Analysis of Urban Green Infrastructure Suitability Using the TOPSIS Method and Land Surface Metrics (Case Study: Tehran City)

تحليل مدى ملاءمة البنية التحتيّة الخضراء الحضرية باستخدام طريقة TOPSIS ومقاييس سطح الأرض (دراسة حالة: مدينة طهران)

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Abstract **Turnit in:10%**

One of the key challenges of urban growth and population increase is the change in land use and the disappearance of green infrastructure. In recent decades, urban green infrastructure in Tehran, the city with the fastest urban growth in the country, has been sacrificed for various reasons, including urban expansion by managers and sometimes by citizens themselves, economic opportunism, and gray land uses. Therefore, the present research, with an applied and descriptive-analytical developmental nature, has focused on the spatial distribution of urban green infrastructure in Tehran's urban areas. In this study, the landscape metrics method was used to assess the suitability of green infrastructure, and the Topsis method was used for ranking regions. On the other hand, the landscape metrics (CA, PD, CAP, MPS, and MNND) were obtained in the Fragstats software environment. The results of the research, based on the desired final suitability map of green infrastructure and the area classification of Tehran's green infrastructure, indicate changes in the assumed patches of areas in the 10-year period from 1990 to 2000. The number of red patches in areas 1, 2, 3,

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5, 13, 14, 15, 16, 17 to 22 has increase is related to patch number 4 with 471 mosaic units.

Keywords: Topsis, Spatial Suitability, Urban Green Infrastructure, Landscape Metrics, Tehran City

إنّ أحد التحديات الرئيسة للنمو الحضري، وزيادة السكان هو التغيير في استخدام الأراضي واختفاء البنية التحتية الخضراء. في العقود الأخيرة، ضُحِي بالبنية التحتية الخضراء الحضرية في طهران، المدينة ذات أسرع نمو حضري في البلاد، لأسباب مختلفة، بما في ذلك التوسع الحضري من المديرين وأحيانًا من المواطنين أنفسهم، والانتهازية الاقتصادية، واستخدامات الأراضي الرمادية. لذلك، ركز البحث الحالي، ذو الطبيعة التنموية التّطبيقيّة، والوصفيّة التّحليليّة على التوزيع المكاني للبنية التحتية الخضراء الحضرية في المناطق الحضريّة في طهران. في هذه الدراسة، استُخدِمت طريقة مقاييس المناظر الطبيعية لتقييم مدى ملاءمة البنية التحتية الخضراء، واستُخدِمت طريقة Topsis لتصنيف المناطق. من ناحية أخرى، جرى الحصول على مقاييس المناظر الطبيعيّة (CA و PD و CAP و MPS و MNND) في بيئة برنامج Fragstats. تشير نتائج البحث، استنادًا إلى خريطة الملاءمة النهائيّة المرغوبة للبنية التحتيّة الخضراء وتصنيف منطقة البنية التحتية الخضراء في طهران، إلى تغييرات في البقع المفترضة للمناطق في المدّة الممتدة لعشر سنوات من العام 1990 إلى العام 2000. انخفض عدد البقع الحمراء في المناطق 1 و2 و3 و5 و13 و14 و15 و16 و17 إلى 22، مع زيادة البقعة رقم 4 فقط. ينتمي أكبر انخفاض إلى البقعة رقم 1 (المنطقة 1) مع 340.05 وحدة فسيفسائية، وأعلى زيادة مرتبطة بالرقعة رقم 4 مع 471 وحدة فسيفسائية.

الكلمات المفتاحية: توبسيس، الملاءمة المكانية، البنية التحتية الخضراء الحضرية، مقاييس المناظر الطبيعية، مدينة طهران

Introduction

With the rapid urbanization, especially in developing countries, and the departure of urban growth from the steady trend of its physical development, the physical growth and horizontal expansion of cities have been influenced by inadequate planning in response to the influx of migrants to the city. As a result of the creation of informal settlements, this has led to market disarray, particularly the underutilization of a significant portion of land within the city limits and the negative impact of horizontal expansion of cities (Shafter et al., 2019). Introducing green infrastructure as a shift from protecting open spaces from a community dilemma to a necessity for communities indicates the importance of this concept (Macfarlane, 2015). Green infrastructure is a term that is mostly discussed in land development and conservation and has taken on different meanings depending on the various contexts in which different people use it (Benedict & McMahon, 2006). There are many definitions of urban green infrastructure, but what almost all of them have in common and encompass in all dimensions is framing green infrastructure as an ecological framework necessary for environmental, social, and economic sustainability. Green infrastructures differ from conventional approaches to open space planning because they look at the values of conservation and actions related to land development, growth management, and infrastructure planning to create a sustainable form of cities (Stranton, 2019). In the May 1999 report titled "Towards Sustainable America," green infrastructures were identified as a comprehensive approach to the development of sustainable communities. The report states: "Green infrastructure strategies actively seek to understand, harness, and value the environmental, social, and economic functions provided by natural systems for more sustainable and efficient land use and the protection of ecosystems" (Williamson, 2018).

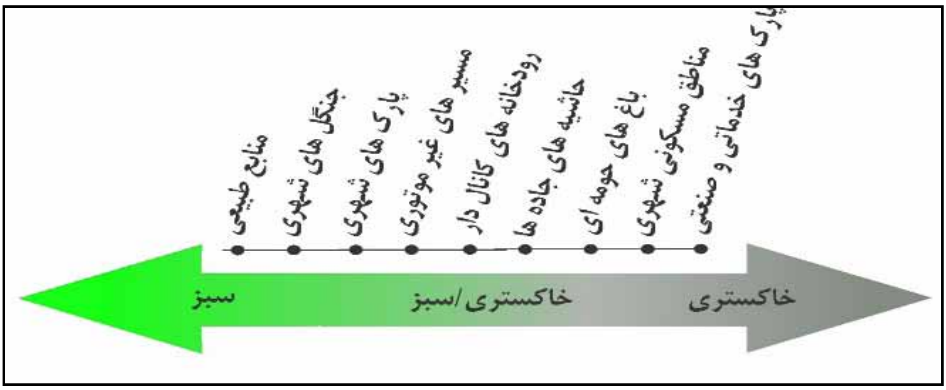
The importance of attention to rapid urbanization growth and its consequences, as well as planning green urban infrastructure in Iran, becomes evident when, according to research and the categorization of the Land Cover Organization from 2001 to 2020, Iran has been classified in a category with minimum vegetation cover. The continuation of this trend, alongside serious water scarcity, noticeable air pollution, the disappearance of many natural ecosystems, etc., has put Iran on the path of environmental instability. It is clear that neglecting this challenge can lead to various social and economic problems. Given the above issue and the emphasis on the role of green urban infrastructure in creating multi-functional spaces, innovation, sustainable spaces, providing living and non-living functions, as well as cultural functions in urban sustainability, this research will focus on evaluating the environmental, social, cultural, economic, and physical dimensions of these infrastructures and their relevant indicators, especially ecosystem services and human well-being. It aims to answer the question of how, considering the prevailing climatic and environmental conditions in the country, an appropriate model of green urban infrastructure elements can lead to long-term sustainability in the form and structure of cities, urban economy, various urban communities, and urban environmental environments, thereby creating livable cities and spaces for everyone. Since environmental problems are more assessable at the regional and ecosystem levels, and on the other hand, the metropolis of Tehran, as the capital of Iran, has been struggling with serious crises in various social, economic, and especially environmental dimensions for years, and the solutions to these problems have been temporary, the urban complex of Tehran is being studied as a case study.

Theoretical Foundations

Green infrastructure is a term that has been increasingly emerging in discussions of land conservation and development worldwide since the early 21st century (Hakimian and Luck, 48:1396). The precedent of green infrastructure can be traced back to issues and examples of open spaces such as greenways, green cities, and landscape ecology. However, the birth and expansion of this concept with its main title can be divided into three periods. The first period, related to the exploration and identification of the concept in the late 20th and early 21st centuries (19982007-), is associated with the publication of resources such as the Sustainable Development Document in America and the famous article by Benedict and McMahon in 2002, which introduced the concept and its prevalence in research and professional reports. The second period, encompassing the expansion and extension of this concept in the early 21st century (20052010-), focused on discussions, policy documents, and research projects with a special emphasis on the benefits and applications of green infrastructure in regional and strategic development. Finally, the third period (from 2010 to the present) includes the consolidation of the green infrastructure concept in literature, research, and reaching a common consensus on defining this concept and how to develop and apply it, such as the formation of a more detailed and credible body of evidence (Mell, 2017: 137 .(140-Green infrastructure includes the physical environment within and between cities and villages, networks of open spaces, waterways, gardens, forests, green corridors, street trees, and open margins that bring social, economic, and environmental benefits to people and local communities (TEP, 2005: 1)

(Figure 1). It is a connected network of green spaces that preserves the values and functions of natural ecosystems and provides benefits to human populations. Green infrastructure is the environmental framework needed for environmental, social, and economic sustainability (Benedict and McMahon, 2002:12). Some authors also consider green infrastructure as a reconstruction of existing concepts in green space planning (Davies et al., 2006:9). In the present study, green infrastructure encompasses natural and man-made green spaces (such as parks, green roofs, street trees, and green corridors). According to Morish and Brown, green infrastructure should become a platform for the existence, identity, presence, and history of our human society. It can also have broader cultural, social, and ecological applications beyond its profitable functions. In fact, green infrastructure should not only aim for profitability but also achieve goals of enriching the sense of place, linking benefits and public interest, and enhancing ecological performance (Moorish and Brown, 2008: 138-154). Green infrastructure, in its main function, provides a strategic approach to land conservation, enabling the identification and prioritization of conservation opportunities to optimize land use for meeting the needs of both humans and nature in future development planning. This approach can be called intelligent conservation (in contrast to the term smart growth that emerged in the United States to control uncontrolled development) whose function is to counteract the ecological and social impacts of uncontrolled development, consumption, and fragmentation of vacant and open lands (Benedict and McMahon, 2006: 7).

Figure 1- Types of urban green and grey infrastructure (Davies et al., 2006:24)



Research Background

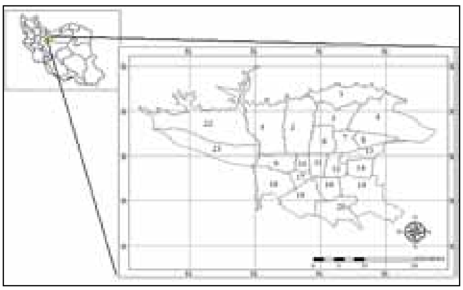
Various studies have been conducted on urban green infrastructure, some of which are mentioned in Table 8.

Table 1- Internal and external studies on the subject of the present research

Result	Method	Title	Authors (Year)
The main problems of urban green infrastructure network in Tehran are their inappropriate distribution, lack of connectivity in the urban matrix, low sustainability, and their decline in the urban fabric.	Analysis of ecological structure at landscape scale using Fragstats software.	Evaluation of urban green infrastructures for their gradual improvement in the landscape of Tehran.	Yazdan Panah and Colleagues (1394)
There is no relationship between the distribution of green space in Ardabil city and the population distribution, and the analysis of the green space per capita index indicates a very low figure for this ratio.	The AHP model and weighting processes in Expert Choice software for standardizing layers using DRISI software.	Analysis of urban green space distribution with a spatial justice approach (Case study: Ardabil city)	Mahmoudzadeh and Colleagues (1395)
The distribution of land uses in green spaces in Zanjan city is not balanced and the spatial distribution of green space land uses follows a clustered pattern.	The nearest neighbor models and hotspot analysis tools	Spatial analysis of access to urban green space in Zanjan with a focus on spatial justice	Alizadeh Zenoozi and Colleagues (1397)
There is no suitable green infrastructure in areas with first priority, except for improving heat islands, air quality, or enhancing habitat connectivity. This concept can be developed in places where there is a simultaneous presence of heat islands, rainwater, and air pollution.	Green Infrastructure Planning Model (GISP)	Urban green space, public health, and environmental justice challenges in creating relatively green cities	Voll and Colleagues (2014)
There is no suitable green infrastructure in the study area because land use changes have significant impacts on the urban green infrastructure system.	Multi-criteria based green space planning model using Geographic Information System (GIS) approach	Multi-purpose green infrastructure spatial planning for resilient growth in Detroit	Miro and Newell (2017)
There is a growing concern about green infrastructure in cities; therefore, policymakers and stakeholders need to make decisions about current and future land use. The goal of land use policy-making processes should be to balance green infrastructure with other land uses towards sustainable urban development.	Erdas Imagine software and Geographic Information System for five-class LULCC classification for goal analysis	The trend of urban growth in land use and infrastructure changes in the two Ethiopian cities of Bahir Dar and Hawassa	Gashu and Gire (2018)

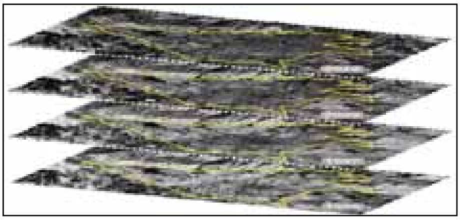
Introduction of the Study Area

Tehran, the capital of Iran, is located geographically between 51 degrees and 4 minutes to 51 degrees and 33 minutes east longitude and 35 degrees and 35 minutes to 35 degrees and 50 minutes north latitude, covering an area of 730 square kilometers. The city of Tehran is situated at an elevation of approximately 900 to 1800 meters above sea level. The elevation in Tajrish Square in the north of Tehran is about 1300 meters, while in the Railway Square in the south of the city, which is 15 kilometers away, it is 1100 meters, resulting in a slope of 13 meters per kilometer. Tehran is surrounded by mountains, which act as a barrier to atmospheric currents and influence the local climate of the city. Tehran has a semi-arid climate. In most years, winter provides half of Tehran's annual precipitation, and summer is the driest season in Tehran. Administratively, Tehran is divided into 22 districts and 122 urban areas, and according to the 2016 national census, the population of Tehran in these 22 districts is 8,693,706 people (Statistical Center of Iran, 2016).



Given the percentage of urban development growth in the study area in Tehran Province, which is 31.87%, and the decrease in urban green infrastructure by approximately 57.12%, it is evident that if about 32% of this green infrastructure in the area has been lost due to human interventions, but an area of approximately 25% has been lost due to negligence and lack of preventive strategies in macro-ecological issues, as a result of mismanagement effects, natural hazards, droughts, etc. The extent and percentage of this loss can be observed in analytical tables. It should be noted that due to the limitations of basic data in the references and the lack of establishment and updating of information databases available, the researcher was forced to use methods for determining the extent and area through digitizing aerial photographs, in the absence of up-to-date and integrated databases such as GIS or LIDAR. Therefore, to examine the forty-year range of urban green infrastructure from 1990 to 2020, most patches have been prioritized based on the large-scale nature of the research topic, and areas ranging from approximately 1 to 186 square kilometers have been selected by considering the maximum likelihood index. The classified layers in IDRISI software, after refinement using FRAG STATS software and a mosaic structure in the form of green infrastructure, are evaluated.

Figure 3 - Satellite images of the development of Tehran city over a 30-year period



Research Methodology

The present research is applied in terms of objective and descriptive-analytical in terms of cognitive method. In this study, after collecting information through reviewing library resources and documents, the data obtained from remote sensing in the research area has been studied and analyzed in two stages, which are:

- Land Metric Method

The present research aims to investigate the suitability of green infrastructure in Tehran city (spatial locational suitability). Spatial locational suitability is a process that determines the appropriate location in the designated area for a specific use (386400- Hopkins, 1977:). Land suitability analysis refers to the process of determining the compatibility, capability, and suitability of a part of the land for a specific and defined use, and in other words, it is a process to determine the suitability of land resources for a certain number of uses and determine the level of suitability (Manlun, 2003:21). In order to determine the most desirable path for future development, it is necessary to study the suitability for various uses with the aim of growth in the most suitable locations. This analysis is an important method for ecological planning. Land suitability is determined based on characteristics such as hydrology, geography, topography, geology, biology, social aspects, etc. (AL Shalabi et al., 2006: 2). Therefore, in the first stage, the factors affecting the suitability of urban green infrastructure (three environmental, social, economic criteria, and fifteen sub-criteria) were identified using library resources, documents, electronic sources, reviews, and field observations. The metric features used in the research are as follows:

Metrics Translation

- CAP Metric (Coverage Area Ratio): The ratio of the area of each specific land cover or land use in the land surface. CAP provides basic information about the land surface composition and is used in various cases such as land cover change analysis, natural resource conservation planning, or strategic land use planning. It should be noted that this metric does not provide information about the arrangement and spatial characteristics of the patches, so using other metrics such as average patch size and patch density will be more effective.

- MPS Metric (Mean Patch Size): The average size of patches in a specific land cover or land use on the land surface; patches are the main physical and functional components that control land surface processes. The size of patches and many land surface characteristics such as primary production, nutrient reserve, and their distribution composition are affected. Therefore, the average patch size can be used to assess land surface functions.
- PD Metric (Patch Density): Patch density indicates the number of specific land cover or land use patches per unit area of the region. This metric is used to identify processes such as fragmentation. In this process, large patches are fragmented into smaller patches, so the patch density metric provides information about this process.
- MNND Metric (Mean Nearest Neighbor Distance): The average distance between patches of each specific land cover or land use to the nearest neighboring patch on the land surface. The MNND metric is very useful for identifying the spatial distribution of specific land cover or land use patches. It is worth noting that using metrics, the composition and distribution of various land covers are evaluated. Metrics such as PD and CAP indicate the composition of patches. However, when zonation and differentiation of zones are considered, they can also indicate the distribution dimensions (Botequilha and Ahren, 2002)).

- TOPSIS Method

TOPSIS is a multi-criteria decision-making method for evaluating and prioritizing options based on criteria by considering their distances from positive and negative ideals. This method was proposed by Hwang and Yoon in 1981 and quickly found its place in multi-criteria decision-making. The acronym stands for Technique for Order of Preference by Similarity to Ideal Solution. The underlying logic of this method is to select the optimal option. TOPSIS was introduced after the simple SAW method and became a widespread method for solving decision matrix-based problems. In this method, m options are evaluated by n criteria. Once the options and their evaluation criteria are determined, each option is assigned a score based on each criterion. These values can be based on available statistics or expert opinions. If expert opinions are used for scoring, TOPSIS method can be employed. Options that have the highest similarity with the ideal solution will achieve a higher rank (Aryanezhad, et al, 2011:51).

Research Findings

1.1 Land Surface Metrics

The ability to quantitatively describe the structure of the land surface is a prerequisite for studying the performance and structural changes in the land surface. Various metrics are used in ecology to achieve the goal of understanding the land surface. In this research, four land surface metrics were used due to their ability to interpret the composition and spatial distribution of green infrastructure. Based on the recognition and analysis of green infrastructure focusing on evaluation and considering land surface indicators and compliance with landscape evaluation principles as well as spatial planning, the following points are explained and concluded:

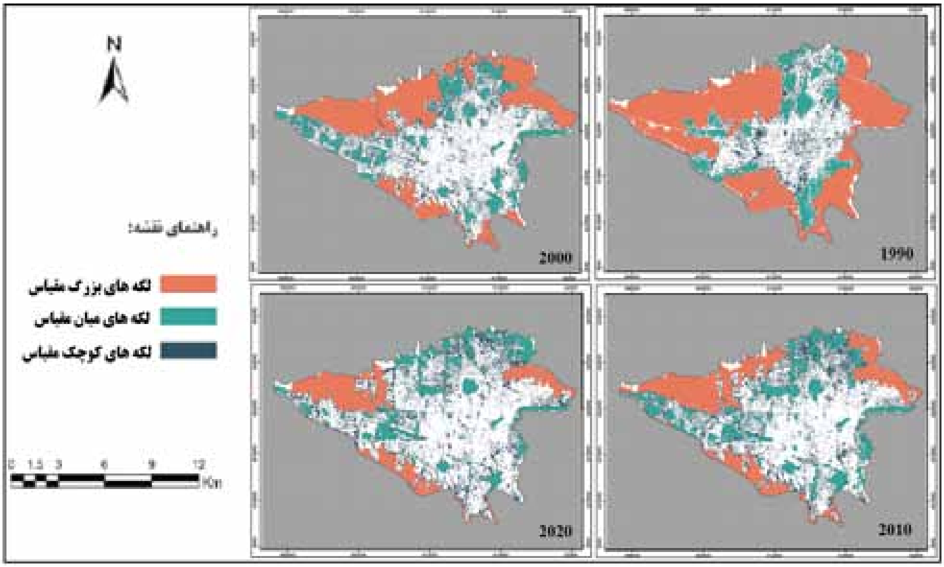
- Explanation of the current structure based on data analysis
- Explanation and analysis of changes in green infrastructure patches according to zones and ranking based on a ranking system

Table 2- Land Surface Metric Indicators for the twenty-two districts of Tehran (1990-2020)

MNND metric	MPS metric	metricCAP (Percent)	PD metric (percentage of hectares)	Metric CA (hectares)	Land class (hectares)	Year
7.9	7020.3	80	0.006	108016.1	Large-scale translation	1990
11.45	177.525	8.17	0.0225	10878.74	Inter-scale spot	
6.1	5.415	11.83	0.575	14337.5	Small-scale spot	
9.05	7407.095	77.5	0.00705	98551.29	Large-scale translation	2000
12.75	189.2535	9	0.0335	11589.07	Inter-scale spot	
8.2	6.7559	13.5	0.95	13005.41	Small-scale spot	
10	7642.465	74.975	0.005	80541	Large-scale translation	2010
16.9	152.0855	11.605	0.041	12225.69	Inter-scale spot	
9.55	7.705	13.42	0.95	13963.53	Small-scale spot	
10.55	5828.41	56.29	0.003	51877.7	Large-scale translation	2020
18.35	183.9305	23.46	0.04	20289.53	Inter-scale spot	
8.5	6.991	20.385	0.945	17732.19	Small-scale spot	

Figure 4- Distribution of urban green infrastructure patches in Tehran (1990-2020)

Table 3- Values of the highest increase and decrease observed during the 40-year period from 1990 to 2020



2.2 Applying the TOPSIS Model in Ranking Boundary Patches

Stage 1: According to the structure of the TOPSIS model, the decision matrix will consist of the average changes of patches considering 22 options equivalent to the identified patches. By considering pairwise comparisons to confirm the initial decision weights, including a spectrum of 9 hourly criteria and examining internal relationships while fixing one criterion with the other dual criteria using the Delphi method, the decision matrix is expressed.

Stage 2: The decision matrix was normalized according to the following formula to scale the matrix (normalization), resulting in the normalized matrix as follows obtained using equation 1.

$$(1)\quad r_{ij} = \frac{x_{ij}}{\sqrt{\sum_i^m x_{ij}^2}}$$

Stage 3: Determining the Dimensionless Weighted Matrix considering the steps: obtaining criterion weights, linear scaling using the SAW method, and multiplying the linearly scaled dimensionless matrix in the SAW method by multiplying it by the column vector of criterion weights.

Table 4- Decision matrix values, linear dimensionless values, and values considering the importance impact coefficient

Area	Decision matrix			Dimensionless linear matrix			Based on the importance coefficient		
	Small-scale	Inter-scale	Larg scale	Small-scale	Inter-scale	Larg scale	Small-scale	Inter-scale	Larg scale
Area1	22.3333	14.3333	-113.5000	0.2027	0.9247	0.1322	0.040545	0.323656	0.059482
Area2	5.8333	4.1667	-108.5000	0.0530	0.2688	0.1264	0.01059	0.094086	0.056861
Area3	3.1667	-22.0000	-1.0000	0.0287	-1.4194	0.0012	0.005749	-0.49677	0.000524
Area4	10.6667	31.1667	-146.6667	0.0968	2.0108	0.1708	0.019365	0.703763	0.076863
Area5	9.3333	19.0000	-122.3333	0.0847	1.2258	0.1425	0.016944	0.429032	0.064111
Area6	2.3333	-6.1667	0.0000	0.0212	-0.3978	0.0000	0.004236	-0.13925	0
Area7	0.1667	-0.8333	0.0000	0.0015	-0.0538	0.0000	0.000303	-0.01882	0
Area8	-0.3333	-1.5000	0.0000	-0.0030	-0.0968	0.0000	-0.00061	-0.03387	0
Area9	1.8333	9.0000	0.0000	0.0166	0.5806	0.0000	0.003328	0.203226	0
Area10	-0.6667	0.0000	0.0000	-0.0061	0.0000	0.0000	-0.00121	0	0
Area11	0.5000	0.0000	0.0000	0.0045	0.0000	0.0000	0.000908	0	0
Area12	-0.1667	0.5000	0.0000	-0.0015	0.0323	0.0000	-0.0003	0.01129	0
Area13	1.6667	1.0000	-8.3333	0.0151	0.0645	0.0097	0.003026	0.022581	0.004367
Area14	-0.5000	-6.5000	-13.8333	-0.0045	-0.4194	0.0161	-0.00091	-0.14677	0.00725
Area15	8.3333	-8.1667	-42.3333	0.0756	-0.5269	0.0493	0.015129	-0.18441	0.022186
Area16	0.8333	-3.6667	-0.3333	0.0076	-0.2366	0.0004	0.001513	-0.0828	0.000175
Area17	-0.3333	0.0000	-2.8333	-0.0030	0.0000	0.0033	-0.00061	0	0.001485
Area18	6.1667	5.0000	-46.3333	0.0560	0.3226	0.0540	0.011195	0.112903	0.024282
Area19	8.6667	5.3333	-46.8333	0.0787	0.3441	0.0545	0.015734	0.12043	0.024544
Area20	2.1667	-19.1667	-23.8333	0.0197	-1.2366	0.0278	0.003933	-0.4328	0.01249
Area21	8.6667	-23.6667	-9.3333	0.0787	-1.5269	0.0109	0.015734	-0.53441	0.004891
Area22	19.5000	17.6667	-172.6667	0.1770	1.1398	0.2011	0.035401	0.398925	0.090489

Stage 4: Finding the Ideal and Anti-Ideal points considering the negative aspect of the criterion with the highest decrease, and the positive aspect of the criteria with the highest increase and stability will be explained as follows: For criteria with positive weights, the ideal positive value is the maximum value of that criterion. For criteria with positive weights, the ideal negative value is the minimum value of that criterion. For criteria with negative weights, the ideal positive value is the minimum value of that criterion. For criteria with negative weights, the ideal negative value is the maximum value of that criterion.

Stage 5: Calculating the distance from the Ideal and Anti-Ideal points based on the following relationships:

(2) $$\boldsymbol{d_i^+} = \sqrt{\sum_{j=1}^{n}(\boldsymbol{v_{ij}} - \boldsymbol{v_j^+})^2}$$

(3) $$d_i^- = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^-)^2}$$

Table 5- Distance from the positive and negative Ideal points of linear dimensionless values

Area	فاصله از حد ایده‌آل					
	Small-scale		Inter-scale		Larg scale	
	Negative	Positive	Negative	Positive	Negative	Positive
Area1	0.001743	1.37E-13	0.736277	0.144481	0.003538	0.000961
Area2	0.000139	0.000897	0.395007	0.371706	0.003233	0.001131
Area3	4.84E-05	0.001211	0.001416	1.44129	2.75E-07	0.008094
Area4	0.000423	0.000449	1.533073	1.94E-13	0.005908	0.000186
Area5	0.00033	0.000557	0.928221	0.075477	0.00411	0.000696
Area6	2.97E-05	0.001318	0.156154	0.710666	0	0.008188
Area7	2.29E-06	0.001619	0.265836	0.522122	0	0.008188
Area8	3.66E-07	0.001693	0.250539	0.544104	0	0.008188
Area9	2.06E-05	0.001385	0.544107	0.250537	0	0.008188
Area10	8.26E-14	0.001744	0.285594	0.495282	0	0.008188
Area11	4.48E-06	0.001571	0.285594	0.495282	0	0.008188
Area12	8.23E-07	0.001669	0.297789	0.479518	0	0.008188
Area13	1.79E-05	0.001408	0.310239	0.464009	1.91E-05	0.007417
Area14	9.14E-08	0.001718	0.150262	0.723414	5.26E-05	0.006929
Area15	0.000267	0.000646	0.122501	0.788849	0.000492	0.004665
Area16	7.41E-06	0.001524	0.203955	0.618675	3.05E-08	0.008157
Area17	3.66E-07	0.001693	0.285594	0.495282	2.2E-06	0.007922
Area18	0.000154	0.000861	0.419014	0.349115	0.00059	0.004383
Area19	0.000287	0.000616	0.428816	0.340277	0.000602	0.004349
Area20	2.65E-05	0.00134	0.010325	1.291766	0.000156	0.006084
Area21	0.000287	0.000616	1.95E-12	1.533069	2.39E-05	0.007327
Area22	0.00134	2.65E-05	0.871114	0.092926	0.008188	1.7E-14

Stage 6: Calculating the similarity index and ranking the 22 patches based on the score using equation 4, where the closer the value is to one, the higher the score, rank, and desirability of the patch of interest based on the three indices of maximum decrease, maximum increase, and stability.

$$(4)\quad cl_i^* = \frac{d_i^-}{d_i^- + d_i^+}$$

Stages 5 and 6 involved calculating the distance from the Ideal and Anti-Ideal points, as well as the similarity index and ranking of the 29 patches. Summary of the analysis of changes in patches relative to the entire urban area of Tehran, as well as their placement in the stable-unstable spectrum based on the analysis of the obtained information using the mentioned method, the ranking of the 22 patches has been determined. Patch number 4 had the best condition and ranked 1st, while patch number 21 had the worst condition and ranked last in the analytical ranking. Therefore, the following ranking can be considered as the result of the analysis:

Table 6- Positive and negative elements of regions and ranking in proximity to the Ideal point

	di+	di-	Cl	
Area1	0.38137	0.861138	0.693065	4
Area2	0.611338	0.631173	0.507982	8
Area3	1.204406	0.038277	0.030802	19
Area4	0.025185	1.240728	0.980106	1
Area5	0.277001	0.965744	0.777105	2
Area6	0.84863	0.3952	0.317728	17
Area7	0.729335	0.515595	0.414156	14
Area8	0.744302	0.500539	0.402091	15
Area9	0.510011	0.73765	0.591226	5
Area10	0.710784	0.53441	0.429178	13
Area11	0.710663	0.534414	0.429222	11
Area12	0.699554	0.545701	0.438224	10
Area13	0.687629	0.557024	0.447533	9
Area14	0.855605	0.387704	0.311832	18
Area15	0.891157	0.351084	0.282622	20
Area16	0.792688	0.451623	0.36295	16
Area17	0.710561	0.534412	0.429256	12
Area18	0.595282	0.647887	0.521158	7
Area19	0.587573	0.655519	0.52733	6
Area20	1.13982	0.102508	0.082513	21
Area21	1.241375	0.017636	0.014008	22
Area22	0.304882	0.938425	0.754782	3

Conclusion:

The presence of balance and coordination among the areas of interest in terms of development potential is essential. Failure to observe this can result in investments and plans not leading to development. It also deepens inequalities and leads to uneven and glandular growth with environmental capacities and capabilities. Therefore, in urban planning, what can contribute to greater urban justice is focusing on spatial justice or planning that distributes services fairly across different regions. In this regard, attention should be paid to urban ecology and planning towards establishing environmental balance at the city level, which is a crucial aspect of spatial justice. In this context, urban green infrastructure by creating a kind of balance and equilibrium in the pillars related to sustainable development and spatial justice, which encompass environmental, social, economic sustainability, etc., helps us achieve the desired goals and reach a balanced and equitable city from the perspective of spatial justice.

The research results based on the final zoning map of green infrastructure desirability and the area classified for green infrastructure in Tehran show that, based on the analysis results, the extent of changes in the assumed areas' patches in the 10-year period from 1990 to 2000, the number of red patches in areas 1, 2, 3, 5, 13, 14, 15, 16, 17 to 22 decreased, and only in patch number 4 increased. The highest decrease belongs to patch number 1 (area 1) with 340.05 mosaic units, and the highest increase belongs to patch number 4 with 471 mosaics. The rest of the mentioned patches have a constant number of mosaics. Regarding the blue patches, the number of decreases and increases is somewhat balanced, with 7 patches decreasing and 14 increasing. The highest increase is related to patch number 18, and the highest decrease is related to patch number 6. As for the orange patches, the highest number of increases is related to patch number 9, and the highest decrease is related to patch number 2, while the others have changed within the range of 150 to -50.

Based on the analysis of the changes in assumed regions of patches over the 10-year period from 2000 to 2010, it is observed that the number of red patches in areas 1, 3, 17, and 21 has decreased, while patches 2, 5, 6, 19, 20, and 21 have increased. The greatest increase is related to patch 4 and the greatest decrease to patch 3. Additionally, 12 patches have a constant number of mosaics and have undergone changes in area and in some cases in shape. Regarding the blue patches, 4 patches have increased and 5 patches have decreased, with the greatest decrease being related to patch 6 and the greatest increase to patch 22.

For orange patches, the number of red patches in areas of patches 2, 6, 10, 13, 15, 20, and 21 has decreased, while patches 1, 5, 9, 12, 14, 19, and 20 have increased. For white patches, some patches like 23 and 26 have experienced the greatest decrease, while patches 27 and 28 have the greatest increase. An important point is that in regions 6 to 17, there are minor changes in range that are noteworthy considering the restructuring.

In the analysis of the changes in assumed regions of patches over the 10-year period from 2010 to 2020, the index of the number of red patches in areas 3, 17, 20, and 21 has decreased, with 4 patches increasing and the greatest increase being related to patch 4 and the greatest decrease to patch 21. An interesting point in this period is the significant number of 16 constant patches. For blue patches, 6 patches have increased and 5 patches have decreased. The greatest decrease is related to patch 5, with the decrease and increase of other patches ranging from +50 to 0. For orange patches, except for two patches 3 and 21, the rest have had balanced changes, with the range of changes between +50 to 45-.

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