# Modeling the Spatial Characteristics of City Parks Based on Geographically Weighted Regression (GWR) Analysis Using Coefficients of General Performance of Park (GPP) and Area of Supply and Demand (ASD)
## (Case Study: First Region of Tehran)

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**ABSTRACT:** The spatial weighted regression method is one of the best methods to achieve higher accuracy in analyzing space-affected relations. This article attempts to introduce a model of the results of Area of Supply and Demand and general park performance with a spatially weighted regression model for evaluating parks in Region 1 of Tehran. The density of parks and population density in Region 1 of Tehran with the help of some environmental variables-space such as the area of parks. To follow the theoretical framework, spatial distribution and urban green space efficiency indices were used. With their help, environmental-spatial variables have been extracted, and the required data have been collected through systematic scientific methods and turned into information in determining the relationship between the data. Based on the findings, it is expected that this indicator will help landscape planners to understand the supply and demand index of parks and their relationship with the general efficiency of parks. It can help planners reconsider their projects' policies, goals, and costs. The results show that the general performance development index of parks in the first Region of Tehran is not commensurate with their supply and demand. In some areas, parks with appropriate performance indexes have low demand. Predictions of this research show that parks with index (-0.5>StdError) value will need more demand in the future, and demand for parks with index (StdError>2.5) will decrease.

**Keywords:** Spatial Accessibility, Weighted Geographical Regression, Urban Park Service, Supply And Demand.

## INTRODUCTION

Green spaces provide appropriate service capabilities for urban dwellers and satisfy people's everyday demands for high-quality environmental goods. The advantages of natural ecosystems and their sustainable expression in urban green spaces (UGS) are well established. However, people's preferences and perceived need for UGS is not always obvious. Thus, they are frequently disregarded, particularly in urban planning choices, which might benefit greening programs' success. (Christoforidi et al., 2022).

One of the most significant repercussions of Iran's fast urbanization and physical development in recent decades has been the fragmentation of the distribution system of urban service centers. Parks and green spaces had a specific role in generating this socioeconomic gap in access to municipal services for inhabitants. Park spatial equality is a prominent problem in environmental justice research. Many metrics have been used to assess park accessibility, but few researchers have looked into the impact of travel behavior on park accessibility(Li et al., 2021).

When the high need for green space in densely populated areas is addressed, people regard park access as easy. Earlier studies revealed that park accessibility is determined by whether or not the spatial distribution of its supplies corresponds to population demand(Xing et al., 2018; Liu et al., 2022; Chen et al., 2021).

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On a worldwide scale, there are five techniques for planning and assessing urban green areas. Population ratio, area %, catchment area, facility features, and local norms are among them (Veal, 2013), as described in Table 1.

Unlike the per capita method, supply and demand measurement works based on the amount of service space provided. That is the amount of useful area of the space that affects the work of that space. Therefore, the use of methods such as per capita is not accurate. Here are some examples of research done in this field.

Gyoungju Lee, at the Korea National University of Transportation, used the ASD index for the first time. After that, Ilyoung Hong from the GIS department at Namseoul University developed this variable for the university. (Zhang et al. from Hubei University (2022) and Buckland & Pojani (2022) used ASD based on their processing for research.

Khalida Lifam Marthya (2022), in their Master's thesis "Spatial logic of access to parks in Qatar," The pattern of green park distribution in Greater Doha, Qatar, examined the Doha landscape planning based on two criteria: (a) walkable service areas to highlight park-covered areas, and (b) Identify neighborhoods that need a park based on variables such as population density, type of housing and population subgroups.

According to new research, "Exposure to parks through the lens of urban mobility," data for each city is displayed in a bipartite weighted network, with link weights representing the number of likely visits to a park from each census tract on an average weekday The number of parks around a census tract's occupants' daily activities is used to determine park exposure(Salgado et al., 2022).

The study from Tang et al. (2022) Reveals that by utilizing AHP and EW methodologies, the degree of synchronization between greenway service provision and public Demand in Guangzhou, a big Chinese metropolis, has been assessed. The outcome of combining the pair coordination degree model and spatial autocorrelation analysis revealed that the average value of the GSS subsystem at the city level is somewhat greater than that of the PD subsystem, indicating that the services offered by Greenway in Guangzhou may theoretically.

Research from Kamble et al. (2022)[1] The goal of determining the state of UGS[2] change is to determine the current state of UGS and the ideal population density at which UGS may be made available and accessible. The results reveal that traveling from the city center to the suburbs reduces the availability index of UGS and increases the distance between green spots. The investigated urban region has an uneven distribution of UGS categories. Low-density locations have more UGS per capita than high-density areas, while medium-density areas have the most UGS access.

Liu et al. (2022), In their "research Evaluating the disparity between supply and demand of green park space using a multi-dimensional spatial equity evaluation framework," showed serious spatial inequality in the supply and Demand for PGSs[3], especially the spatial disparity between different PGSs. The results show that the supply of mini parks is severely insufficient, and the distribution of comprehensive parks is too concentrated, leading to the polarization of saturated and insufficient supply. Some of the social groups studied in this article, such as the elderly, rural residents, and low-income people, are deprived of access to PGSs.

Zhang et al. (2021), in the article named "Characteristics of spatial-temporal distribution and the evolutionary mechanism of urban parks in Beijing, China," examined the dynamic growth of Beijing's urban parks by comparing spatial distribution features in three distinct eras in 2005, 2010, and 2017.

In addition to changes in quantity and area, the methods of direction distribution, kernel density estimation, and network analysis involve spatial structure and accessibility. The three-factor analysis approach is then utilized to understand the evolutionary mechanism. Stability factors, dynamic factors, and random variables all play essential roles in urban park spatial growth via the restriction mechanism, supply-demand mechanism, and incentive mechanism, respectively.

Research from Xiao et al. (2019) under the Title "Exploring the

Table 1: Types of standards

| Types | Description |
| --- | --- |
| Population ratio/fixed standards | A certain percentage of the land is allocated for open space (e.g., 10% of the total development area is allocated to open space). |
| Area percentage standards | A specified percentage of land is to be allocated for open space (e.g., 10% of the total development area is allocated for open space). |
| Catchment area-based standards | Distances residents must travel to access them (e.g., ¼ mile walk from users' quarters). |
| Facility standards | Specifications (size, signs, and sports field equipment) |
| Local standards | Delivery standards specific to a local area are based on local conditions and data, determined locally or expressed in any of the above formats. |

disparities in park access through mobile phone data: Evidence from Shanghai, China" In addition to changes in quantity and area, the methods of direction distribution, kernel density estimation, and network analysis involve spatial structure and accessibility. The three-factor analysis approach is then utilized to understand the evolutionary mechanism. Stability factors, dynamic factors, and random variables all play essential roles in urban park spatial growth via the restriction mechanism, supply-demand mechanism, and incentive mechanism, respectively.

This study aims to analyze the spatial equivalence between the ASD index and GPP[4]. This analysis helps to identify parks that do not have a proper relationship between the facilities and the population, which is outside the normal range. (ASD) as an indicator to emphasize the scarcity and oversupply of park services previously proposed by Lee & Hong (2013).

Therefore, in this study, the concept and dimensions of the supply and demand approach and general efficiency of parks are explained by using different sources and data on parks in Tehran Region 1. GWR[5] analysis will be used to measure the spatial equivalence of parks. Thus, this paper will try to measure the information and quantitative and descriptive data of the environment in converting data into digital information in GIS. The main question of this research: Which park performance index has the greatest impact on the supply and demand of parks? Sub-question of this research: Which parks have an unusual situation between their general efficiency and supply and demand index?

## MATERIALS AND METHODS

This research is an information modeling research. For this purpose, the distributional justice of the parks is determined by mathematical calculations in the GIS for each park. Then, with the help of its coefficients and weighting, the spatial distance of ASD is determined. In the final step, GWR and analysis will be performed using GIS analysis in mathematical equations. This research is mixed regarding data collection methods, relies on library methods to review resources, selects 50 areas for field observations to collect location information, and extracts the required parameters to create a database based on Geo reference information. This research will depend on the modeling analysis method and GIS analysis functions. The analysis of input data, including qualitative and quantitative information, is performed using standard coding and weighting methods. This paper calculates the ASD index using distributive justice coefficients and denotes spatial weight. The advantage of this method is the more accurate calculation of ASD, which is discussed in detail below. Figure 1 outlines the ASD calculation procedure and the use of the analytical results $ASD_i$, which is defined as the quantitative difference between supply and demand in park services per unit area ('area' hereafter):

Equation. 1:

$$ASD_i = P_i - \frac{Si}{pcpa}$$

$P_i$ = population

$S_i$ = refers to the actual park-service supply in area i,

PCPA[6] = denotes the per capita park area specified in applicable laws and regulations (e.g., The Law on Urban Parks, Greenbelts, and so on); Si in Equation. In this paper, the actual park services provided for areas i or j are affected by two indicators, which are defined as follows:

Equation. 2:

$$S_i = \sum_{j=1}^{k} Sij \ , \quad S_{ij} = A_j \times SW_{ij} \times E_{ik} \ , \quad SW_{ij} = \frac{1}{dij^\beta} \quad \beta > 0, E_{ik} = \sum f(W_i, D_{ij}, G_j, P_i)$$

The main concern of this research is the development of ASD due to the spatial inequality between supply and demand and the study of its experimental application. In addition, the space unit center shows many starting points for dividing a large area into smaller space units, making it easier to analyze. Calculating the distance of the road network and paths between all starting points (residential places) and endpoints (park positions) will be very difficult and time-consuming. For this reason, the straight-line spacing between parks and residential blocks
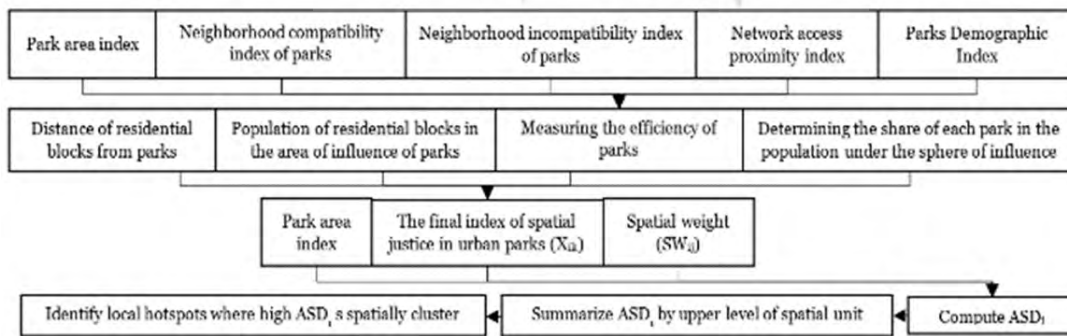


Fig. 1. Analytical framework for calculating ASD

helps us focus on the methodological highlights proposed in this study.

As pointed out by Equation. 2, Si is the cumulative value of the service size provided by (K) parks ($S_{ij}$) ($SW_{ij}$ denotes spatial weight). In Equation. 2, $S_{ij}$ is inversely proportional to spatial weight ($SW_{ij}$) on the straight line between i and j, meaning the area of park j is allocated to residential location i. Similarly, the aggregated services supplied by k parks distributed in the area indicate the actual supply level of park services. To measure the efficiency of each service, in this study, the compatibility and incompatibility of parks are described in a common section, and other indicators are discussed separately. The five indicators are shown in Figure 1; their relationship is plotted and can be calculated by Equation 3. 1) compatibility of parks with adjacent uses ($M_i$), 2) incompatibility of services with adjacent uses ($T_i$), 3) proximity to the access network ($N_i$), 4) elasticity of the applicant population ($Q_i$) and 5) area Services ($S_i$). The necessary communications and indicators for measuring the general efficiency index and ASD are presented in Table 2. Table 2 shows Factors determining the spatial distribution general efficiency index and ASD, which is presented in a summary form.

Equation 3: $G_i= (Z_1 M_i + Z_2 T_i + Z_3 N_i + Z_4 Q_i + Z_5 S_i)$

## Case Study

Region 1 of Tehran Municipality is located at the northeastern tip of this city and is considered the northernmost point of Tehran.

This region is limited to the Alborz mountain range from the north, the Evin region from the west, Ayatollah Sadr Highway from the south, and Lavasanat from the east. According to the census of 2016, region1 of Tehran has a population of 428,457 people, and according to the divisions of the municipality, it

has 27 neighborhoods. Four hundred thirty-seven parks are located in this area. According to the division of hierarchical parks, Tehran Region 1 has 20 regional parks and 417 parks in the region and neighborhood, all of which are under study in this study. Figure 2 shows the location of neighborhoods in Region 1.

## Theoretical Framework
### Spatial justice and Urban Green Spaces Efficiency

Gardens, parks, greenways, and other areas containing grass, trees, and bushes are examples of urban green spaces (Cramm et al., 2013). They can be common spaces where people congregate for leisure, socialization, and amusement. Urban green areas also allow individuals to come outside and engage with nature and others in ways that would not be possible otherwise(Jennings et al., 2016). The primary concern of the Post-Industrial Revolution urban planners and landscape architects focused more on order, public health, urban management, and quality of life in cities (Fainstein, 2013).

### Land Revaluation, Environmental Justice, and Access to Urban parks

Environmental justice is a dynamic and heterogeneous notion that arose from the exposure of environmental activists' environmental concerns. The original notion of environmental justice emphasized socio-spatial proximity and the distributional dimension, which highlights the involvement of all socioeconomic groups in the benefits of environmental amenities such as urban parks(Hughey et al., 2016).

Scholars such as Whyte (2011), Holifield (2012), and Martin et al. (2016) advocate for looking beyond the distributive dimension and combining the dimensions of cognition and participation, which confirms group differences in terms of their diverse interests and capabilities, and in achieving procedural

Table 2: Factors determining the spatial distributive general efficiency index and ASD

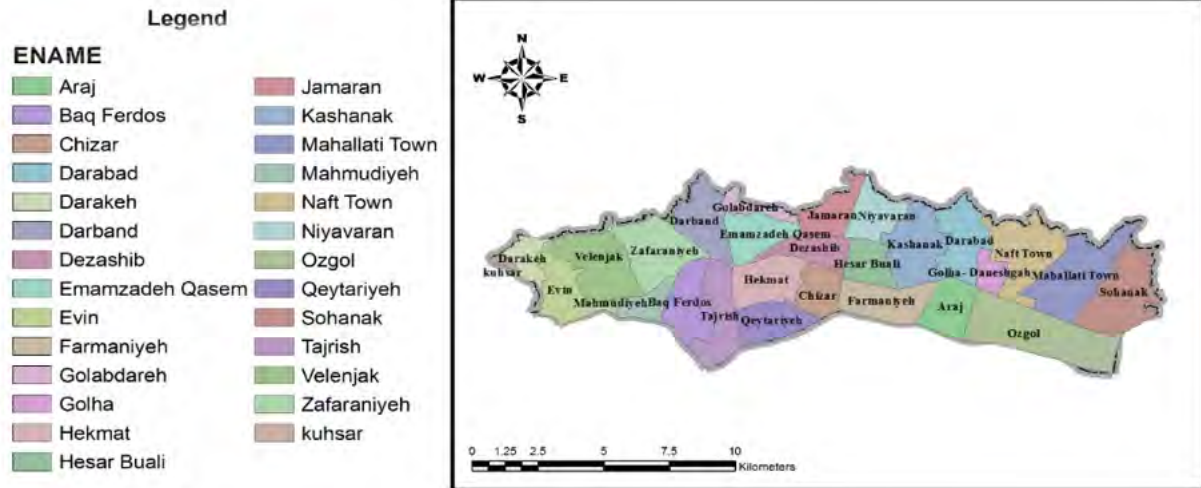| Index | Sub- Index | Communication | Definition |
|---|---|---|---|
| Distribution standards | Park area location park service capacity | $A_i= \sum f(W_i, G_j, P_i)$ | Spatial Justice of Parks (**Ai**) The amount of access of residents of urban units to services (**Wi**) The efficiency of each service (**Gj**) The population of blocks (**Pi**) |
| Spatial impact and proximity | The share of city units from the service capacity of public facilities Exhibition of inequity map | $W_i = \sum_{n=1}^{\infty} B_i$ | The number of residents enjoying the services of the parks around them (**Bi**) |
| Differences in the impact levels | Impact of access | $SW_{ij} = 1/d_{ij}^{\beta} \quad \beta>0$ | The distance of blocks from the service (Dij) |
| Definition of spatial disparity | The proportion of enjoyment | $ASD = P_i - \dfrac{S_i}{PCPA}$ | Population (Pi) refer to actual park-service supply in area i(Si) represents the per capita park (PCPA) |

Fig. 2: Spatial location of neighborhoods in region 1 of Tehran

environmental justice in decision-making processes, and implementation plays an important role. However, the ethical authority assigned to urban greening and the worldwide reach of the desirability of the green city has the potential to function as a dominant agenda-setting force, with extremely troubling consequences for fair green city design. Greening ideals, like the concept of "public goods" and the supposed distributed advantages of access, can serve as a method of de-emphasizing asymmetric power relations and disputes over competing resources, which risks reproducing unjust outcomes. The unfavorable consequences in this instance concentrate on mid- and long-term access to the benefits of urban (green) life. So, who exactly is a green city for? Recent ecological or environmental gentrification studies have revealed that a combined approach of environmental clean-up, land restoration, and green amenity building is progressively reconfiguring urban districts for richer and whiter residents (Anguelovski et al., 2018).

Features of Urban Parks and Their Suitability Assessment

One of the most important aspects of urban planning has always been the appropriateness of the distribution of the urban park system and the population's need for a public resource. Three features of a public urban facility related to population demand should be assessed to determine appropriateness. These characteristics include "distribution standards," "spatial and proximity impact," and "disparity in urban park impact," which are described below.

**Distribution Standards**

Landscape design guidelines for situating park systems offer a standardized foundation for assessing program effectiveness and planning area needs (Rigolon et al., 2018). Service area,

spatial segregation, and resident desire for different services are all essential elements of urban parks that have varying consequences on inhabitants (Bibri & Krogstie, 2017). Top-down planning aids in the distribution of urban parks. Although they are not constant and can alter over time depending on the condition of a park, a set of standards is required to gauge equality. Generally, there are two kinds of standards (Dadashpoor et al., 2017).

The first is the per capita of a park, which determines the amount of land allocated to provide facilities for each resident. Koch is also called the " per capita park area[8]."The application of urban green space standards varies from city to city. According to the World Health Organization[9], each one of the cities is recommended to provide at least 9 square meters of accessible, safe, and functional urban green space for each individual.

It also implies that the appropriate quantity of urban green space may be generously given to the tune of up to 50 square meters per person (WHO, 2010). This type of standard (PCPA) sometimes lacks the expected efficiency. The second type is the service radius of an urban park, which is related to the coverage of parks, such as a park or a school, which is served by traffic networks and in terms of its capacity to serve a certain segment of the population. The population supported by an urban park decreases with increasing distance from park facilities. At the same time, the service coverage increases in a larger radius. To solve this problem, we will focus on the upper radius, which corresponds to a smaller share of the supported population in the service radius. Regarding the service radius, the service radius and service capacity of urban public facilities are generally considered the optimal and maximum situation, and factors such as the scale of the facilities, the desirability of the

location, and the compatibility of the facilities play a key role.

**Spatial Impact and Proximity**

Social and commercial activities that use access networks to communicate are concentrated in cities. For density to be dynamic and represent changes in social and spatial relationships, spatial influence and closeness between units must be considered (Liang et al., 2021);. However, the population is not fairly dispersed over the entire city (this includes districts, neighborhoods, and blocks), and there comes a point where it should be regarded as an integrated unit. The city block is the smallest currently used unit. However, urban blocks are considered a single entity at the neighborhood level, with all blocks sharing the privileges of the neighborhood due to the spatial influence and closeness in the attractiveness of facilities. Neighborhoods nearby are also impacted. However, urban blocks are considered a single entity at the neighborhood level, with all blocks sharing the privileges of the neighborhood due to the spatial influence and closeness in the attractiveness of facilities. This impact also affects nearby neighborhoods. (Dadashpoor et al., 2017).

**Definition of Spatial Disparity**

The basis of our approach to uncovering breakthrough growth opportunities is the situation of demand. Our proven approach is constantly evolving but usually requires identifying Segments of Demand and digging into them to understand the needs of a multi-dimensional framework. Assessing the discrepancy between supply and demand for ecosystem service can provide relevant insights for improving human well-being in urban areas. Parks are not simply evaluated based on area and distance from residential blocks. This study's approach is that each park, except for the area and distance from the blocks, will be more or less effective due to spatial characteristics.

For this reason, this paper defines spatial disparity from an entirely different perspective: it is defined as the spatial discrepancy between levels of supply and demand of park services in a Geographic unit (for example, 100 m × 100 m

square grid). Figure 3 shows the theoretical framework of this research. The purpose of presenting this figure is to show the relationship between theoretical variables.

## RESULTS AND DISCUSSIONS

This study uses mathematical relationships and formulas to measure an urban park's supply and demand and general efficiency. Using the geographically weighted regression formula, the cross-correlation between the two main variables of this study is the supply and demand index. Indicators are:
• Determining the share of each park in the affected population,
• Measuring the efficiency of parks,
• Distance of residential blocks from parks,
• The population of residential blocks in the area of influence of parks.

Table 3 shows the neighborhoods of Region 1 of Tehran that have the most efficient parks. The final divergence of the general performance index of parks is also high, with the difference in areas where regional parks and areas adjacent to park neighborhoods improve and extend the final ASD index relative to their performance. Figure 4 presents the conceptual model of the research data processing process. This figure helps to understand the data processing steps better.

**Measuring the Efficiency of Parks**

To measure the efficiency of parks in each of the services, five indicators have been considered that will have different types. The points of the urban unit can be classified as follows:
1) Compatibility of services with adjacent uses($M_i$)
2) Incompatibility of services with adjacent uses($T_i$)
3) Proximity to the access network($N_i$)
4) The elasticity of the applicant population ($Q_i$)
5) Area of parks($S_i$)

Figure 2 shows the distribution of parks in Tehran Region 1 concerning their general performance, which has been done with the help of equation 3 and GIS software analysis.

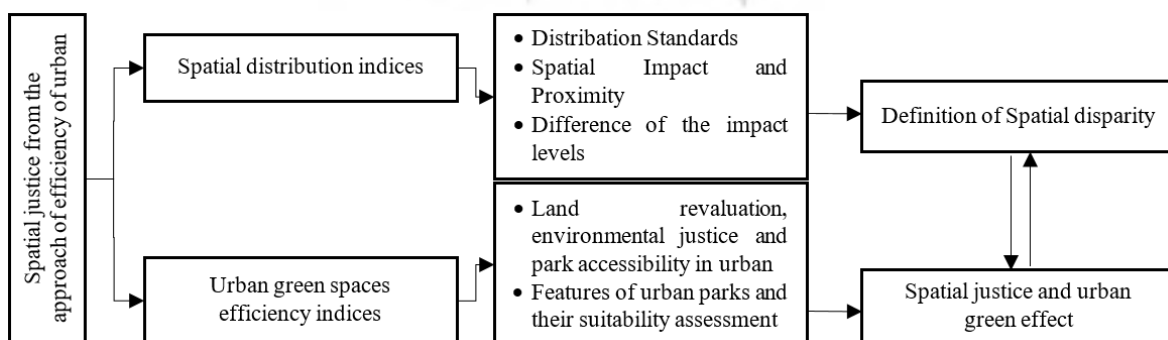**Geographically Weighted Regression (GWR)**



Fig. 3: The theoretical framework of the research

Table 3. Factors determining the spatial distributive justice index of parks

| Region | Zaferanie | Dezashib | Darake | Darband | Dar abad | Hekmat | Hesar Bo Ali | Jamaran | Tajrish | Bagh ferdos | Evin\ | Emam zadeh ghasem | Ozgol | Araj |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ASD | 987 | 242 | 0 | 414.75 | 886.18 | 1080.75 | 9055.83 | 37.43 | 1660.5 | 1636.7 | 535.78 | 707.57 | 1520.2 | **889.3** |
| GEI | 24.56 | 78.62 | 150.61 | 218.82 | 166.85 | 6.9 | 24.45 | 20.87 | 53.59 | 41.63 | 6.5 | 6.52 | 17.21 | **108.52** |

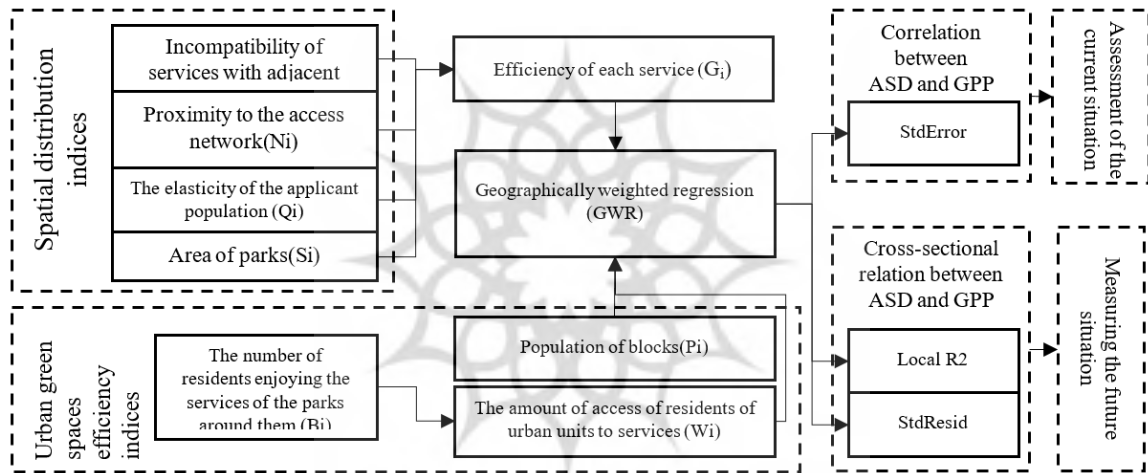| Region | Golha | Golab dare | Kashanak | Chizar | Velenjak | Hezar sang | Niavaran | Mahmo-die | Mahalati | Gheitarie | Farmanie | Shahrak naft | Sohanak |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ASD | 9851.75 | 1135 | 2495.5 | 985.5 | 1401.7 | 0 | 242 | 1202.4 | 1860.1 | 5827.54 | 1378.8 | 1326 | 1279.7 |
| GEI | 205.54 | 863.54 | 65.99 | 32.55 | 406.87 | 0 | 0.05 | 11.86 | 43.31 | 31.62 | 0.06 | 0.11 | 1.125 |



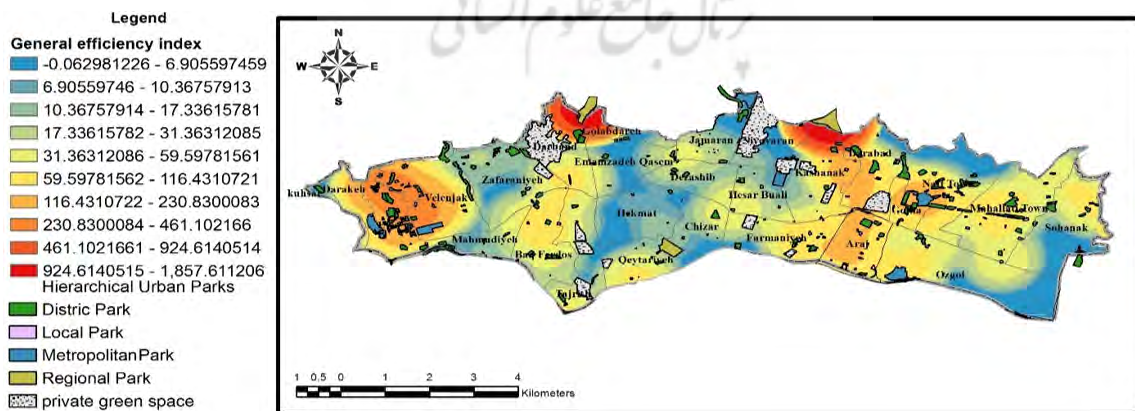Fig.4: Conceptual model of research data processing process



Fig. 5: The final index map of the general efficiency index of hierarchical parks in Region 1 of Tehran

These regression tools model the relationships between variables related to geographic features and allow us to predict the values of unknown variables and better understand the factors that affect a variable. Regression - allow us to examine the relationships between variables and measure the intensity and weakness of those relationships. A typical regression in which there is only one explanatory variable is written as follows (Equation 4):

Equation 4: $Y_0 = \beta_0 + \beta_1 X_1 + \varepsilon$

Here both the dependent variable and $X_1$ are independent variables, β0 and β1 are coefficients that must be estimated, and ε is part of the error assumed to be normally distributed. In this type of regression, it is also assumed that the values of the coefficients are the same throughout the study range. Therefore, if there are any geographical fluctuations in the relationship, it should be reflected in the error component. The main issue of this relationship is the reflection of error uniformly on our data, which reduces the measurement accuracy and the result's accuracy. The statistical relationship of several points that have coordinates (v, u) in the linear regression model when there is a P prediction quantity is defined as follows:

Equation 5: $Y(v,u) = \beta_0(v, u) + \beta_1(v, u) + \beta_2(v, u) + \cdots + \varepsilon(v, u)$

This model can be fitted with a minimum of squares To estimate the place coefficients (u, v) through it. This is done by performing geographic weight regression. Feminization is adjusted, so data closer to (u, v) receive more weight than data farther away. Usually, (u, v) is where the data is collected. Python coding in GIS and its analysis allows regression coefficients to be calculated separately for all parks.

**Local Standard Errors**

The standard error of the mean is usually calculated in an absolute reference frame where the zero point is defined outside the data. Rasch measures are defined relative to a local zero point. The local Rasch origin is generally considered the absolute location on the latent variable to which the empirically obtained location corresponds. Therefore, means and standard errors are considered in an absolute frame of reference.

Equation 6: $\sigma = \sqrt{\frac{\sum_{i=1}^{N}(xi - x)^2}{N-1}}$

Equation 7: $SE = \frac{\sigma}{\sqrt{n}}$

Using GIS analysis and Equations 6 & 7, the error standard for each park has been calculated. Still, since the number of



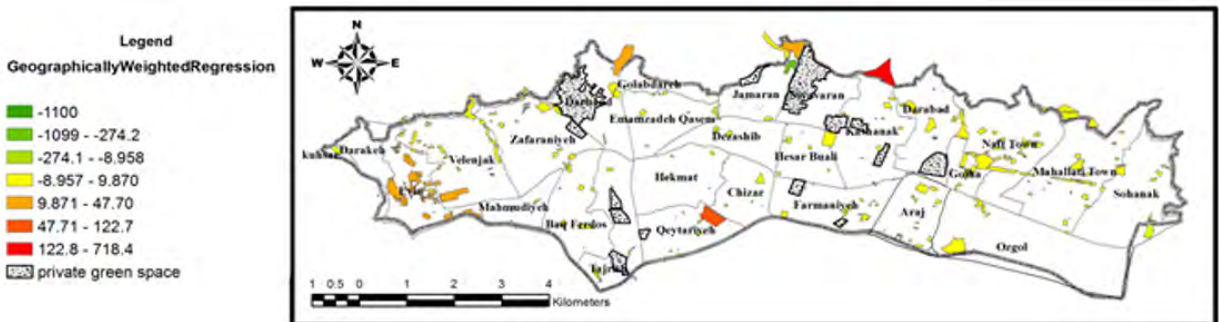Fig. 6: Geographically weighted regression in parks of region 1 of Tehran



Fig. 7: Values projected to increase the general efficiency of parks in accordance with the ASD index

Table 4: The value of indicator LocalR2 , StdError, StdResid of neighborhoods in region 1 of Tehran

| Field | Zaferanie | Dezashib | Darake | Darband | Dar abad | Hekmat | Hesar Bo Ali | Jamaran | Tajrish | Bagh ferdos | Evin | Emam zadeh ghasem | Ozgol | Araj |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Local R2 | 0.9135 | 0.0053 | -1.25 | 0.3654 | -1.1054 | -0.1354 | 0.165 | -1.2648 | -2.136 | -0.0322 | 8.256 | -3.215 | 0.228 | **0.036** |
| StdError | 12468.14 | 8945.24 | 34000.08 | 23449.56 | 5477.41 | 33547.59 | 33760.85 | 33654.87 | 30500.98 | 33650.45 | 34000.54 | 29364.98 | 33521.98 | **33854.45** |
| StdResid | 21 .0 | 0.46 | -0.21 | 0.16 | 1.05 | -0.17 | 0.31 | 0.23 | 0.01 | -0.08 | 0.03 | -0.04 | -0.07 | **-0.05** |

| Field | Golha | Golab dare | Kashanak | Chizar | Velenjak | Hezar sang | Niavaran | Mahmodie | Mahalati | Gheitarie | Farmanie | Shahrak naft | Sohanak | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Local R2 | 0.0046 | 0.351 | 8.603 | 12.456 | 7.658 | -1.224 | 0.003 | 9.41 | 0.2641 | 20.364 | -0.006 | 0.29 | -0.022 | |
| StdError | 33752.65 | 1823.65 | 33752.65 | 33645.21 | 33900.36 | 1932.21 | 1796.32 | 33921.32 | 33189.32 | 2254.32 | 33465.21 | 34111.32 | 33200.14 | |
| StdResid | 0.03 | 0.16 | 0.75 | -0.08 | -0.02 | 0.05 | 0.04 | 0.041 | -0.04 | 2.21 | -0.1 | -0.32 | -0.204 | |

parks in Tehran's Region 1 is large, these values are presented as averages for neighborhoods in the form of Table 4. Here are the parameters of the model and statistics that indicate the model's desirability. The most important values here are $R_2$ and Adjusted $R_2$, which indicate the model's desirability and accuracy. The closer these values are to the value of one, the better the descriptive variables can explain the changes in the dependent variable.

"LocalR$_2$" represents the $r_2$ local weighted values between the observed and fitted values. This statistic shows how accurately the model has been able to estimate and how far the observed values are from the estimates (Fotheringham et al., 2002)." Std Error" indicates the standard error of the residual values."StdResid "Standardized Residual Values - These values have a mean of zero and a variance of one. To understand Figure 3, it should be noted that in parks, the residual values are abnormally high or low. If the values are less than -0.5, the general efficiency of the parks is higher than the ASD, but if the values are more than 0.5, it is the opposite. The higher the deviation from our standard values between -0.5 and 0.5, the greater the severity of the issue and the more unbalanced the situation. In this analysis, any park that has values higher than the remaining values of the high standard (StdResid >3) means that in spatial planning, the population demand for these parks is estimated to be less than their actual value. Figure 4 shows the predicted values of the general performance of the parks and the ASD index in the areas according to the calculated values together. As can be seen, this model has been able to predict the ratio of these two variables to a large extent.

**Finding**

The applications of spatial regression are very wide and are used in urban landscape planning. Spatial regressions can also be used as much as the element of space and place is important. In urban green spaces and analysis of factors affecting the types of parks, the spatial distribution of parks, and access to them, spatial regressions are widely used. A classical regression interrupted in space cannot correctly and accurately determine the relationship between explanatory and dependent variables when the relationship is positive in some parts of the study area and negative in others. The models of urban green areas do not recognize spatial heterogeneity in processes.

In theoretical models, it is necessary to explain the inversion of logic results. Geographically weighted regression is used as a possibility to direct this research and to create a strong and effective tool for the complete analysis of classical regression. In addition, due to its holistic nature, classical regression does not have enough precision in analyzing the linear relationship between independent and dependent variables. Spatially weighted regression is a linear relationship between independent and dependent variables - when the category of space becomes important in the relationships of variables, it acts as a more successful alternative to spatial regression. To increase the accuracy and efficiency of the models built with spatially weighted regression, this research considered the number of independent variables and divided the studied area

into smaller areas.

Figure 4 shows that there are parks in Golab Dareh areas in Region 1 of Tehran that have much wider possibilities than others. According to Figure 4, Gulab Dere Park and Nilofer park have many public facilities compared to others. According to Table 3, the areas where these parks are located do not have ASD compared to others, but Figure 6 shows that these parks have problems coordinating between ASD and GPP. >2.25std Resid Figure 6 shows that the demand for these parks exceeds their efficiency. We notice that with the increase of GPP, the ASD increases, which can be considered unfavorable from the point of view of spatial arrangement. It can be seen that instead of building parks with high facilities, it is better to build a series of parks with functions that are proportional to each other so that the ASD is distributed among them in a balanced way and to avoid centralization. Figure 7 shows that the problem of increasing demand for Nilofer park increases over time, but this problem is more balanced in Gulab Dareh park. Examining and comparing figures 6 & 7 makes it possible to understand which parks need to be planned in the future so that their ASD is balanced with their GPP.

## CONCLUSION

Geographically weighted regression has grown in popularity as a GIS analysis function in landscape planning and development due to rising urbanization in emerging nations due to development goals. There can now be no long-term safeguards for future effects owing to unregulated and unpredictable growth. However, the physical, environmental, and socioeconomic components are the most affected. The planning system appears vital in managing and regulating development processes. GIS provides an integrated user assessment for planning and monitoring urban landscape development.

In response to the main question of this research with the title: Sub-question of this research: Which park's performance index has the greatest impact on the supply and demand of parks? In response to the main question of this research entitled: It can be stated that increasing the efficiency does not necessarily increase the value of the ASD index. According to the findings of this research, in Kashank and Gulab Dareh neighborhoods, with the increase in the general efficiency of parks, the amount of supply and demand increases, while in Naft, Mahalati, Valenjak, and Evin areas, despite the high-efficiency index of parks, their ASD index. And to answer the sub-question of this research, which parks have an abnormal situation between public efficiency and supply and demand index? The results show some parks have high supply and demand while not knowing the required performance. The higher the value, the higher the difference. In parks where this value is more than 2.5 (StdError>2.5), the position of bitumen is considered normal and critical. Values less than -0.5 (-0.5> StdError) indicate parks where supply and demand are less than the general

efficiency of the park.

In many studies in urban parks, spatial weighted regression analysis is used under the influence of space and environment. In such studies, the amount and manner of the effect of space are important, and ignoring the effect of space will lead to errors in estimation, estimation, and prediction. Joint studies with the subject of this research confirm this. This research has used ASD and GPP coefficients to estimate the state of urban parks. Other researchers in this field analyze such issues by using the location data of mobile phones. The analysis of these data uses methods such as fuzzy logic, which requires software knowledge and strong hardware.

On the other hand, access to data requires spending money. Therefore, the present study based on the spatial weight regression model has presented a model for measuring access to urban parks. This model, without the need for mobile data and traffic network, using the coefficient of ASD and GPP, provides accurate measurement compared to the initial models. Presented using the most accessible data.

## ENDNOTES

1. "Availability and Accessibility of Urban Green Spaces in a High-Density City: The Case of Raipur, India"
2. Urban green spaces
3. Park Green Spaces
4. General performance of parks
5. Geographical Weighted Regression
6. Per Capita Park Area
7. GEI
8. PCPA
9. WHO

## AUTHOR CONTRIBUTIONS

H. Ghoddusifar has done the literature review, experimental design, and team management. A. Salehabadi and A.Mohammadpor collected, analyzed, and interpreted the data and prepared the text of the manuscript.

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## CONFLICT OF INTERESt

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