tabriz metropolitan area have the highest correlation with 99/751 and the available ecological spaces (lands). Water, gardens and green spaces are the least correlated among land cover. The analysis of IIC index also shows the most consistency of spots 32, 33 and 34 in landscape of Tabriz city. Finally, analysing the results of the correlation indices analysis (IIC and Cohesion). Also, Google images of green spots of higher importance (based on the patch area and its location in landscape) in Tabriz were used. These spots, which are generally located on the outskirts of the city, play a key role in creating a continuous network of spots and corridors and improving environmental quality.

To improve the ecological connectivity of the landscape, a network of low-cost corridors may be proposed, which usually extend to areas with less land cover, less resistance to displacement and networking. For this purpose, the highest resistance (100 and 80) was made to urban areas and the least resistance (1-50) for green lands (parks, gardens and agricultural lands), vacant land and irrigated lands as the most suitable areas for networking. Given the weight intervals and cost layers, the corridor network only crosses the points of least resistance and connect from one habitat core to another. Finally, communication corridors based on the least cost and graph theory were identified by Linkage Mapper software, which connect the most important green spots in Tabriz metropolis.

Most of the corridors created were drawn around the city like a green belt, mainly due to the location of the main habitats in the suburbs. The central part of the city is also very resistant, so it is not possible to create ecological corridors in this part of the city. The main idea of this research is to create corridors, use of green lands, urban rivers, as well as waste and vacant land in the city that has been abandoned or owned by incompatible land uses. Proper utilization of vacant and waste land for the development of urban ecological networks can provide many ecosystem and social services to residents and improve the quality of urban environment.

Studies at the Tabriz metropolitan area show that the destruction of habitat and urban green patches has been the result of years of poor planning and land management, which would be even more difficult if continued. Therefore, based on the results of this research, using the principles of land landscape ecology and concepts in graph theory and the least cost can be used to simulate and analyse ecological networks and ultimately to provide optimal solutions and operational solutions and optimal development of urban ecological networks.