DOKUZ EYLÜL UNIVERSITY

GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

ASSESING THE ADEQUACY OF URBAN GREEN SPACES IN PROPOSED PLANNING DECISIONS USING GIS

by

Feyza ONAY

October, 2016

İZMİR

ASSESING THE ADEQUACY OF URBAN GREEN SPACES IN PROPOSED PLANNING DECISIONS USING GIS

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We have read the thesis entitled **"ASSESING THE ADEQUACY OF URBAN GREEN SPACES IN PROPOSED PLANNING DECISIONS USING GIS"** completed by **FEYZA ONAY** under supervision of **PROF.DR. KEMAL MERT ÇUBUKÇU** and we certify that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.

....

Prof. Dr. K. Mert ÇUBUKÇU

Supervisor

....

Doc. Dr. Muhammed Aydoğan Yrd. Doç. Dr. Görkem Gülhan

(Jury Member) (Jury Member)

Prof.Dr. Ayşe OKUR

Director

Graduate School of Natural and Applied Sciences

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ABSTRACT

In the literature, the adequacy of the urban green spaces have been discussed for a long time. Most of the time, the adequacy of the urban green spaces are tested using per person green areas. Discussing the adequacy of urban green spaces with more parameter is possible, but the adequacy of urban green spaces in proposed planning decisions are evaluated in terms of distribution in this study. The distances from the users are often neglected and accessibility measures are usually based on Euclidean distances. In this study, the distribution of the urban green spaces is measured by using the nearest neighbor distance methods within the framework of point pattern analysis. This measurement is presented in two ways, and two results will be compared. One of the methods is Nearest Neighbor Distance Method which the distance of two points is measured by Euclidean distance and the other method is Network Nearest Neighbor Distance Method which is integrated the real world. This method will be calculated by SANET, the GIS-based tool for spatial analysis along networks. The study is conducted using development plans for Seferihisar, which is a district of Izmir. A total of 11 neighborhoods are present in the Development Plans of Seferihisar and the plan decisions are assessed at the neighborhood level.

In this research, the results from the two nearest neighborhood analyses show that, the distribution of proposed urban green spaces are not uniform or dispersed, which would be the ideal distribution over the cityscape. This finding is valid for both the nearest neighborhood analysis based on Euclidean distances and the nearest neighborhood analysis based on network distances. Consequently, that can be accepted as a failure in planning decisions. In this case, it is revealed that the urban green spaces are planned independently from each other.

Keywords: Distribution of the urban green-spaces, nearest neighborhood analyses, euclidean distance, network distance, Geographical Information Systems(GIS).

İMAR PLANI KARARLARI İLE ÖNGÖRÜLEN KENTSEL YEŞİL ALANLARIN YETERLİLİĞİNİN CBS KULLANILARAK DEĞERLENDİRİLMESİ

ÖZ

Literatürde açık-yeşil alanların yeterliliği uzun yıllardan beri ele alınmaktadır. Çoğu zaman, açık-yeşil alanların yeterliliği kişi başına düşen yeşil alan miktarına göre ölçülür. Yeşil alanların yeterliliğini daha fazla parametre ile ele almak mümkündür. Fakat, bu çalışmada plan kararları ile öngörülen yeşil alanların yeterliliği mekansal dağılım yönünden değerlendirilir. Kullanıcılara olan uzaklık genellikle ihmal edilir ve erişilebilirlik ölçüsü genelde öklid uzaklığına dayanır. Bu çalışmada açık-yeşil alanların dağılımı noktasal doku analizi çerçevesinde en yakın komşu analiz yöntemi ile ölçülür. Bu ölçüm iki farklı yöntem ile yapılır ve elde edilen iki farklı sonuç karşılaştırılacaktır. Uygulanacak olan yöntemlerden biri iki nokta arasındaki uzaklığın öklid uzaklığı ile ölçüldüğü en yakın komşu mesafesi metodudur, diğer yöntem ise gerçek dünyaya entegre edilen ulaşım ağı temelli en yakın komşu mesafesi metodudur. Ulaşım ağı temelli en yakın komşu analiz yöntemi, Coğrafi Bilgi Sistemi (CBS) kaynaklı ulaşım ağı temelli mekansal analiz için geliştirilen SANET aracı ile hesaplanır. Araştırmada İzmir iline bağlı Seferihisar ilçesinin imar planı kullanılarak çalışma yürütülür. Seferihisar imar planında toplamda 11 mahalle ele alınır ve plan kararları mahalle düzeyinde incelenir.

Bu araştırmada, önerilen yeşil alanların dağılımının kentsel peyzajdaki ideal dağılım şekli olan tekdüze veya dağınık dağılım olmadığı en yakın komşu analizlerinin ikisinin de sonuçlarında görülmüştür. Bu bulgu hem öklid uzaklığı temelli en yakın komşu analizi için hem de ulaşım ağı temelli en yakın komşu analizi için geçerlidir. Sonuç olarak, plan kararlarının başarısızlığı kabul edilebilir duruma gelmiştir. Bu durumda açık yeşil alanların birbirinden bağımsız olarak planlandığı sonucu ortaya çıkmaktadır.

Anahtar Kelimeler: Kentsel açık- yeşil alanların mekansal dağılımı, en yakın komşu analizi, öklid uzaklığı, ağ uzaklığı , Coğrafi Bilgi Sistemleri (CBS).

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BACKGROUND

Unplanned development in cities has been occurred because of the industrial revolution and quick urbanization. These unplanned developments have negative influences of cities on people. The required open spaces where people go to lighten the stress load are important to use one's time well and acquire energy.

The urban open-spaces have a vital role to balance at urban areas. They take on a task about entertainment, resting and protection function. The urban green spaces control urban growth and determine degree and direction of the urban growth (Etki 2002; Müftüoğlu 2008). Generally the urban open-spaces comprise a whole and combine with each other at cities. Because of this reasons, the urban open-spaces generate and form a physical structure. Also the fields are equilibrant to combine other usage of place (Alkay & Ocakçı, 2003).

As a consequence of these explanations, urban open-spaces are essential. We can summarize their purposes as follows:

- Generating and reestablishing natural balance,
- Partially preventing air pollution,
- Giving the community an opportunity for resting and entertainment,
- Talking about requisiteness aesthetically.

When the urban open-spaces are taken into consideration about the city growth, the distribution of the fields is too important. Development plans aim to control the growth of the city. Distance to the urban open-spaces should be accessible and the green spaces should be distributed in a rational way. Within this scope, spatial statistical analysis method can be used for probing distribution of green area. So, reaching to clear result is possible.

1.1 The Concept of Urban Green Area

The green spaces are that where people take advantage of recreational usage, social communication, and public health. Besides of healthy environment, there are many factors that people come to a condition of recreation are behaving according to needed of physiologic recreation and benefit from presented opportunities of open/green space. Because of that, specially designed green spaces which people come to a condition of recreation by the help of them, are centerpiece of community facilities (Ergin, 1989).

When people move away from nature due to industrialization, concomitant urbanization and increasing building density, open/green spaces provide contacting the nature again, continuation and progress to people. Concordantly, first of all, the concept of urban green spaces should be identified. According to Keleş (1977) an urban green area is a part of the settlement, a natural space, and segregated part of city for recreation. An urban green area is unbuilt and suitable for recreational usage (Gül & Küçük, 2001).

According to Alexander (1977), green spaces can be categorized two under classes. These are negative and positive open-space areas. When the gap between the buildings is shapeless, it means that the area is negative. In the exact opposite situation, the area is described as positive (Figure 1.1). In negative areas, the buildings are figures, and open space area is a background. The most distinct difference between negative and positive areas is how people feel when they spend in these areas. After testing, it has been observed that people feel comfortable in positive areas. However, in negative areas, they feel uncomfortable and they do not want to use it (Kap, 2006; Müftüoğlu, 2008).

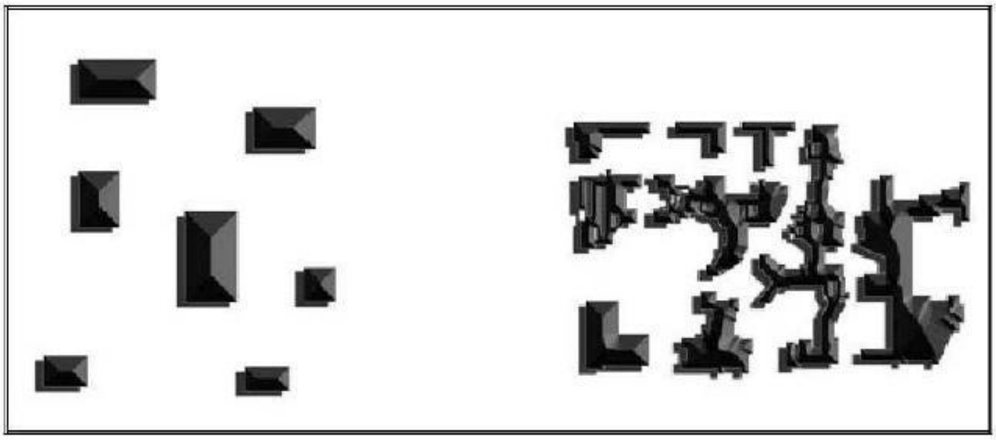

Figure 1.1 Defining of open space (Kap,2006)

Open green spaces play an important role in the urban areas, and generally undertake entertainment and relaxation functions in the neighborhoods. On the other hand, it undertakes protection function in the city, and affects the pattern of the city. Furthermore, regional open green spaces create prolongation of rural. They prevent the urban growth, as well as determining degrees and direction of urban growth, so nature protection function comes to the forefront in regional open green spaces (Etli, 2002; Müftüoğlu, 2008).

In urban areas, generally open space and green space complete each other. Open green spaces as basic space usage, present and form the physical structure of the city. They integrate and balance the other urban usages (Alkay & Ocakçı, 2003). Their functions can be summarized as follows:

- To constitute and reorganize the natural balance,
- To create buffer for air pollution,
- To enhance public health,
- To provide opportunities for relaxation and entertainment to people,
- To improve urban esthetics.

Scale, distribution, and variety are distinctive characteristic of open green spaces, so it means that system of open green spaces can be formed to balance between different aims and preferences.

1.2 The System of Green Spaces

The design of the system of green spaces is largely related to their spatial continuity. The spatial continuity means uninterrupted connection, succession, and joining. Table 1.1 shows the differences in the properties of spatial continuity and non-continuation.

Table 1.1 Differences in properties of spatial continuity and non-continuation (Kahraman, 1998)

Spatial Continuity	Spatial Non-Continuation
succession	disconnectedness
series creation	breaking
union	diffuse
linear growth	haphazard growth
correlativity	irrelation
order	chaos/complexity

According to Wright (1976), when urban green spaces are planned, their relation with each other should be taken into consideration. According to the planners, this continuity visually and physically provide easiness and safety in usage, enable the user cross one from another easily and safely. Corridor of the urban green spaces creates areas for walking, bicycling and running (Değirmencioğlu, 1997).

Whyte (1968) criticizes this point of view and argues that the dispersed urban green spaces are better. Interconnecting the open spaces provides the meronymy better. It is argued that the physical continuity is not a critical subject, and a continuous system of green spaces is unnecessary.

Accessibility to green area is a more important subject in designing urban gren areas rather than continuity. Thus whether continuous or not a system of green spaces is required in planning. We can sort the system of urban green spaces physically and spatially as follows: (1) green belt, (1) green wedge, (3) green network, and (4) green heart.

1.2.1 Green Belt

The Green Belt is developed on the propose of avoiding the troubles which show up after urban development. In this theory, around of the settlement has green belt and there are two models of city; one of them is central city and the the others are its satellite (satellite city). Such as this system of urban green space, in the ancient period, around of the settlement had open space area. People use this area for recreation, sport, game and public activity (Değirmencioğlu, 1995; Albayrak, 2006; Müftüoğlu, 2008).

The concept of green belt is based on the garden city which was planned by Ebenezer Howard (Figure 1.2 and 1.3). According to Lewis Mumford, this concept contributes the planning discipline. In this system of urban green spaces, the primary objective is keeping down the unplanned development and avoiding the join with neighbour settlement.

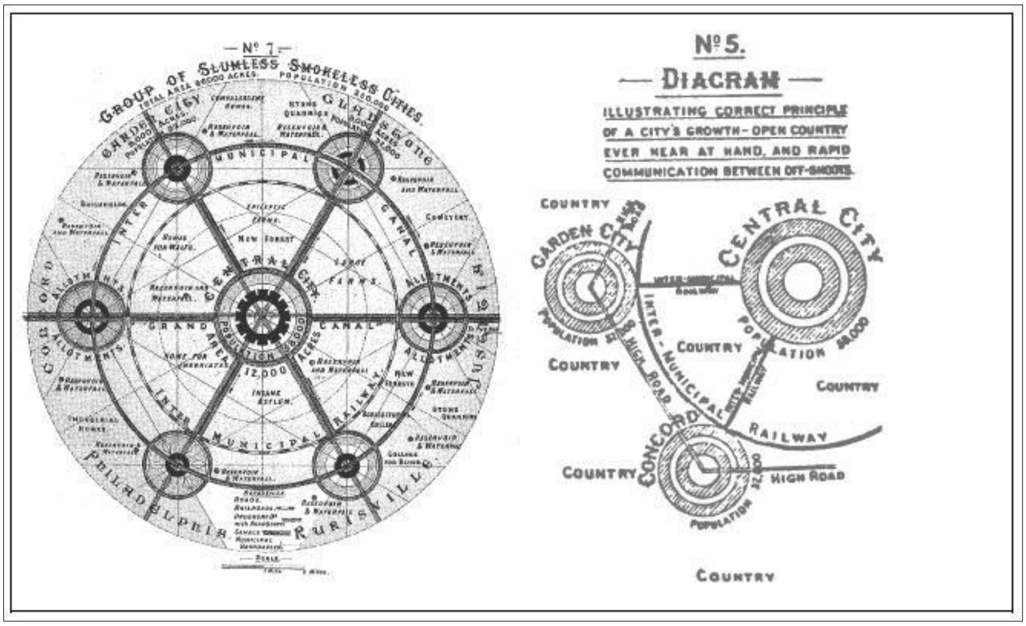

Figure 1.2 The original Garden City concept by Ebenezer Howard (Ward & Hall, 1998; Yeşil, 2006).

The basic principle of green belt planning is sorted as follow;

- To be formed the boundaries and form of the green belt by the natural system,
- Ecologic and integrative planning approach,
- To provide the sustainability between urban and rural areas,
- To keep the balance between resource and space usage (Çulcuoğlu, 1997).

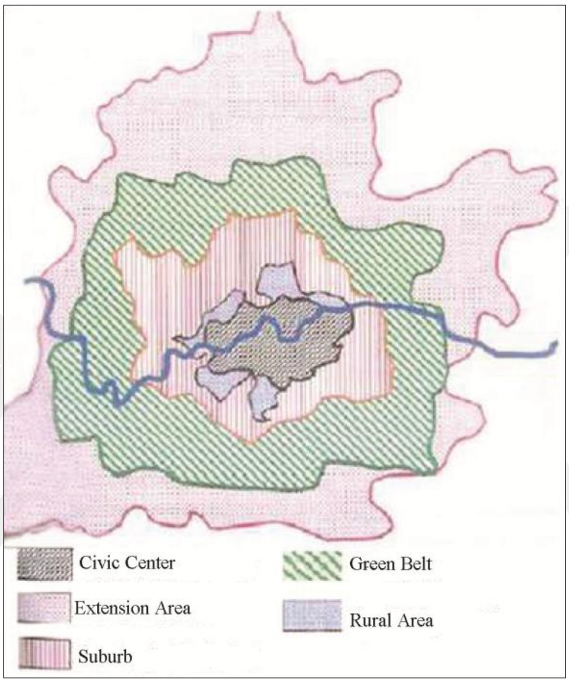

Figure 1.3 The plan of London; green belt (Öztan, 1968; Değirmencioğlu, 1998; Albayrak, 2006; Müftüoğlu, 2008).

1.2.2 Green Wedge

The Green Wedge consists of star city form and it is created depending on linear habitat as stream and valley, so accessibility ratio of the green wedge is higher than The Green Belt. Wedge generation generally expand from rural areas to the city center (Figure 1.4).

In the system of Green Wedge, when the green bands and the green corridors expand from environment to the settlement, the green spaces interlock and connect the rural areas to the city (Çalışkan, 1990).

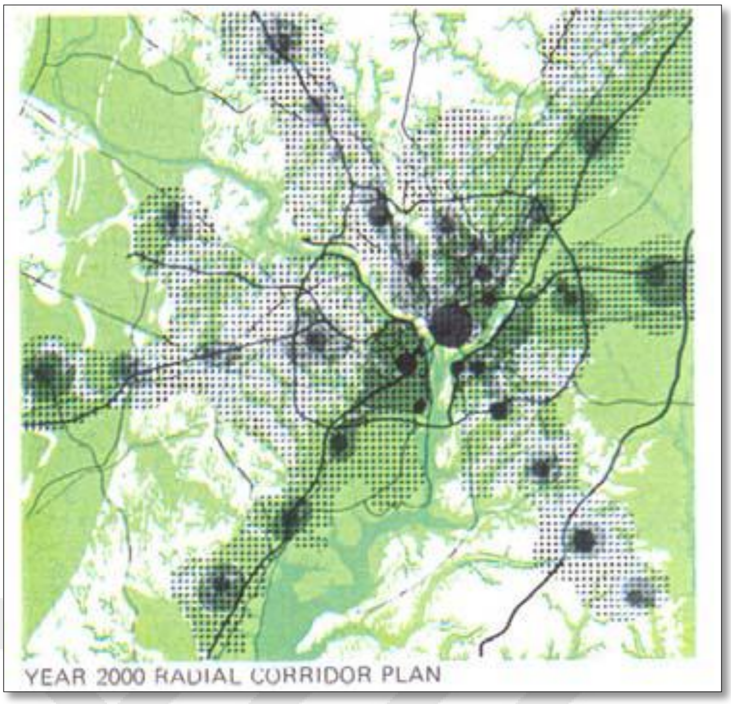

Figure 1.4 The radial corridor plan of Washington (Mc Harg, 1969).

In this system of green space, the growth direction of settlement is determined before planning the green spaces and these areas are brought under control with green spaces. These green wedges avoid the urban development as well as supplying the necessity of recreation area (Uzun, 1987; Çalışkan, 1990; Müftüoğlu, 2008).

1.2.3 Green Network

This system is created for the settlement which has grid form. The main idea is that distribution of the green spaces is uniform in the city. The roads have grid form at the same time, so users can reach the green spaces from all over the city (Figure 1.5). On the other hand, the rural areas are located inside of the green network as in wedges (Tazebay, 1991).

The green network system has five basic principles as follow;

- It is located in the riverside and it can be located in the lakeside and seaside at the same time.

- It should be used for recreation.

- It should include ecological corridors.

- It should include landscape and historical objects.

- It must have a large area.

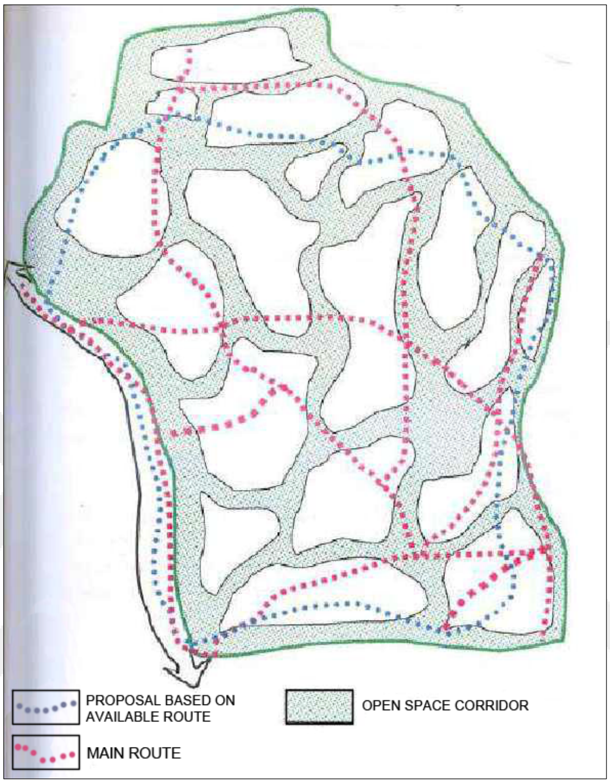

Figure 1.5 Green network (Lewis 1966; Değirmencioğlu 1995; Albayrak 2006).

1.2.4 Green Heart

The green heart system interlock the cities locally. In this system, the cities take place around the central open-space. This system is a multi-centered planning concept which interlock the large cities; for instance, Rotterdam, Hague and Utrecht/Holland. But unfortunately the urbanization trend had become in the green heart of Holland day by day, up to 1970. Then, the idea of creating a large open space in the city center shows up; for example, Central Park of New York (Kühn, 2003; Öztürk, 2004; Albayrak, 2006).

1.3 Point Data Based Spatial Statistic

Limited natural resources and increasing population affect the decision of choosing locations for different urban functions in the settlement. Thus examining the distribution of the exiting uses becomes essential. Point pattern analysis is a powerful tool in analyzing point distributions over space. It is defined within the general spatial statistics framework.

In this approach, at a global or continental scale, geographic objects or events are represented as points on a map. Spatial distributions can be analyzed using three different methods, as a part of the point pattern analysis. These methods are quadrat analysis, nearest neighbor analysis and spatial autocorrelation. All methods evaluate the spatial distribution in different ways, to answer different questions.

In point pattern analysis, scale and extend are very important. A proper geographic scale is needed to choose for analysis. This is because geographic objects may be represented differently at different scales, depending on how they are treated. Before starting the search, determinate to what extend the area surrounding the geographic objects is the second necessity. Another issue is the projection. Objects can be distorted in many ways, including area, shape, direction and distance. Both area and distance are used extensively in the analysis of point patterns. In quadrat analysis, the density of points is affected by the size of the study area. In nearest neighbor analysis and spatial autocorrelation, distance between the points play an important role (Lee & Wong, 2001).

1.4 The Methods Used About Distribution Of Urban Green Spaces

We can categorise the methods used for examining the distribution of urban green spaces as follow: (1) Remote sensing and GIS Approach, and (2) the network analysis. This chapter contains examples of studies conducted using these methods. Below, some example studies are presented. One of the studies used remote sensing and GIS approach, and the others apply the network analysis approach.

- **Colombo Municipal Council Area Study: An example for Remote Sensing and GIS Approach**

The distribution of urban green spaces can be examined with different methods, and a common one is using remote sensing. Senanayake, Welivitiya and Nadeeka (2013) study urban green spaces for development planning in Colombo, Sri Lanka. Colombo Municipal Council Area was selected because of rapidly growing population with a serious air pollution problem. At first, green space areas were extracted from Thailand Earth Observation System (THEOS) satellite imagery using Normalized Difference Vegetation Index (NDVI). Then extracted green space areas were analysed with air quality indicators (SO2 and NO2 concentration) and population density. By using these indicators, air quality distribution map, green space distribution map and green space per capita map were prepared. Results of air quality distribution map were integrated with both green space per capita map and green space distribution map.

This study reveals that how can be balanced the environmental quality, in the city which was produced by the help of overlapping the maps which were created with indicators. Consequently, the results affect the decision of spatial use in the future development planning.

- **Edmund Green in Leicester Study: An example for The Network Analysis Approach**

Another method of examining the distribution of urban green spaces is network analysis. This method is applied for determining the urban green space accessibility for different ethnic and religious groups by Comber, Brunsdon, and Green in Leicester/England (2008).

In this study the natural green space accessibility standards were specified as:

- No person should live more than 300 from their nearest area of natural green space of at least 2 ha in site (Rule 1),

- There should be at least one accessible 20 ha. site within 2 km. distance from home (Rule 2),
- There should be at least one accessible 100 ha. site within 5 km. distance from home (Rule 3),
- There should be at least one accessible 500 ha. site within 10 km. distance from home (Rule 4),

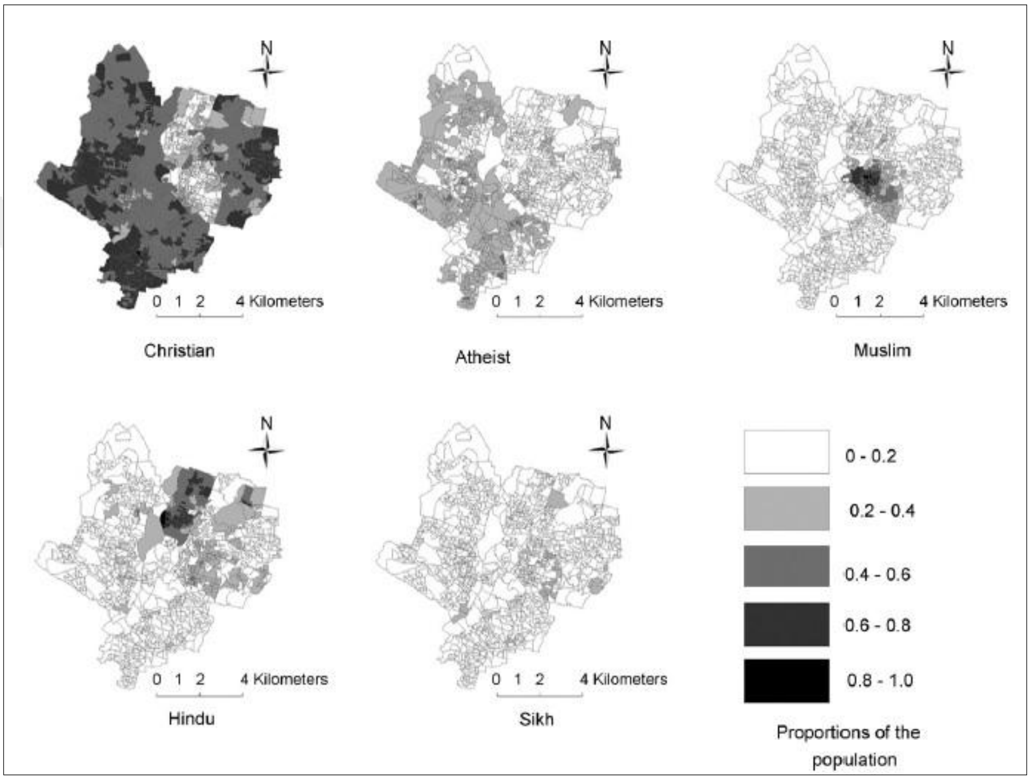

Figure 1.6 The distribution of the major religious groups in Leicester, (Comber, Brunsdon & Green, 2013).

With these standards, the accessibility to green spaces for different religious and ethnic groups were questioned (Figure 1.6). The network analysis was conducted by using SANET which is tool of ArcGIS, and a Poisson regression model was implemented (Figure 1.7).

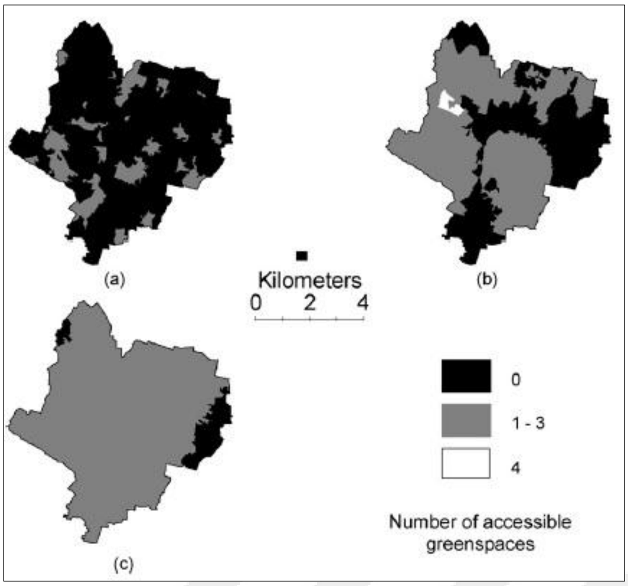

Figure 1.7 The distribution of access to greenspaces in Leicester (a) Rule 1, (b) Rule 2 and (c) Rule 3 (Comber, Brunsdon & Green, 2013).

The other example of network analysis model is the study of accessibility to green spaces using GIS based indicators for sustainable planning in a dense urban context by La Rosa (2013). In this study, the distribution of green spaces is approached with accessibility. There are two indicators. The first is the simple distance indicators (count the number of services e.g. green spaces, hospitals, other urban services), and the second is the proximity indicators.

In simple distance indicators, people/users can have access to particular open spaces. In the second proximity indicators, the distance is calculated from the location of people/users to the open spaces. These indicators are calculated based on Euclidean distance and road network distances. All accounts are calculated by the help of Spearman's rank correlation. La Rosa (2013) concludes that when network distances are used the results are more precise.

Lwin and Murayama (2011) focused on the modeling of urban green space walkability in the United States, Canada, and the United Kingdom. The purpose of the survey is to propose an integrated methodology to model urban green space walkability, so it helps to form an eco-friendly place to live and to choose a route for green exercise. As a result, it is concluded that the distribution of urban green spaces is so important in this disquisition.

The quality of eco-friendly living places is measured by an indicator of walkability score. It is calculated with walk score which is based on green spaces. By this way, three different modalities are proposed to measure the greenness score of urban locations. These greenness score is measured by the help of a web-based platform called “Interactive Park Analysis Tool”. It is a part of “the Green Vision Plan for 21st century Southern California” project which is implemented by Ghaemi Swift (Lwin & Murayama, 2011). In this study, a 10 m. buffer is added both sides of the road, and the greenness score is computed based on the green image which is converted from the high-resolution ortho-image by the help of remote sensing software. Next, a topological road network model is built by VDS technologies (Figure 1.8 and 1.9). The greenness score attribute field is used as a weighted factor to compute the shortest or greenest route between the points.

Figure 1.8 Graphical user interface of the eco-friendly walk score calculator (Lwin & Murayama, 2011).

In this study, an integrated methodology for identifying an eco-friendly place is presented. This web-based and eco-friendly walk score calculator provides users to choose a route for green exercise, to find nearest facilities, to drive and walk routes, to choose an eco-friendly place to live. At the same time, this study can help city planners and policy-makers to build sustainable eco-cities.

Figure 1.9 Get score by user-defined address and default search radius of 250 m. (Lwin & Murayama, 2011).

1.5 The Importance of The Study

In the literature, the adequacy of the urban green spaces have been discussed for a long time. Most of the time, the adequacy of the urban green spaces are tested using per person green areas. The distances from the users are often neglected and accessibility measures are usually based on Euclidean distances.

In this study, the distribution of the urban green spaces is measured by using the nearest neighbor distance methods within the framework of point pattern analysis. This measurement is presented two ways, and two results of will be compared. One of the methods is based on Euclidean distances, and the other method is based on the network nearest neighbor distances. Research on the comparison of Euclidean distances and network distances are limited in number.

Sander et al. (2010) concludes that Euclidean distance is commonly used distance calculation, but this may not be the ideal way of since individuals travel along roads or sidewalks network. Vector-based road-network distances can match accurately to human perceptions of access to open spaces, because it measures the road distance. This research aims to show whether Euclidean distances are sufficient to study the distribution of urban green areas or network distance models are required. In this study the plan decisions are analyzed, rather than the built green areas.

1.6 The Stages of Study

The basic steps of study are the following: (a) Identification of the dispersion of the urban green spaces, (b) assessment of the distribution of the urban open spaces areas by using Euclidean distances and network distances, (c) comparing the two different methods of the measurement of the dispersion of the urban green spaces**.**

The study has five chapters. First, the concept and system of urban green spaces are described. Chapter two involves the modeling methodology including nearest neighbor distance methods in point pattern analysis and spatial analysis along networks (SANET). The database information used in this study is explained in the third chapter. The essential data is 1/1000 scale Development Plan for Seferihisar. The analysis and results of the study is presented in the fourth chapter. Two different analyses which are conducted and their results are compared in this chapter. Finally, all applications of the study are evaluated in the fifth chapter and current situation in the development plan is interpreted according to the results of the study (Figure1.10)

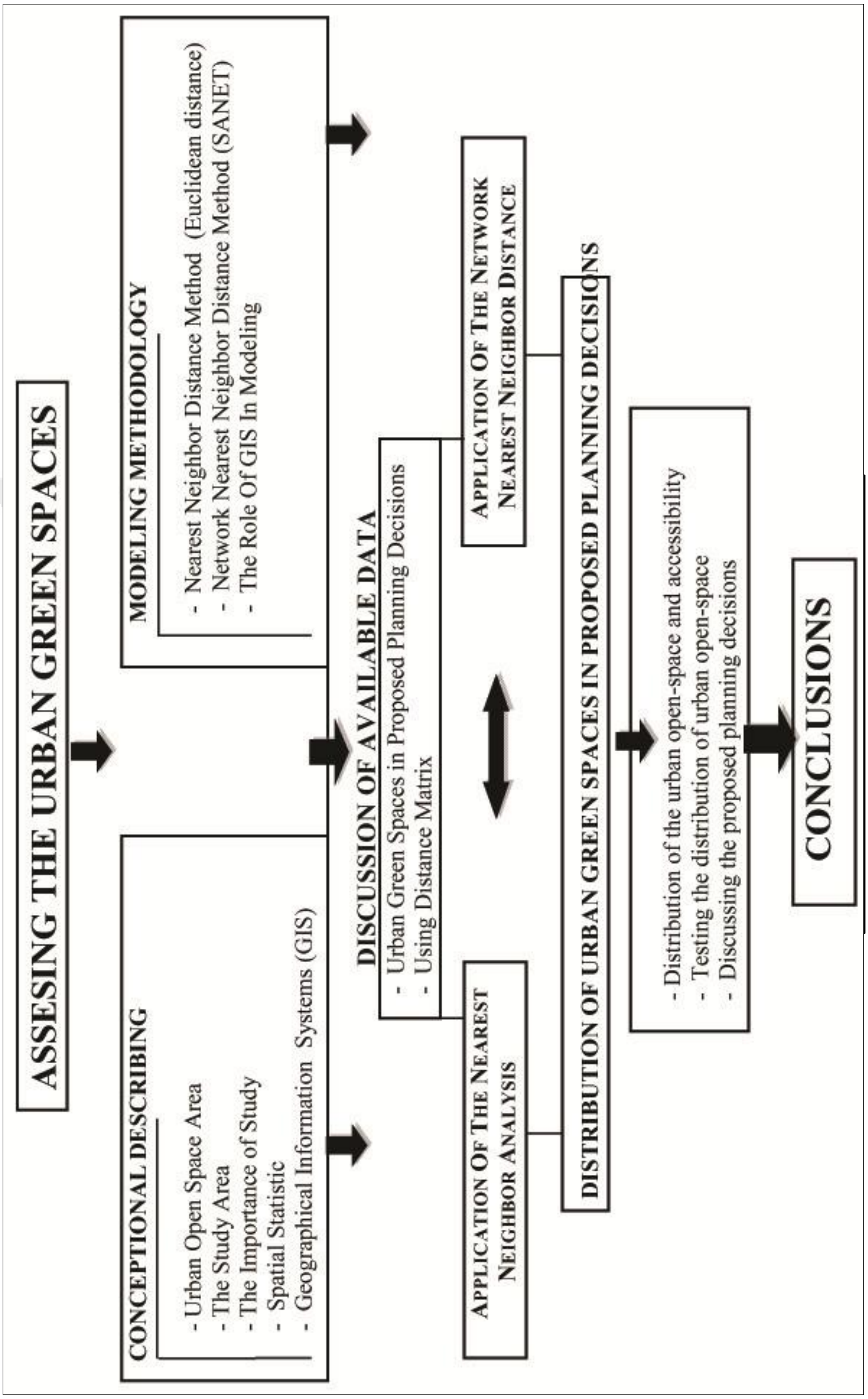

Figure 1.10 Flow chart.

1.7 The Study Area

The study is conducted using development plans for Seferihisar, which is a district of Izmir (Figure 1.11). Seferihisar is about 386 km^2 in size, and it has a population of 36 335. There are a total of 11 neighborhoods within the development plan boundaries. These neighbourhoods are; Atatürk, Camikebir, Çolak İbrahim Bey, Cumhuriyet, Düzce, Hıdırlık, Payamlı, Sığacık, Tepecik, Turabiye, and Ulamış (Figure 1.12).

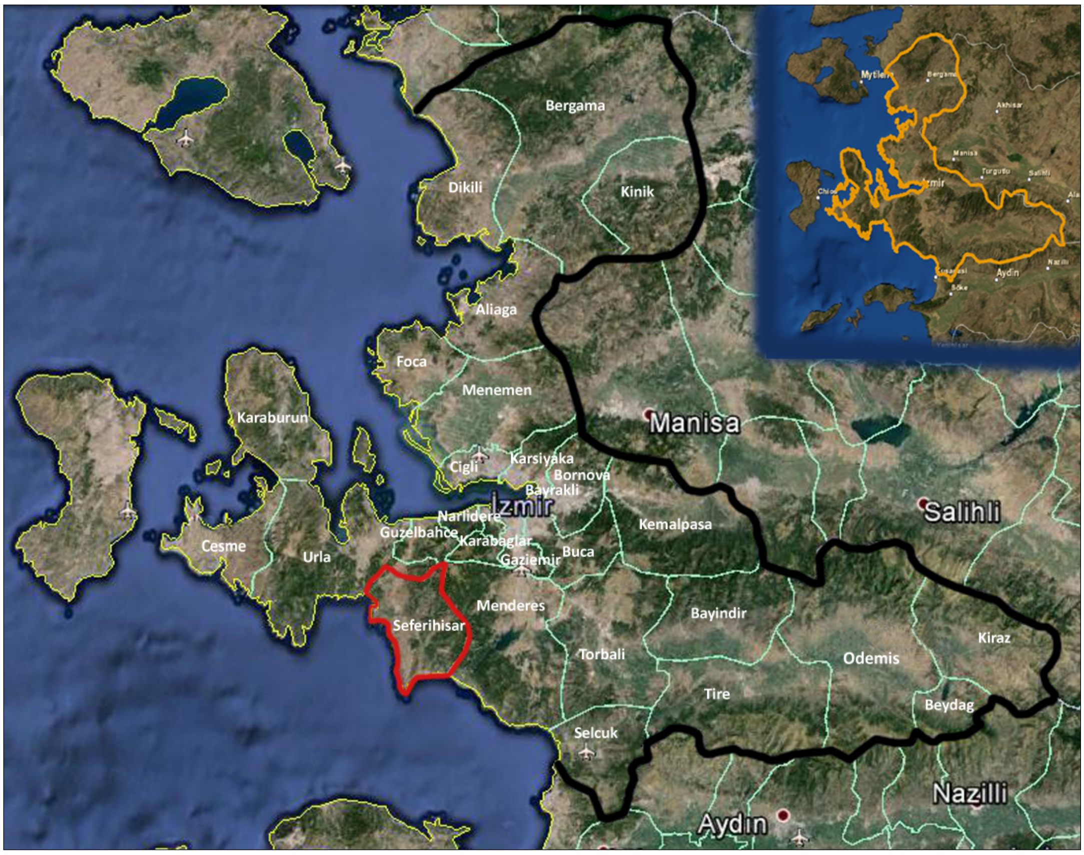

Figure1.11 Satellite images of İzmir metropolitan area in 2015 - Google Earth (Izmir Metropolitan Municipality, n.d.).

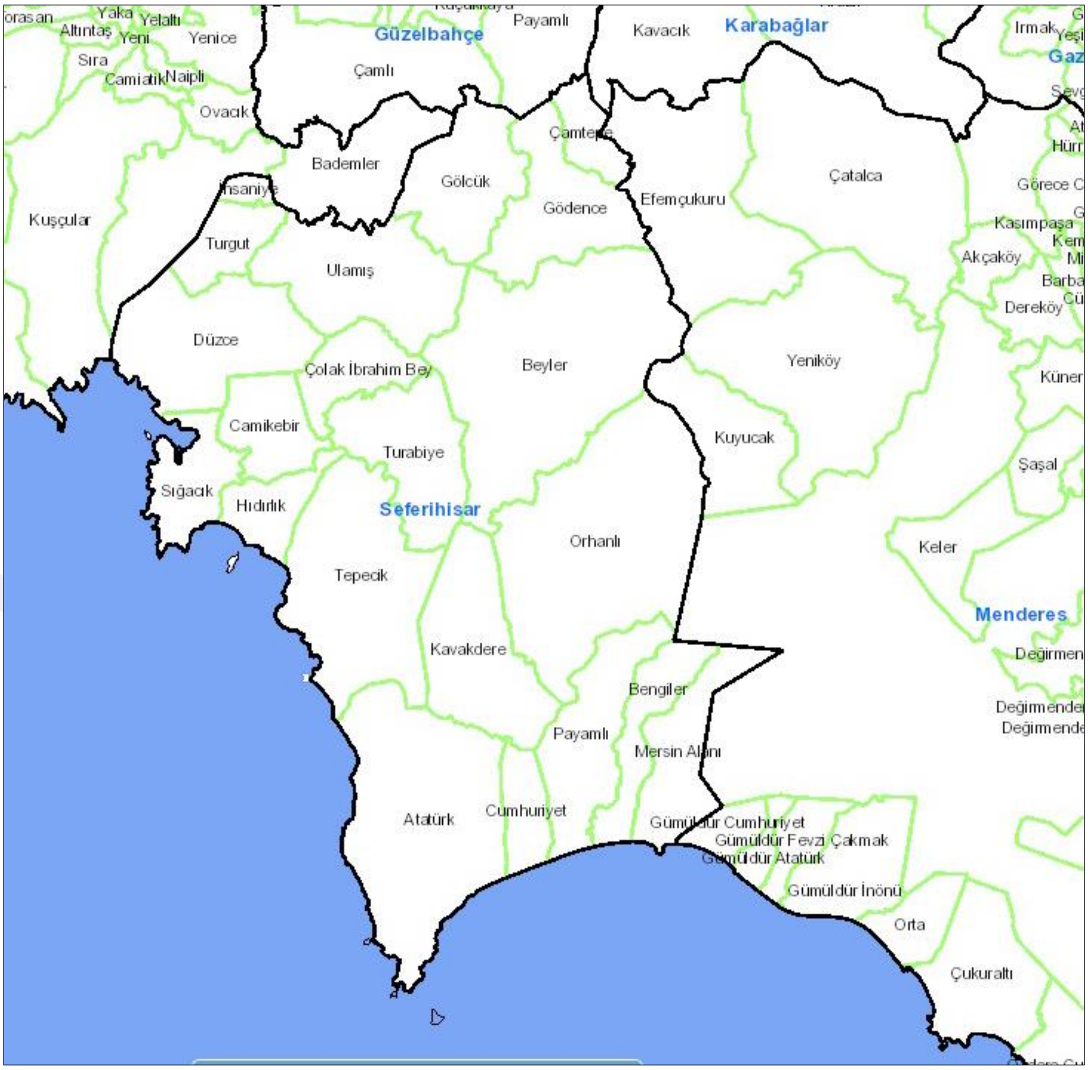

Figure 1.12 The neighbourhoods of application areas (Izmir Metropolitan Municipality, n.d.).

In these study, Point Pattern Analysis, which is one of the Spatial Statistical Analysis Methods, are used. One of the methods is Nearest Neighbor Distance Method which the distance two points is measured by Euclidean distance and the other method is Network Nearest Neighbor Distance Method which is integrated the real world. This method will be calculated by SANET, the GIS- based tool for spatial analysis along networks.

CHAPTER TWO
MODELING METHODOLOGY

In this chapter, three categorized topics which are presented: nearest neighbor analysis using Euclidean distances, spatial analysis along networks, and the role of geographical information systems (GIS) in modeling.

2.1 Nearest Neighbor Analysis Using Euclidean Distances

The Nearest Neighbor Statistic was first described by two botanist, Clark and Evans in 1954. Their basic aim was that to explain the pattern of distribution of population of plants and animals. By the help of the quantitative analysis, interpretation of dispersion patterns would be facilitated. In the formation of particular patterns, various of mathematical models were developed with hypothetical data.

In the earlier studies, measurement of distance was based on different researches. One of them was forecasting the variability of the distance and the other one was revealing the average distance between trees which were randomly selected in a forest. After these applications, the method which was measured the distance between randomly selected individual and its nearest neighbor was first used. Then this model supported the discovery of non-randomness in spatial pattern. A formula was derived from these experiences. Thus, the mean expected distance between nearest neighbors was revealed by the formula. In this situation, the important thing is that assumption of measurement was in a random distribution of specified density. The other important thing is that how we explain the random distribution. It means that all points in the area have the equal chance and the location of each point is not affected by any other point (Clark & Evans, 1954).

Boundaries of the selected space should be chosen carefully for meaningful results, as randomness correlates with boundaries of the space. All points in the specified area can be random, but if the investigators select the area which is larger and includes the specified area, all points can be non-random (Clark & Evan,1954).

The value of the observed mean distance to the nearest neighbors and the mean distance which may be expected if the observations are assumed to have random distribution are calculated. The ratio of the observed mean nearest neighbor to the expected mean nearest neighbor present that if the observed distribution approaches or departs from random expectation (Clark & Evan, 1954). After determination of the type of the distribution, significance is tested statistically.

Nearest Neighbor Statistic is derived from the average distance between points and each of their nearest neighbors. The nearest neighbor problem involves determining the point in a data set that is nearest to a given query point. The nearest neighbor analysis is based on the comparison of the observed average distance and the expected average nearest neighbor distances for a known pattern. This method has been developed based on stochastic point processes on a plane.

To test if the distribution has any recognizable pattern, R-statistic is used for randomness. The R-statistic is the ratio of observed average distance between nearest neighbor of a point distribution and the expected average nearest neighbor distance (Lee & Wong, 2001). It can be calculated as:

$$R=\frac{r_{obs}}{r_{exp}} \tag{2.1}$$

*" If in a population of N individuals having a specified density **p**, the distance **d** from each individual to its nearest neighbor is measured, the mean observed distance may be represented as,*

$$d=\frac{\sum_{i=1}^{N} di}{N} \tag{2.2}$$

The mean distance which would be expected if this population were distributed at random, r_{exp}, *can be shown to have a value equal to"* (Clark & Evan, 1954, p.447),

$$r_{exp} = \frac{1}{2\sqrt{n/A}} \tag{2.3}$$

In this formula, *A* is the study area, and *n* is the number of points.

The R scale ranges from R=0 which indicates completely clustered, to R=1 (random) and to R=2.149. R=0 means that all points are located at the same location (Figure 2.1). When R=1 or approximately 1, it means that $r_{obs} = r_{exp}$ and the pattern being tested should therefore be a random pattern. When R=2 or more, the patterns display various degrees of dispersion (Lee & Wong, 2001).

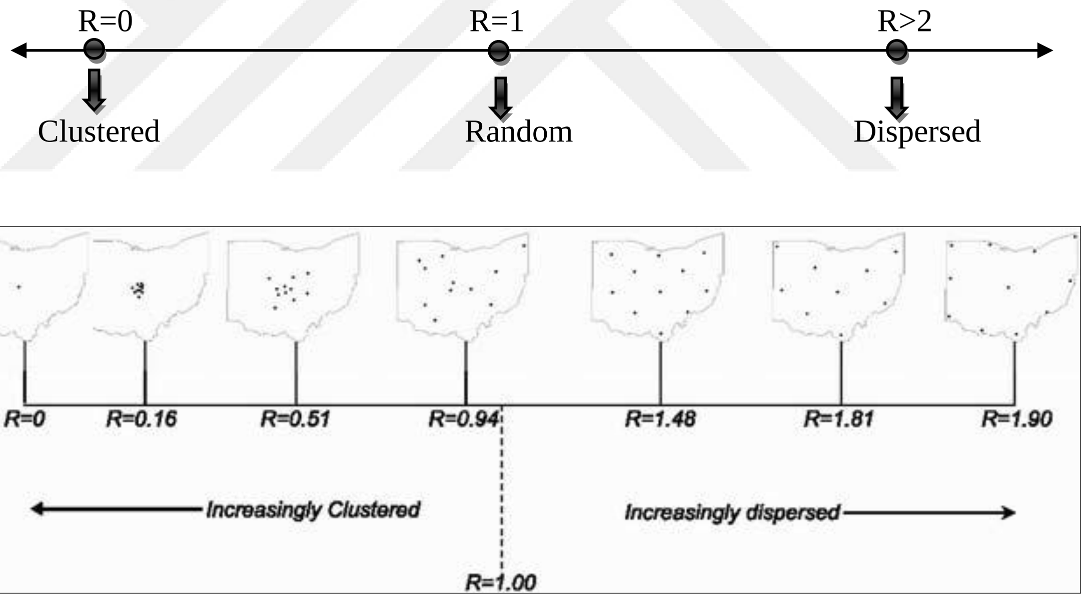

Figure 2.1 The scale of R statistics (Lee & Wong, 2001).

In spatial statistics, especially in point pattern analysis, the distribution of points is illustrated differently. We can classify it under the three main topics (Figure 2.2):

- *Random*, any point is equally likely to occur at any location and the position of any point is not affected by the position of any other point.
- *Uniform*, every point is as far from all of its neighbors as possible.

- *Clustered*, many points are concentrated close together, and large areas that contain very few, if any, points.

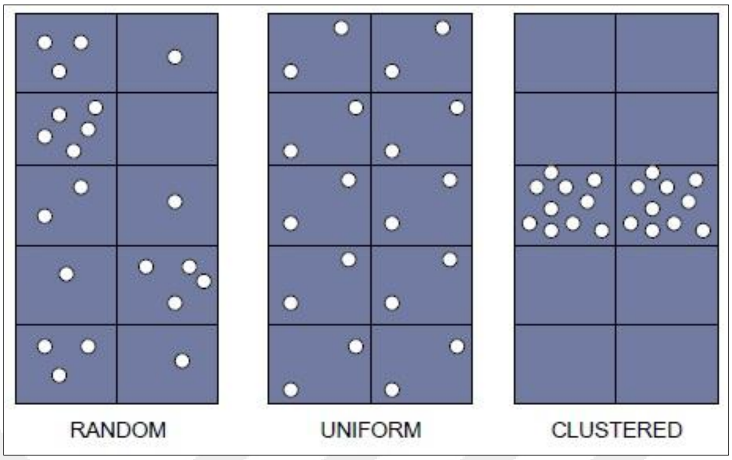

Figure 2.2 Distribution of points.

After indicating the sort of distribution, the question is that how reliable is the result statistically, answered. The formula used in the test of significance is,

$$Z_R = \frac{r_{obs} - r_{exp}}{SE_r} \tag{2.4}$$

To calculate the standard error (SEr) of the difference between the observed and expected average distances for the nearest neighbor statistic, we use the following equation,

$$SE_r = \frac{0.26136}{\sqrt{n^2/A}} \tag{2.5}$$

If Z_R (Z-statistic) > 1.96, it means that the results are statistically significant at the %95 level. Consequently, If Z-statistic > 0, the distribution of points is said to be clustered. On the other hand, If Z-statistic < 0, we conclude that distribution of point is dispersed.

2.2 Spatial Analysis Along Networks (SANET)

In our increasingly global twenty-first century, maps (and geographic knowledge) have become ever more important. Geographic information systems (GIS) is the one of the tools that make use of digital spatial data. Geographic information systems (GIS) can be defined as "*a system of hardware, software, data, people, organizations and institutional arrangements for collecting, storing, analysing and disseminating information about areas of the earth*" (Dueker & Kjerne, 1989, p. 7 - 8; Chrisman, 1999, p. 178).

GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps. In the study, data management is provided by using Geographic Information System (GIS), especially Spatial Analysis on a Network (SANET), tools for GIS.

SANET provides a collection of ArcGIS-based tools for analyzing events that occur on or alongside a network and it's developed by SANET Team (Leader Atsu Okabe). It involves some Spatial Statistical Analysis tools. One of them is the Global auto nearest neighbor distance method.

In the literature, events or facilities are represented by point on the plane and the distance two points is measured by Euclidean distances. This method is called planar spatial methods and spatial analysis with such methods planar spatial analysis (Okabe et al., 2006).

Developers of SANET assumed that the real world is represented by a network embedded on a plane, events or facilities are represented by points on the network. In this method which is called network spatial method, the distance between two points is measured by the shortest-path distance. The most important advantage of using SANET is that the real world can be defined properly (Okabe et al., 1995).

Global auto nearest neighbor distance method is a spatial statistical analysis tool developed within the SANET framework. This tool examines whether or not the points are clustered or dispersed using network data. In this approach, the null hypothesis is that the points are randomly and independently distributed according to the uniform distribution over the network (SANET Team, 2013).

2. 3 The Role of Geographical Information Systems (GIS) in Modeling

The spatial-measurement, proximity-analysis, and network-analysis functions in GIS can support the calculating the straight-line distance and shortest path. Moreover, GIS provides flexibility for the calibration of accessibility measures by the parameter values and different datasets (Liu & Zhu, 2004).

GIS directs planar data and attribute data in an integrated mode, which provides opportunities spatial data to be controlled in all directions. Its advantages are sorted as follow; calculating, visualizing, creating data, handling relations and understanding processes. GIS can overcome the difficulty of enormous amounts of geographical calculations, such as measurements of distance and area. For example, a number of indices including road distances, time, cost and psychological indices can easily and quickly be calculated by using GIS. The other powerful ability of GIS is visualization. Visualization is also useful for improving the spatial thinking (Murayama & Thapa, 2011).

GIS tolls are widely used in this study for two reasons. First is to calculate the distance between the urban green spaces required for calculations and statistical tests. Second is to visualize the results of these measurements. The software of GIS used is ArcMap version 10.

CHAPTER THREE

DATA

The third chapter explains the data used in the study. The essential data sources is the 1/1000 scale Development Plan for Seferihisar. Transportation network and dispersion of urban open spaces are obtained from the Development Plan. In other words, the proposed planning decisions are examined rather than the built green areas. The distance matrix for the urban green spaces are thus derived from the Development Plan decisions.

3.1 Development Plan Decisions for Seferihisar

The Development Plan of Seferihisar, had been prepared by urban planners in different times. Therefore, all plans were joined to achieve the comprehensive planning decisions. Figure 3.1 shows the transportation network and distribution of green open spaces at the 1/1000 scale Development Plans of Seferihisar. A total of 11 neighborhoods are present in the Development Plans of Seferihisar. The plan decisions are assessed at the neighborhood level. Figure 3.2 and 3.3 shows the transportation network and topography of study area, as below.

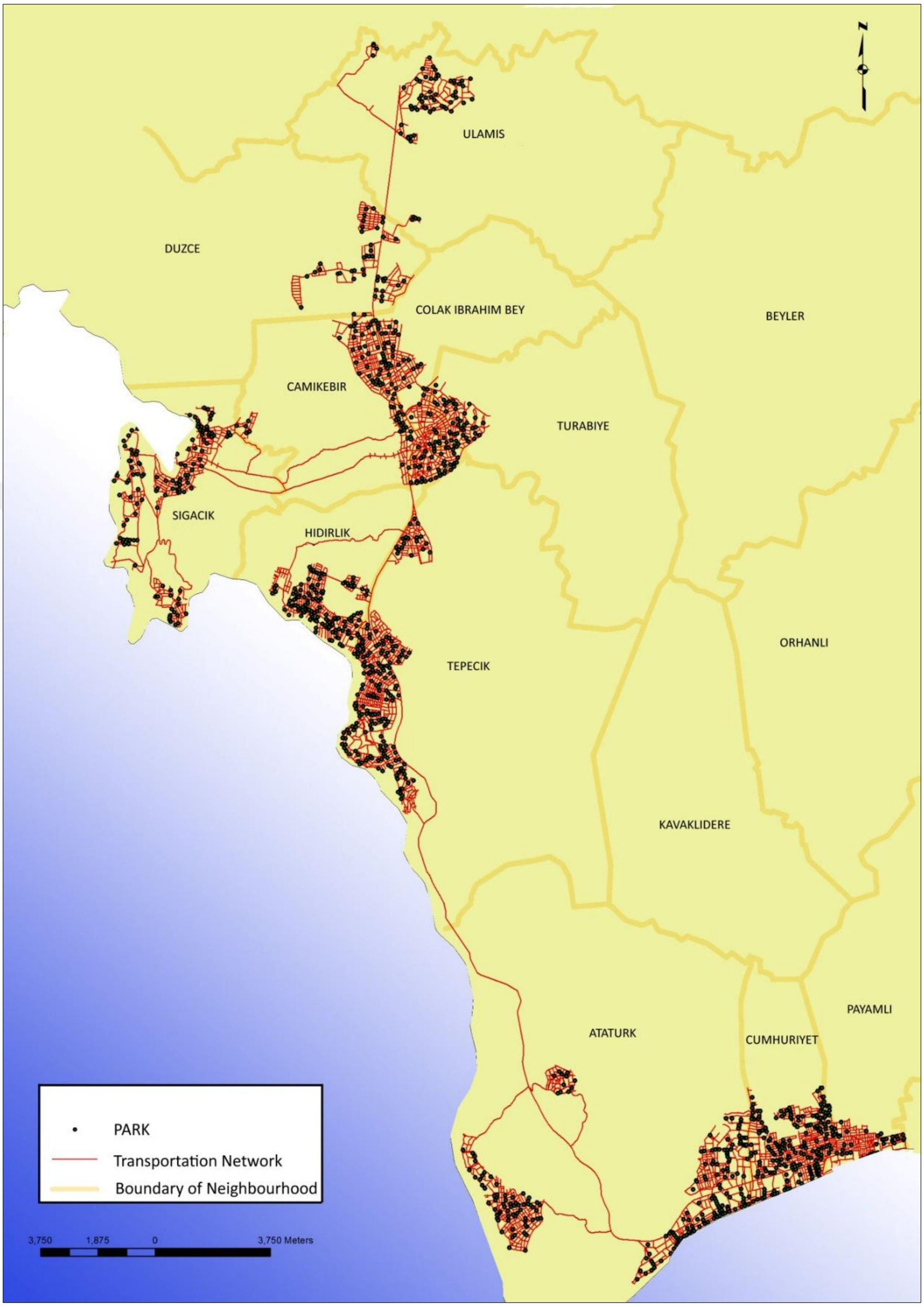

Figure 3.1 Transportation network and dispersion of urban open spaces at Implementary Development Plans of Seferihisar.

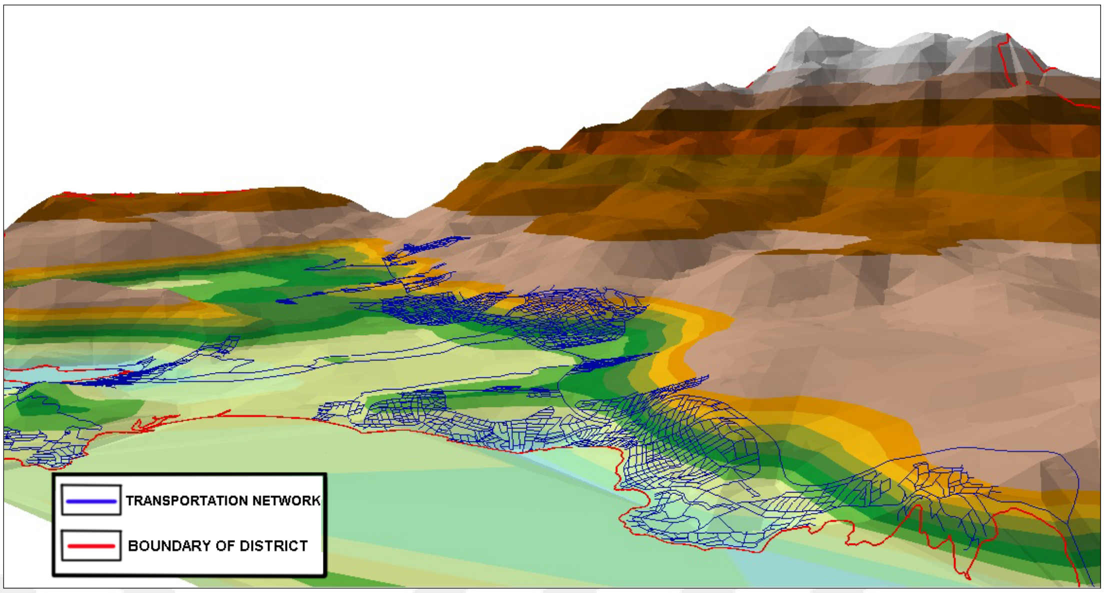

Figure 3.2 Transportation network and topography of study area.

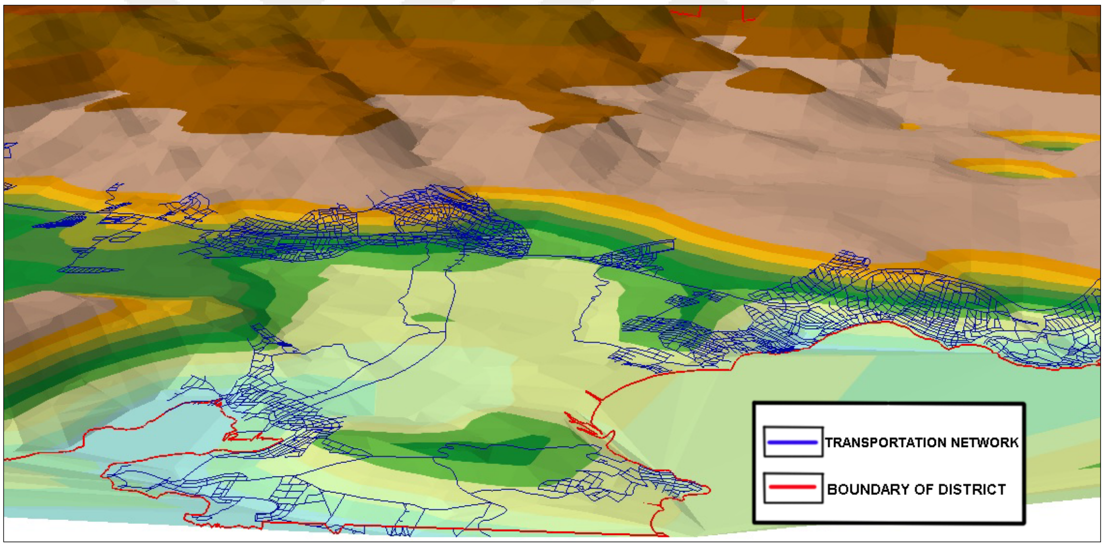

Figure 3.3 Transportation network and topography of study area.

3.2 The Distance Matrix

The nearest neighbor distance across the urban open spaces centers of the total 1226 open spaces are calculated. After these calculations, distance matrices are generated. The plan decisions in the Development Plans of Seferihisar are used for the generation of the distance matrix.

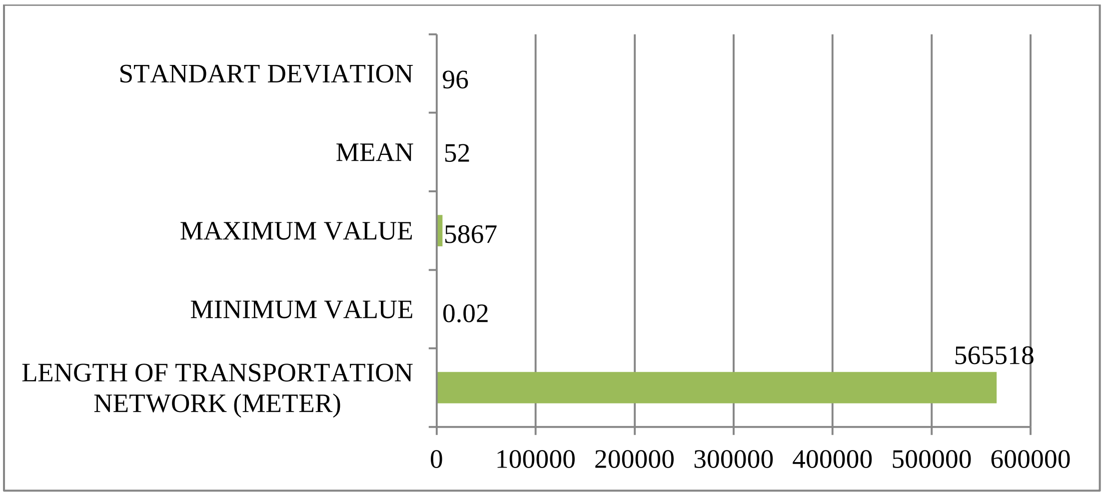

Figure 3.4 Transportation network length values.

The total length of the transport network is 565,518 meters in the Development Plans of Seferihisar. The minimum length is 0.02 meters, the maximum length is 5,867 meters, and mean value is 52 meters. The standard deviation is calculated as 96 meters. The standard deviation is a low value, so it means the all observed values are close to mean value.

Table 3.1 The distance matrix of urban open spaces

Neighborhood	**Euclidean Distance Method (meters)**	**Network Nearest Neighbor Distance Method (meters)**
	Mean Nearest Neighbor Distance	**Mean Nearest Neighbor Distance**
Atatürk	73.194	57.269
Camikebir	87.796	116.638
Çolak İbrahim Bey	96.688	134.180
Cumhuriyet	52.046	72.340
Düzce	114.577	134.030
Hıdırlık	59.338	79.835
Payamlı	68.082	105.500

Table 3.1 The distance matrix of urban open spaces (continue)

Sığacık	58.137	73.576
Tepecik	64.936	86.318
Turabiye	83.390	109.448
Ulamış	83.263	96.681
The Whole Neighborhood	**67.179**	**89.285**

To conduct nearest neighbor analysis, the nearest distances between the urban green spaces are calculated at the neighborhood level. These distances are presented in Table 3.1. This distance is also calculated at the Seferihisar Neighborhood level.

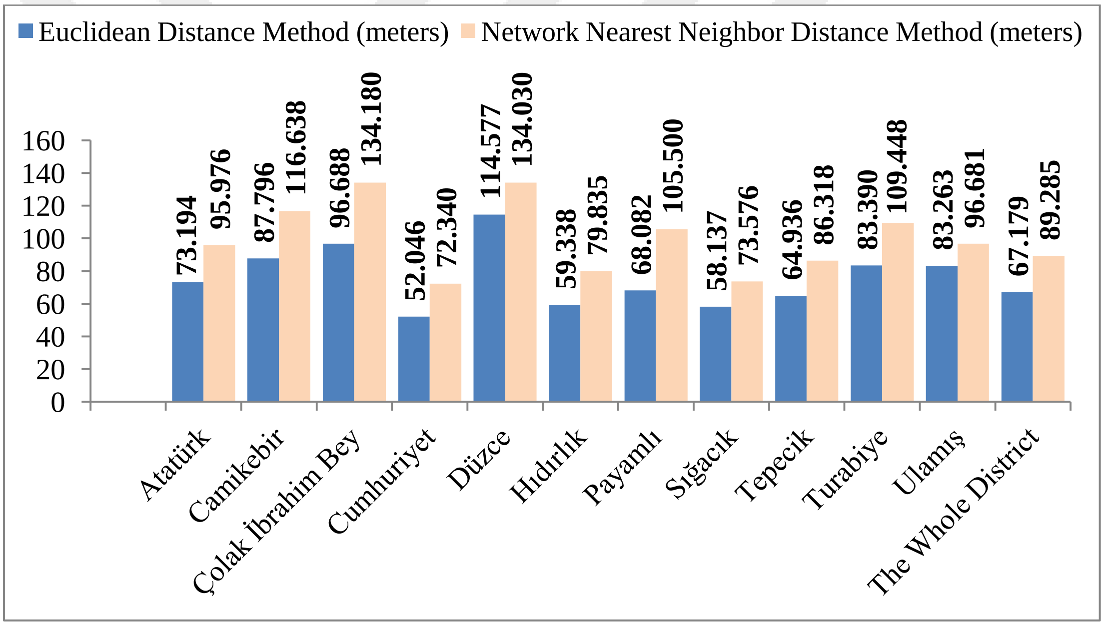

Figure 3.5 The mean nearest neighbor distance of urban green spaces.

3.3 Urban Green Areas

The Development Plans of Seferihisar has 1226 pieces of urban green spaces in proposed planning decisions. These numbers differ among neighborhoods (Figure 3.6). Atatürk neighborhood has the most urban green spaces, and Çolak İbrahim Bey neighborhood has the least urban green spaces.

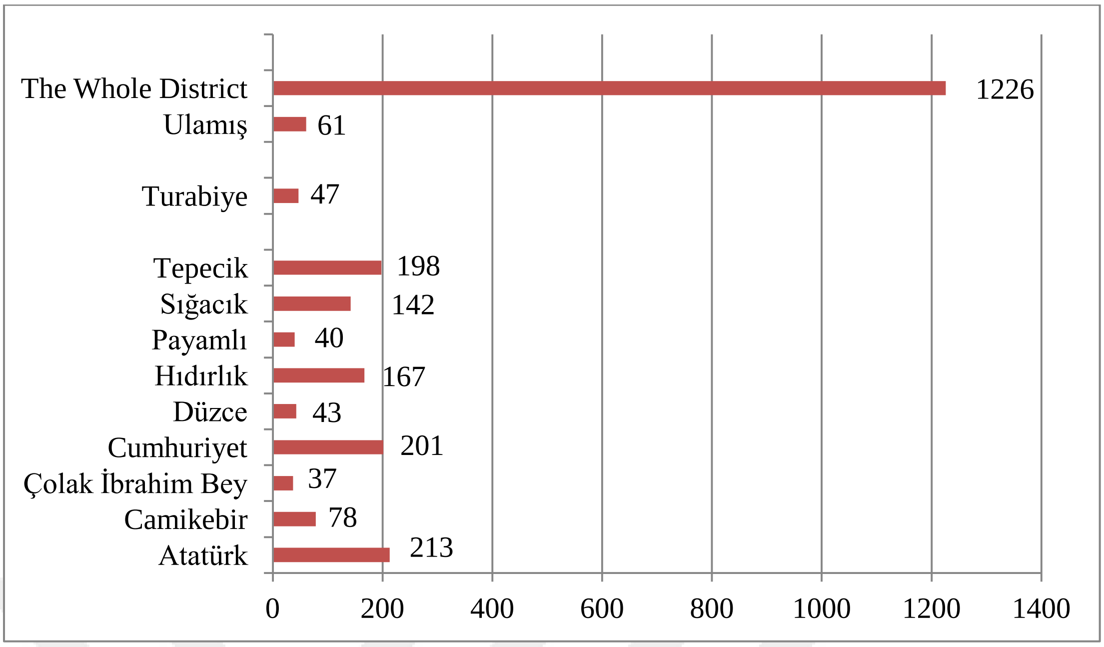

Figure 3.6 The number of urban green spaces.

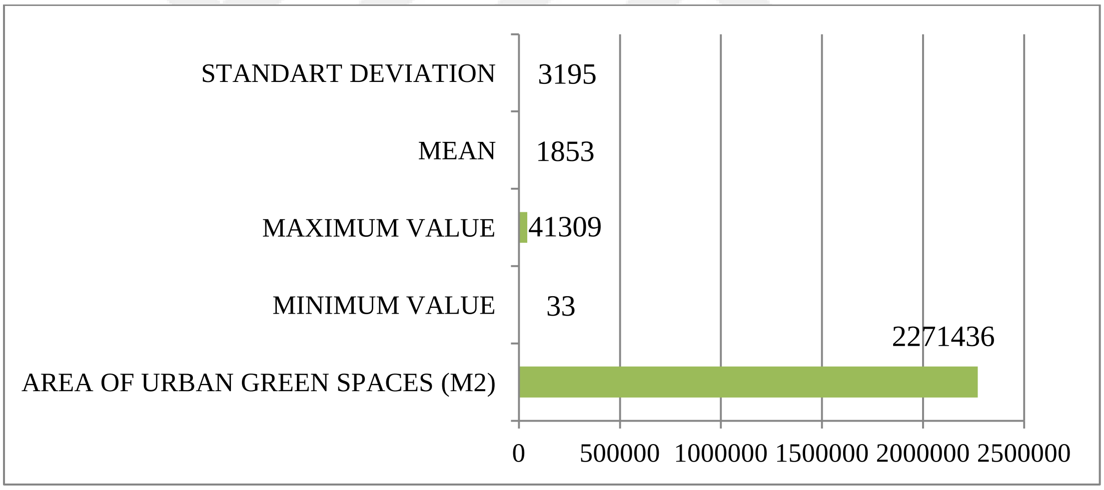

Figure 3.7 The value of urban green spaces areas.

The total area of urban green spaces is 2,271,436 square meters in Seferihisar. The minimum green space proposed is 33 square meters, and the maximum is 41,309 square meters. The mean value is 1853 square meters, and the standard deviation is 3195. The standard deviation observed is low value, it means the observed values are close to mean value.

To show the closest streets to each urban green area visually, the Voronoi diagrams are calculated. It is generated from the polygons, which is the set of the nearest points on the proposed transportation transport network. The closest point sets are categorized with the same colored network in followed figures. As seen in Figures 3.8, 3.9 and 3.10, the service area for each proposed urban area differ.

Figure 3.8 Voronoi Diagram in the north parts of Seferihisar.

Figure 3.9 Voronoi Diagram in the middle parts of Seferihisar.

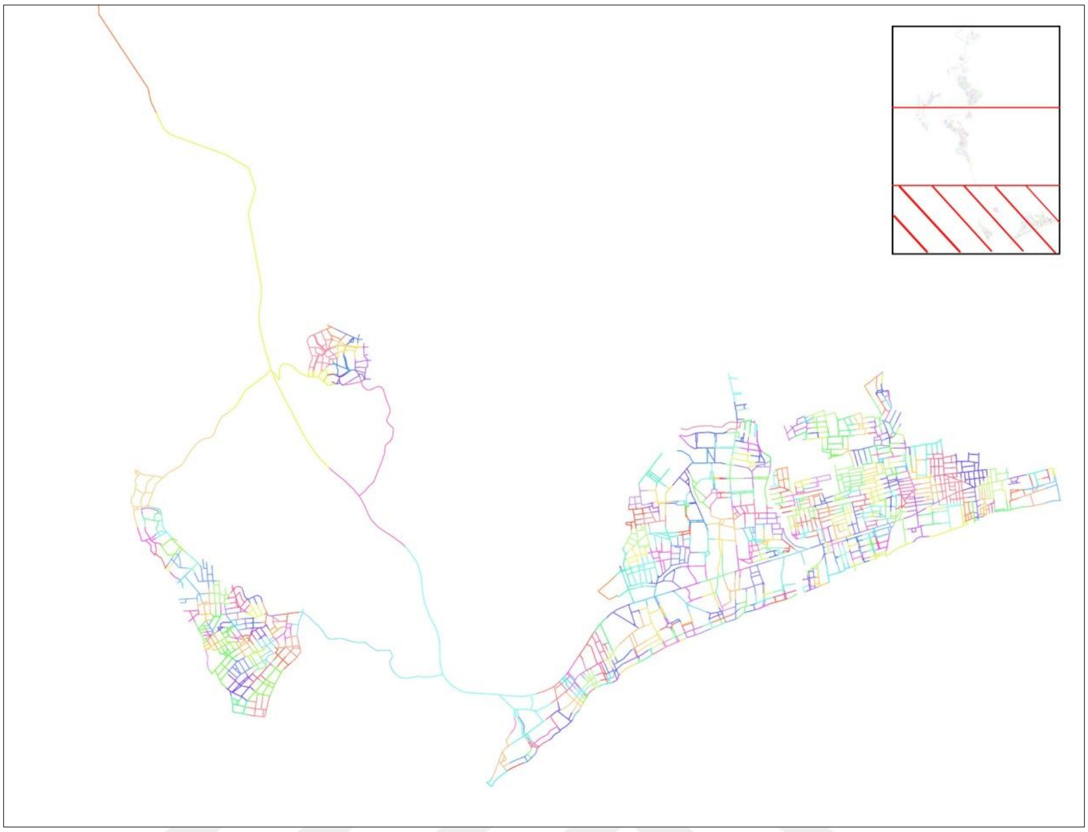

Figure 3.10 Voronoi Diagram in the south parts of Seferihisar.

CHAPTER FOUR
ANALYSIS AND RESULTS

In this chapter, the results of the two analyses are presented and the differences are emphasized: nearest neighborhood analysis based on Euclidean distances and nearest neighborhood analysis based on network distances. Both methods are implemented in the same area, but the results are different from each other.

4.1 Nearest Neighbor Analysis based on Euclidean Distances

The results of the nearest neighbor analysis based on Euclidean distances reveal that the proposed urban green areas are clustered in Seferihisar district (Figure 4.1). This finding is statistically significant at the α=0.01 level. The observed mean distance is 67.178 meters, and the expected mean distance is 215.042 meters (Table 4.1). The R-statistic and Z-score are calculated as 0.313 ($0<R<1$) and -46.058 (Z-score<0) respectively.

The results, however, vary at the neighborhood level. For instance, the pattern of Payamlı, Turabiye and Çolak İbrahim Bey neighborhoods appear to be significantly random. For the remaining neighborhoods, the distributions is clustered.

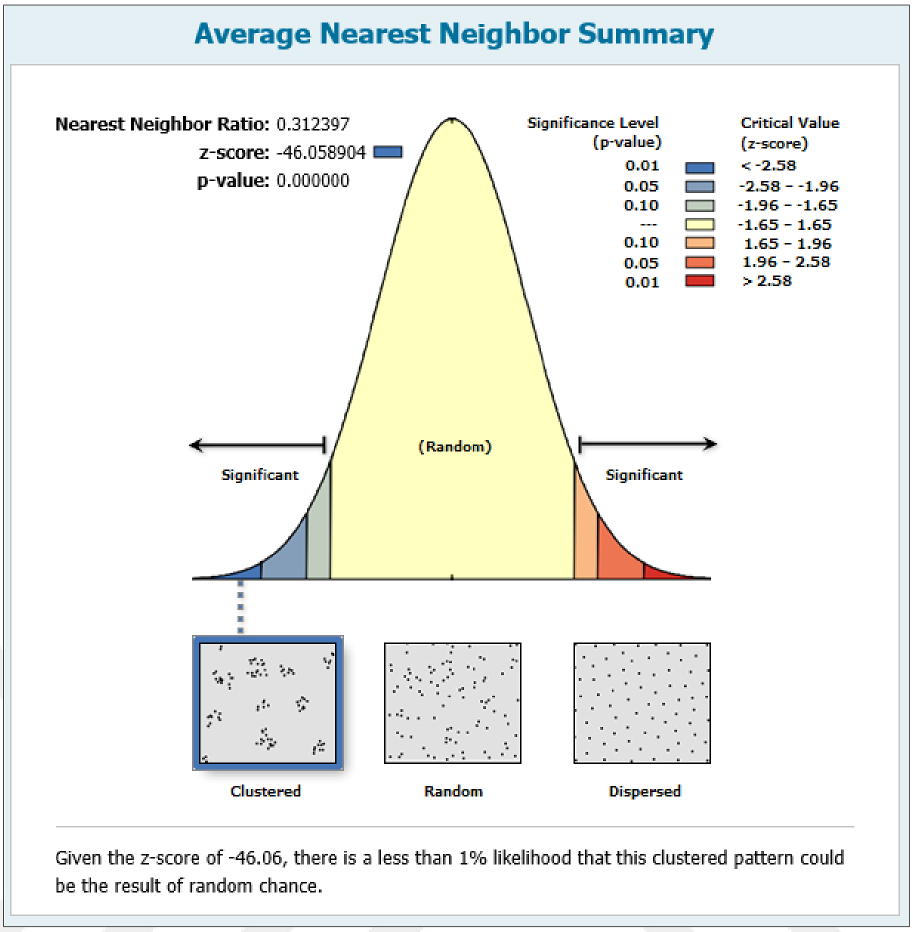

Figure 4.1 Avarage nearest neighbor summary, the whole neighborhood of Seferihisar.

Table 4.1 Avarage nearest neighbor summary, the whole neighborhood of Seferihisar

Average Nearest Neighbor Summary	
Observed Mean Distance:	67.178813 Meters
Expected Mean Distance:	215.042774 Meters
Nearest Neighbor Ratio:	0.312397
z-score:	-46.058904
p-value:	0.000000
Dataset Information	
Input Feature Class:	PARK_POINT
Distance Method:	EUCLIDEAN
Study Area:	226777607.698699
Selection Set:	False

4.1.1 Atatürk Neighborhood

The results of the nearest neighbor analysis based on Euclidean distances reveal that the proposed urban green areas are clustered in Atatürk neighborhood (Figure 4.2). This finding is statistically significant at the α=0.01 level. The observed mean distance is 73.194 meters, and the expected mean distance is 150.695 meters (Table 4.2). The R-statistic and Z-score are calculated as 0.485 (0<R<1) and -14.359 (Z-score<0) respectively.

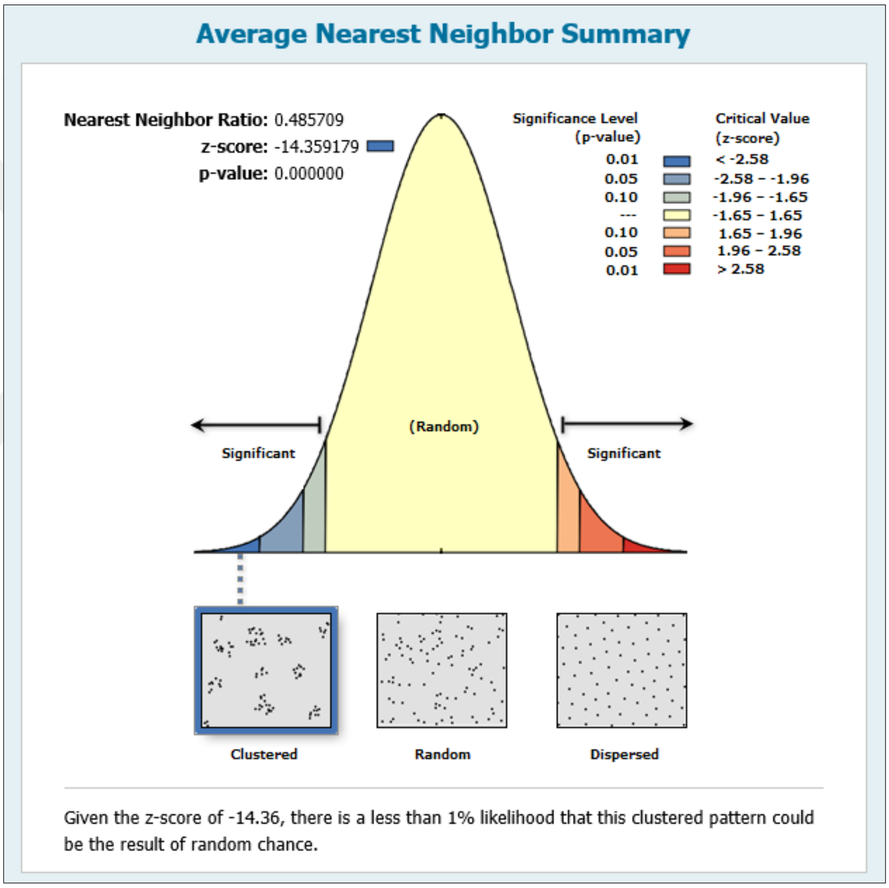

Figure 4.2 Avarage nearest neighbor summary, Atatürk neighborhood.

Table 4.2 Avarage nearest neighbor summary, Atatürk neighborhood

Average Nearest Neighbor Summary	
Observed Mean Distance:	73.194371 Meters
Expected Mean Distance:	150.695936 Meters
Nearest Neighbor Ratio:	0.485709
z-score:	-14.359179
p-value:	0.000000
Dataset Information	
Input Feature Class:	PARK_POINT
Distance Method:	EUCLIDEAN
Study Area:	19348293.760377
Selection Set:	False

4.1.2 Camikebir Neighborhood

The results of the nearest neighbor analysis based on Euclidean distances reveal that the proposed urban green areas are clustered in Camikebir neighborhood (Figure 4.3). This finding is statistically significant at the α=0.01 level. The observed mean distance is 87.796 meters, and the expected mean distance is 169.716 meters (Table 4.3). The R-statistic and Z-score are calculated as 0.517 ($0<R<1$) and -8.412 ($Z\text{-score}<0$) respectively.

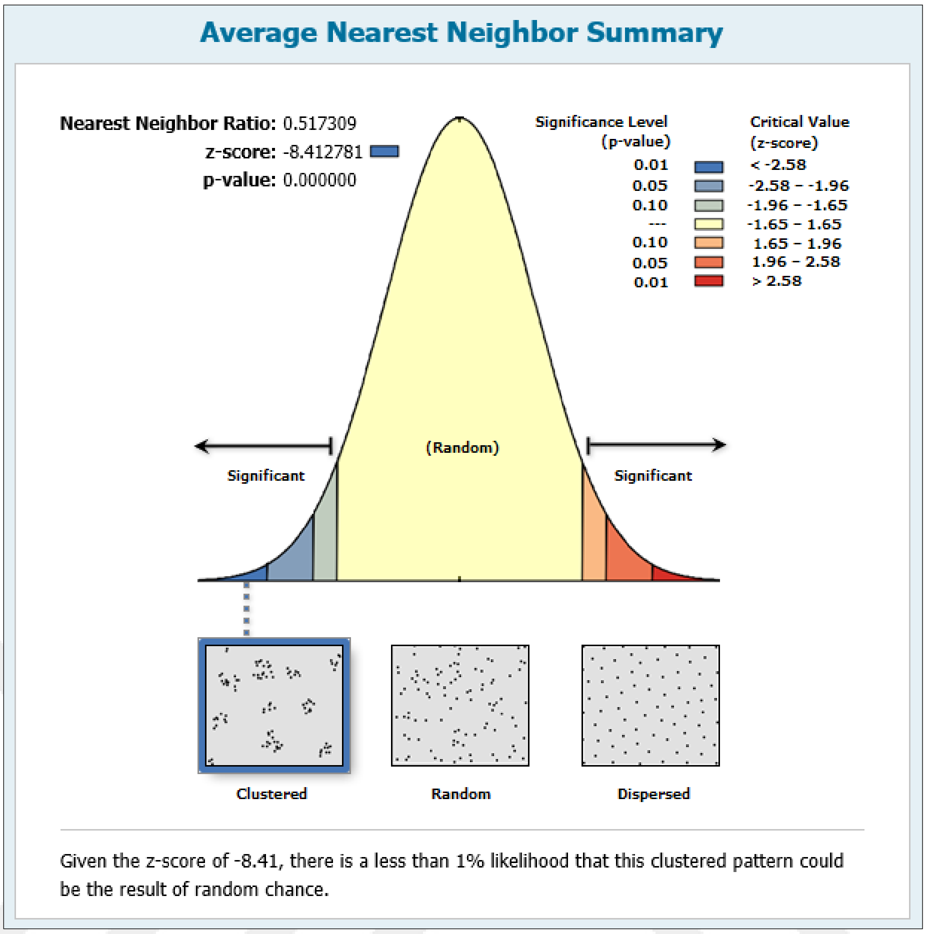

Figure 4.3 Avarage nearest neighbor summary, Camikebir neighborhood.

Table 4.3 Avarage nearest neighbor summary, Camikebir neighborhood

Average Nearest Neighbor Summary	
Observed Mean Distance:	87.796008 Meters
Expected Mean Distance:	169.716922 Meters
Nearest Neighbor Ratio:	0.517309
z-score:	-8.412781
p-value:	0.000000
Dataset Information	
Input Feature Class:	PARK_POINT
Distance Method:	EUCLIDEAN
Study Area:	9562872.704297
Selection Set:	False

4.1.3 Çolakibrahimbey Neighborhood

The results of the nearest neighbor analysis based on Euclidean distances reveal that the proposed urban green areas are random in Çolakibrahimbey neighborhood (Figure 4.4). This finding is statistically significant at the α=0.34 level. The observed mean distance is 96.687 meters, and the expected mean distance is 89.418 meters (Table 4.4). The R-statistic and Z-score are calculated as 1.081 (R is close to"1") and 0.945 (Z-score>0, but close to "0") respectively.

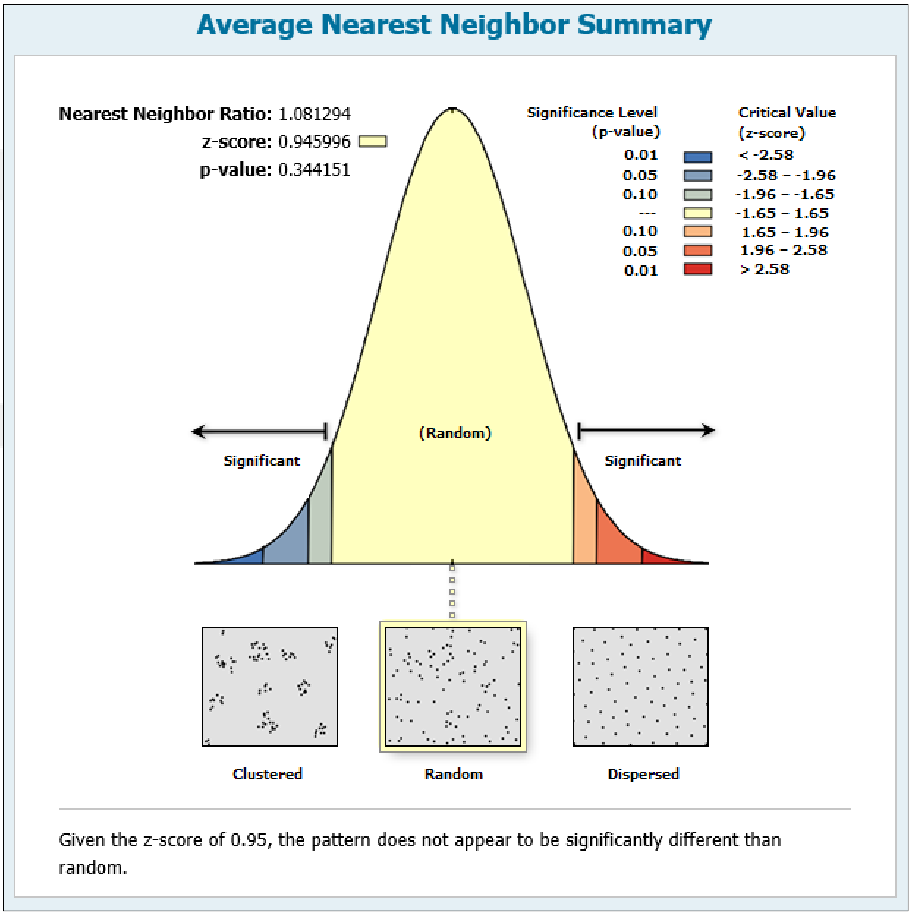

Figure 4.4 Avarage nearest neighbor summary, Çolakibrahimbey neighborhood.

Table 4.4 Avarage nearest neighbor summary, Çolakibrahimbey neighborhood

Average Nearest Neighbor Summary	
Observed Mean Distance:	96.687747 Meters
Expected Mean Distance:	89.418569 Meters
Nearest Neighbor Ratio:	1.081294
z-score:	0.945996
p-value:	0.344151
Dataset Information	
Input Feature Class:	PARK_POINT
Distance Method:	EUCLIDEAN
Study Area:	1183360.707972
Selection Set:	False

4.1.4 Cumhuriyet Neighborhood

The results of the nearest neighbor analysis based on Euclidean distances reveal that the proposed urban green areas are clustered in Cumhuriyet neighborhood (Figure 4.5). This finding is statistically significant at the α=0.01 level. The observed mean distance is 52.046 meters, and the expected mean distance is 64.310 meters (Table 4.5). The R-statistic and Z-score are calculated as 0.809 ($0<R<1$) and -5.172 (Z-score<0) respectively.

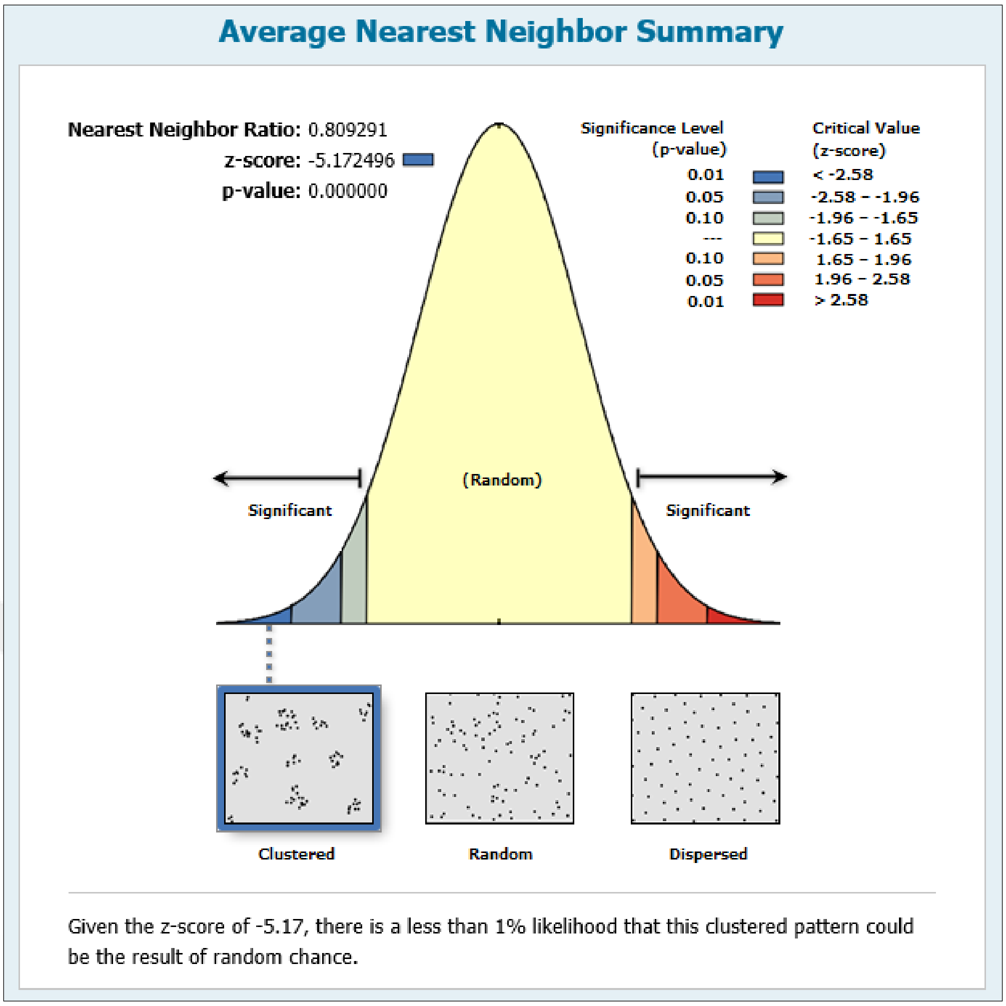

Figure 4.5 Avarage nearest neighbor summary, Cumhuriyet neighborhood.

Table 4.5 Avarage nearest neighbor summary, Cumhuriyet neighborhood

Average Nearest Neighbor Summary	
Observed Mean Distance:	52.046128 Meters
Expected Mean Distance:	64.310773 Meters
Nearest Neighbor Ratio:	0.809291
z-score:	-5.172496
p-value:	0.000000
Dataset Information	
Input Feature Class:	PARK_POINT
Distance Method:	EUCLIDEAN
Study Area:	3325243.931031
Selection Set:	False

4.1.5 Düzce Neighborhood

The results of the nearest neighbor analysis based on Euclidean distances reveal that the proposed urban green areas are clustered in Düzce neighborhood (Figure 4.6). This finding is statistically significant at the α=0.02 level. The observed mean distance is 114.576 meters, and the expected mean distance is 139.522 meters (Table 4.6). The R-statistic and Z-score are calculated as 0.821 (0<R<1) and -2.242 (Z-score<0) respectively.

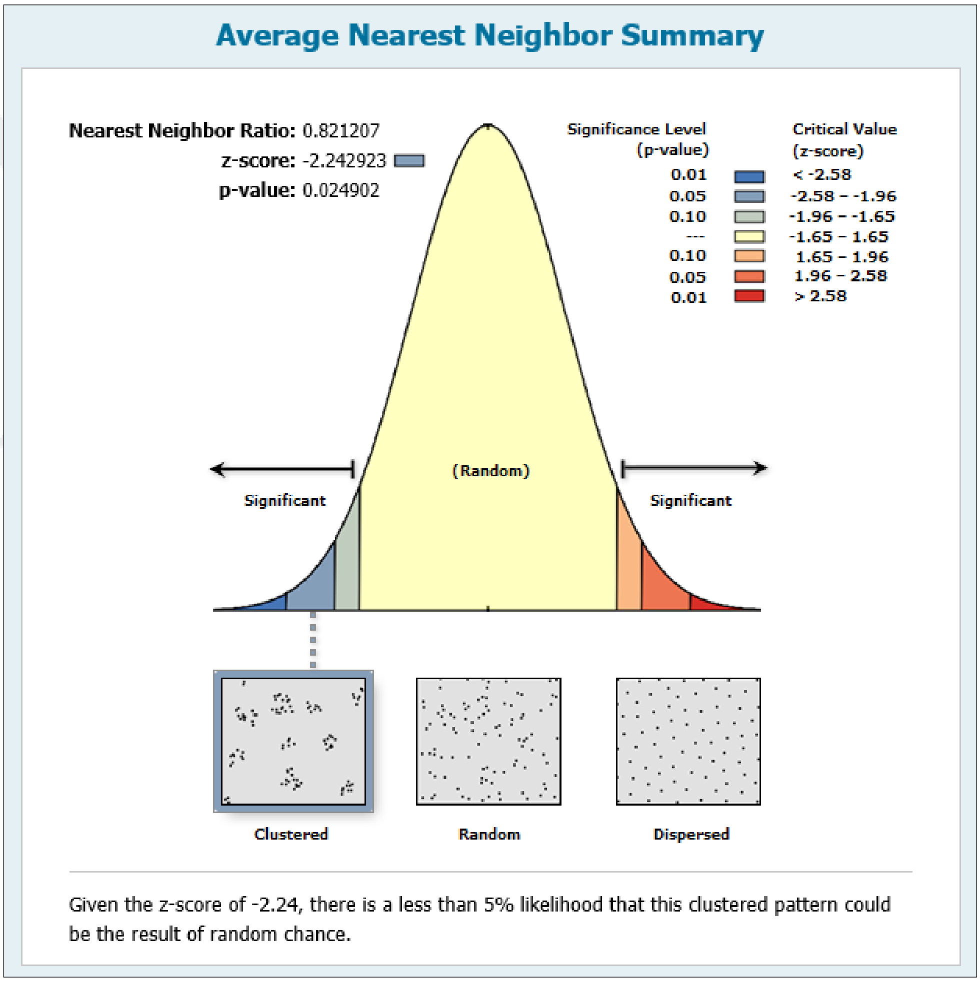

Figure 4.6 Avarage nearest neighbor summary, Düzce neighborhood.

Table 4.6 Avarage nearest neighbor summary, Düzce neighborhood

Average Nearest Neighbor Summary	
Observed Mean Distance:	114.576566 Meters
Expected Mean Distance:	139.522067 Meters
Nearest Neighbor Ratio:	0.821207
z-score:	-2.242923
p-value:	0.024902
Dataset Information	
Input Feature Class:	PARK_POINT
Distance Method:	EUCLIDEAN
Study Area:	3348222.034509
Selection Set:	False

4.1.6 Hıdırlık Neighborhood

The results of the nearest neighbor analysis based on Euclidean distances reveal that the proposed urban green areas are clustered in Hıdırlık neighborhood (Figure 4.7). This finding is statistically significant at the α=0.01 level. The observed mean distance is 59.337 meters, and the expected mean distance is 112.006 meters (Table 4.7). The R-statistic and Z-score are calculated as 0.529 (0<R<1) and -11.590 (Z-score<0) respectively.

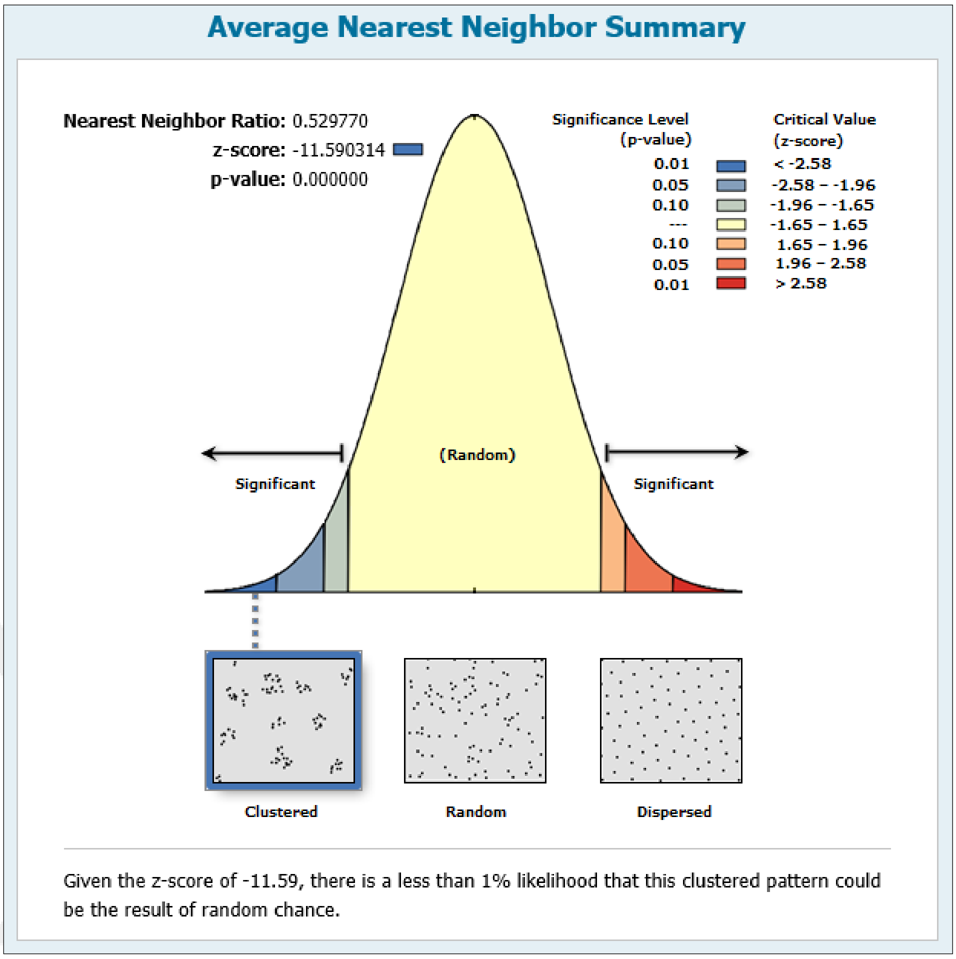

Figure 4.7 Avarage nearest neighbor summary, Hıdırlık neighborhood.

Table 4.7 Avarage nearest neighbor summary, Hıdırlık neighborhood

Average Nearest Neighbor Summary	
Observed Mean Distance:	59.337832 Meters
Expected Mean Distance:	112.006767 Meters
Nearest Neighbor Ratio:	0.529770
z-score:	-11.590314
p-value:	0.000000
Dataset Information	
Input Feature Class:	PARK_POINT
Distance Method:	EUCLIDEAN
Study Area:	8330222.455404
Selection Set:	False

4.1.7 Payamlı Neighborhood

The results of the nearest neighbor analysis based on Euclidean distances reveal that the proposed urban green areas are random in Payamlı neighborhood (Figure 4.8). This finding is statistically significant at the α=0.52 level. The observed mean distance is 68.082 meters, and the expected mean distance is 71.857 meters (Table 4.8). The R-statistic and Z-score are calculated as 0.947 (R is close to "1") and -0.635 (Z-score<0) respectively.

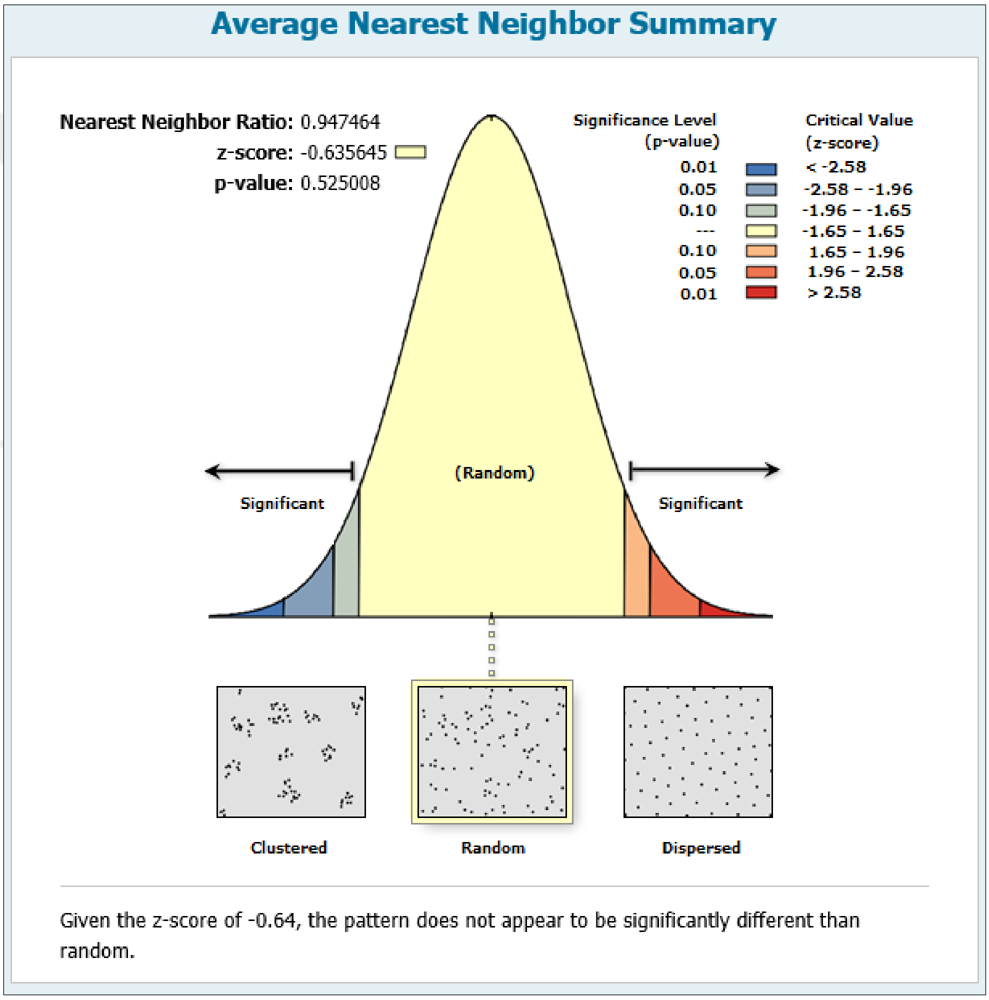

Figure 4.8 Avarage nearest neighbor summary, Payamlı neighborhood.

Table 4.8 Avarage nearest neighbor summary, Payamlı neighborhood

Average Nearest Neighbor Summary	
Observed Mean Distance:	68.082171 Meters
Expected Mean Distance:	71.857235 Meters
Nearest Neighbor Ratio:	0.947464
z-score:	-0.635645
p-value:	0.525008
Dataset Information	
Input Feature Class:	PARK_POINT
Distance Method:	EUCLIDEAN
Study Area:	826153.952422
Selection Set:	False

4.1.8 Sıgacık Neighborhood

The results of the nearest neighbor analysis based on Euclidean distances reveal that the proposed urban green areas are clustered in Sıgacık neighborhood (Figure 4.9). This finding is statistically significant at the α=0.01 level. The observed mean distance is 58.136 meters, and the expected mean distance is 120.357 meters (Table 4.9). The R-statistic and Z-score are calculated as 0.483 ($0<R<1$) and -11.826 (Z-score<0) respectively.

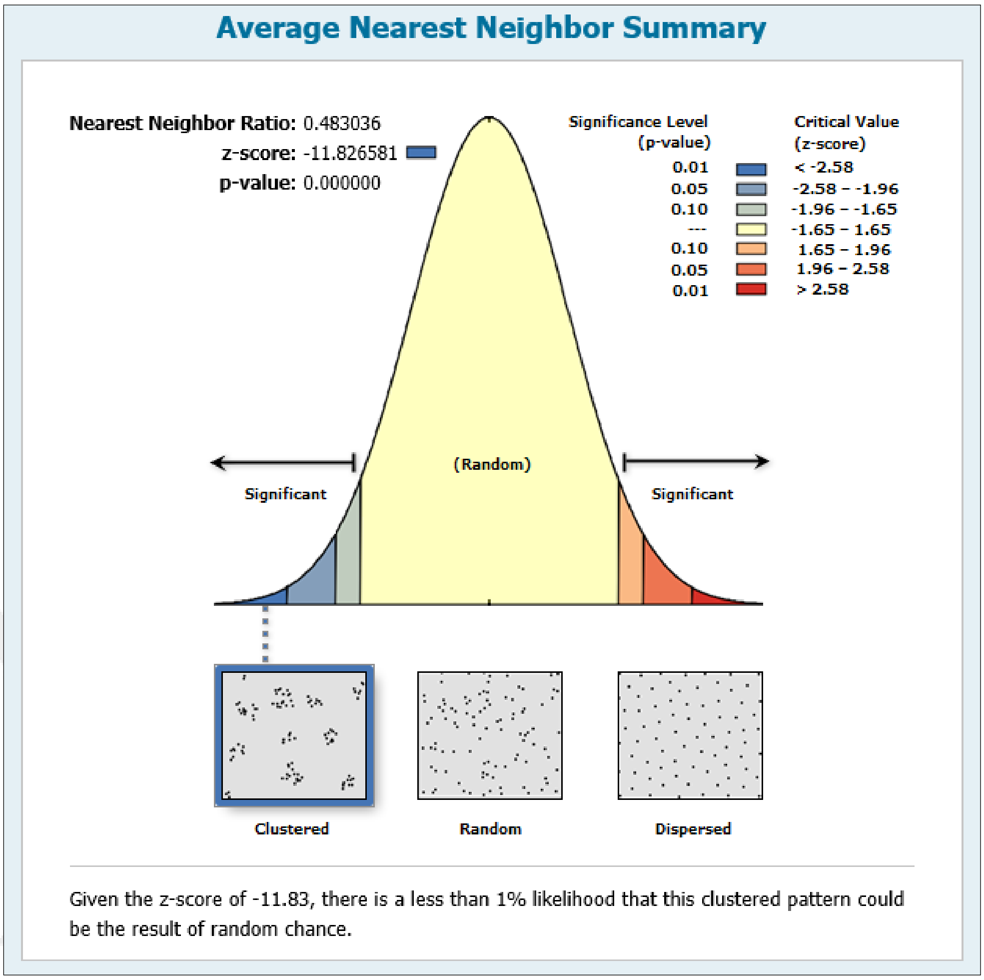

Figure 4.9 Avarage nearest neighbor summary, Sıgacık neighborhood.

Table 4.9 Avarage nearest neighbor summary, Sığacık neighborhood

Average Nearest Neighbor Summary	
Observed Mean Distance:	58.136880 Meters
Expected Mean Distance:	120.357248 Meters
Nearest Neighbor Ratio:	0.483036
z-score:	-11.826581
p-value:	0.000000
Dataset Information	
Input Feature Class:	PARK_POINT
Distance Method:	EUCLIDEAN
Study Area:	8285915.992159
Selection Set:	False

4.1.9 Tepecik Neighborhood

The results of the nearest neighbor analysis based on Euclidean distances reveal that the proposed urban green areas are clustered in Tepecik neighborhood (Figure 4.10). This finding is statistically significant at the α=0.01 level. The observed mean distance is 64.936 meters, and the expected mean distance is 106.618 meters (Table 4.10). The R-statistic and Z-score are calculated as 0.609 (0<R<1) and -10.629 (Z-score<0) respectively.

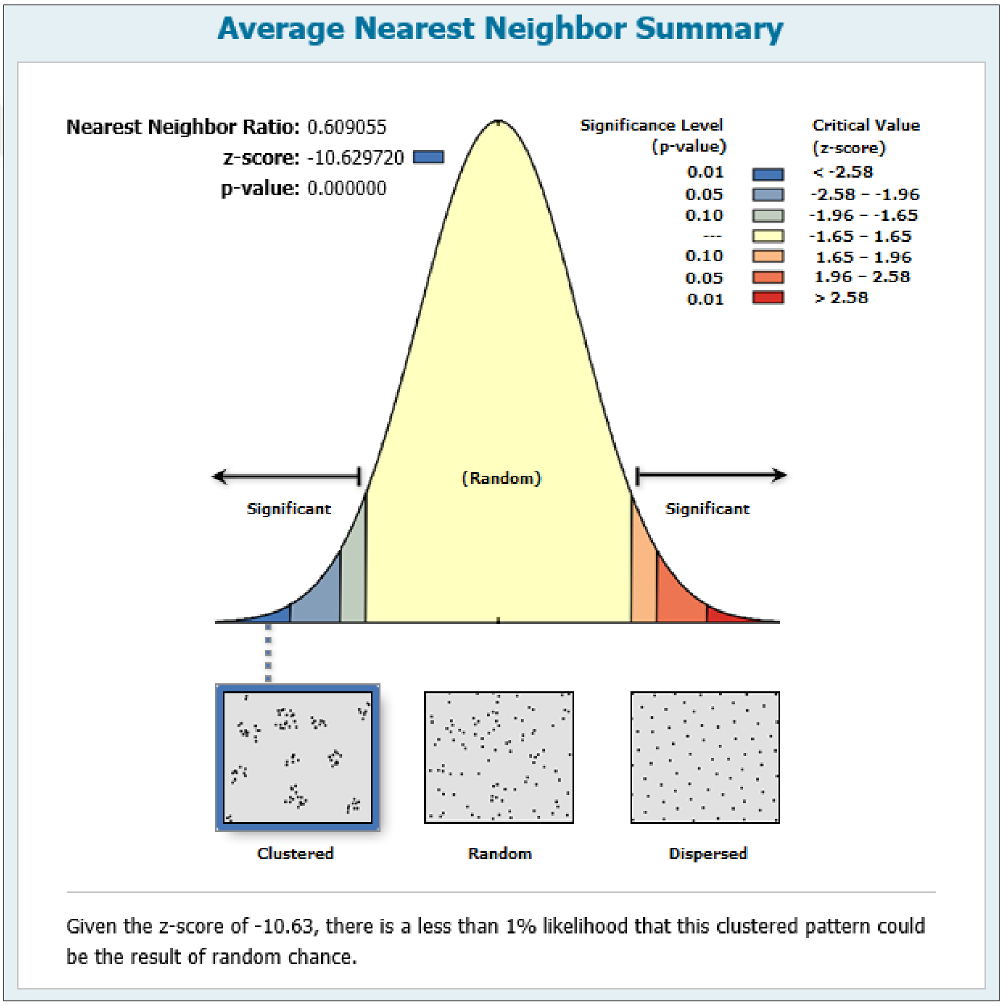

Figure 4.10 Avarage nearest neighbor summary, Tepecik neighborhood.

Table 4.10 Avarage nearest neighbor summary, Tepecik neighborhood

Average Nearest Neighbor Summary	
Observed Mean Distance:	64.936433 Meters
Expected Mean Distance:	106.618277 Meters
Nearest Neighbor Ratio:	0.609055
z-score:	-10.629720
p-value:	0.000000
Dataset Information	
Input Feature Class:	PARK_POINT
Distance Method:	EUCLIDEAN
Study Area:	9184905.319689
Selection Set:	False

4.1.10 Turabiye Neighborhood

The results of the nearest neighbor analysis based on Euclidean distances reveal that the proposed urban green areas are random in Turabiye neighborhood (Figure 4.11). This finding is statistically significant at the α=0.14 level. The observed mean distance is 83.389 meters, and the expected mean distance is 75.053 meters (Table 4.11). The R-statistic and Z-score are calculated as 1.111 (R is close to "1") and 1.456 (Z-score>0) respectively.

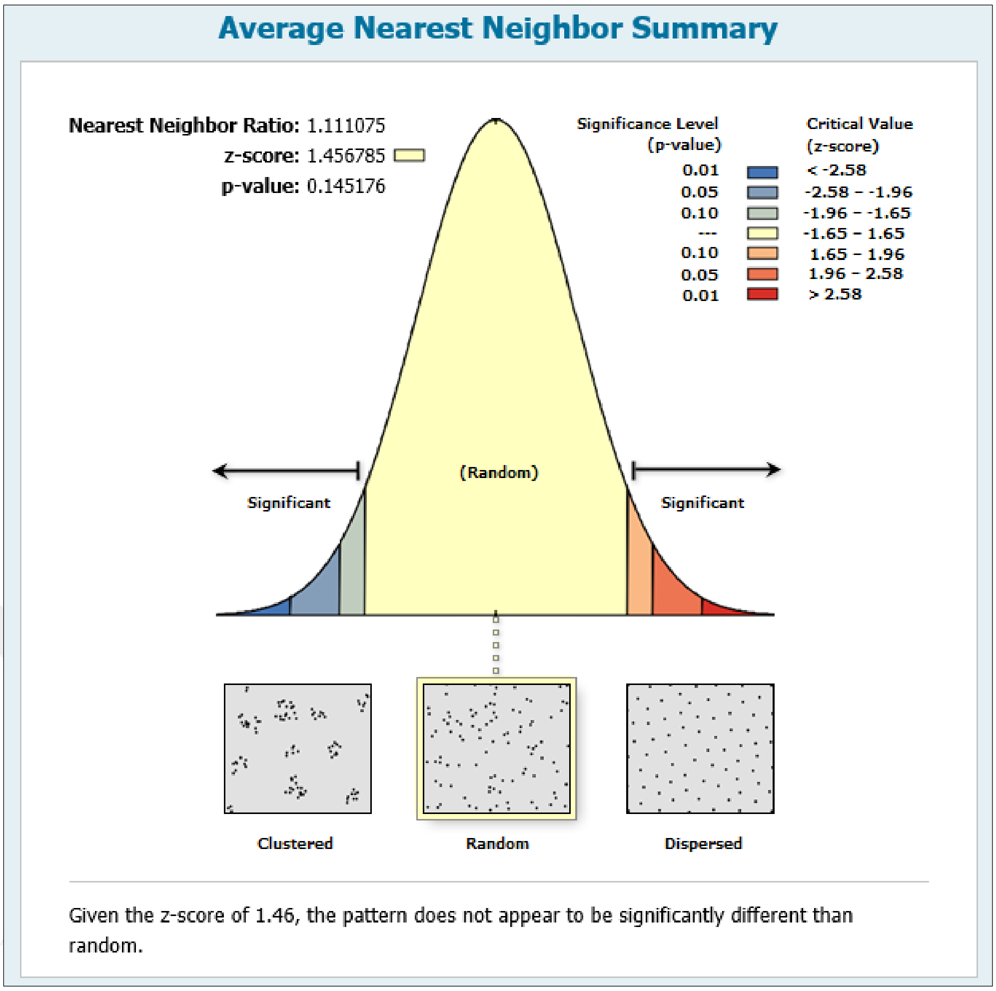

Figure 4.11 Avarage nearest neighbor summary, Turabiye neighborhood.

Table 4.11 Avarage nearest neighbor summary, Turabiye neighborhood

Average Nearest Neighbor Summary	
Observed Mean Distance:	83.389553 Meters
Expected Mean Distance:	75.053047 Meters
Nearest Neighbor Ratio:	1.111075
z-score:	1.456785
p-value:	0.145176
Dataset Information	
Input Feature Class:	PARK_POINT
Distance Method:	EUCLIDEAN
Study Area:	1058996.447423
Selection Set:	False

4.1.11 Ulamış Neighborhood

The results of the nearest neighbor analysis based on Euclidean distances reveal that the proposed urban green areas are clustered in Ulamış neighborhood (Figure 4.12). This finding is statistically significant at the α=0.01 level. The observed mean distance is 83.263 meters, and the expected mean distance is 154.620 meters (Table 4.12). The R-statistic and Z-score are calculated as 0.538 (0<R<1) and -6.895 (Z-score<0) respectively.

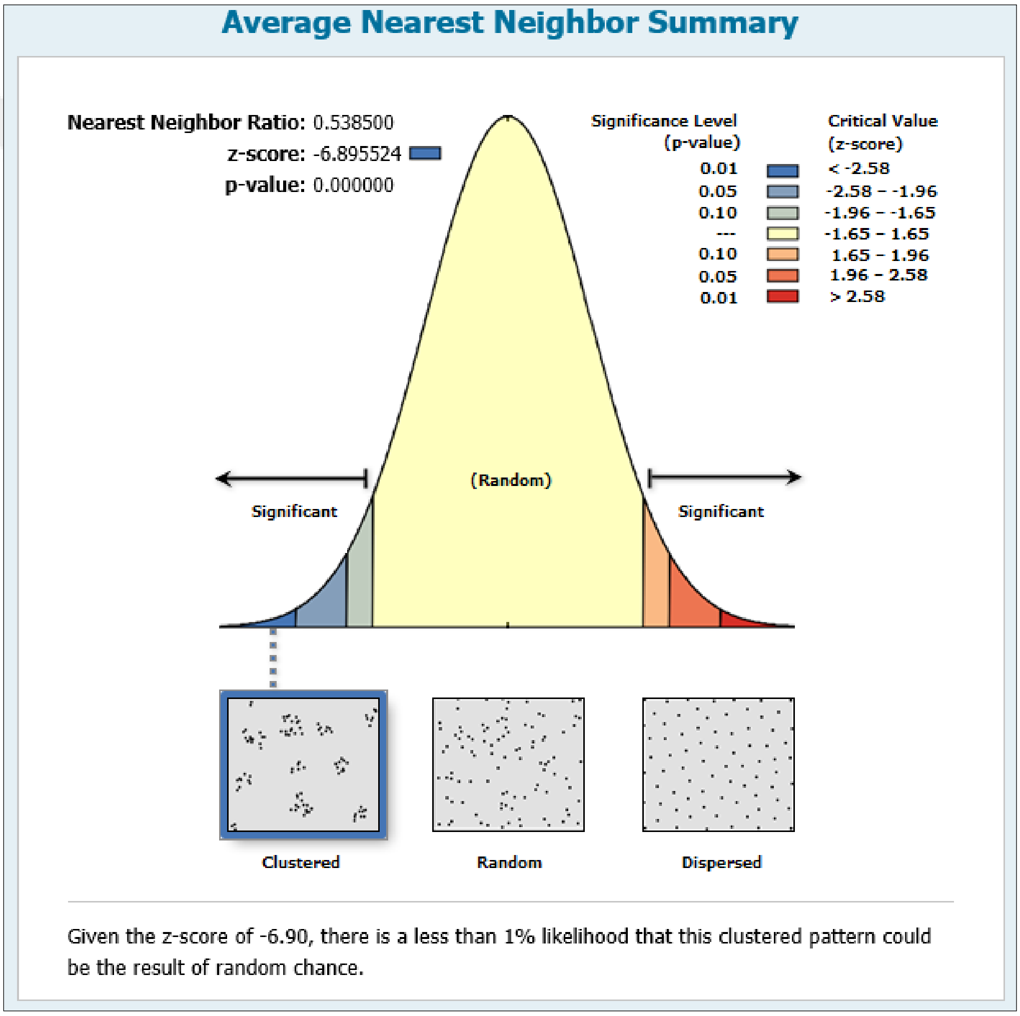

Figure 4.12 Avarage nearest neighbor summary, Ulamış neighborhood.

Table 4.12 Avarage nearest neighbor summary, Ulamış neighborhood

Average Nearest Neighbor Summary	
Observed Mean Distance:	83.263416 Meters
Expected Mean Distance:	154.620950 Meters
Nearest Neighbor Ratio:	0.538500
z-score:	-6.895524
p-value:	0.000000

Dataset Information	
Input Feature Class:	PARKPOINT
Distance Method:	EUCLIDEAN
Study Area:	5833463.679657
Selection Set:	False

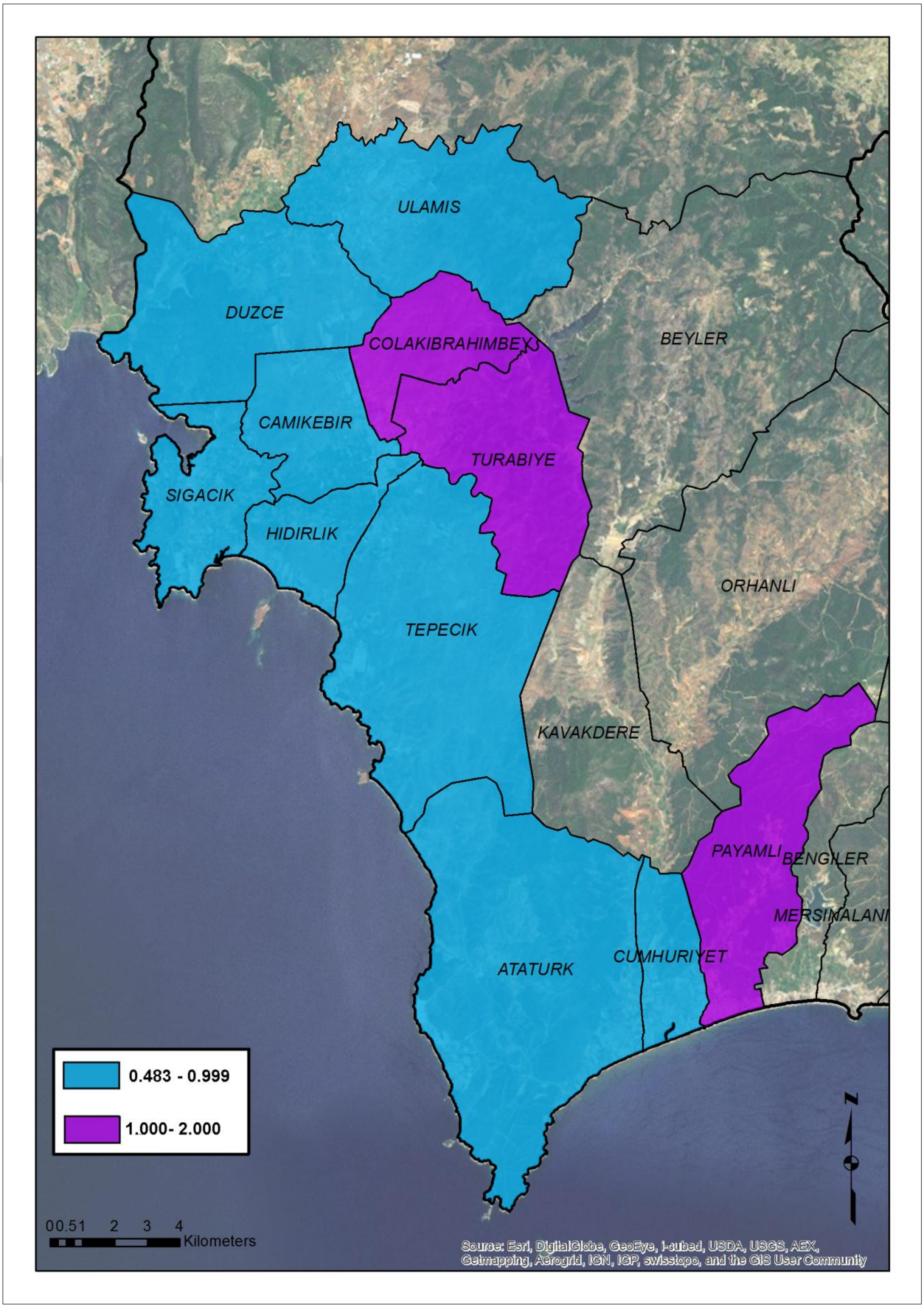

Figure 4.13 R-statistic values of euclidean distances method.

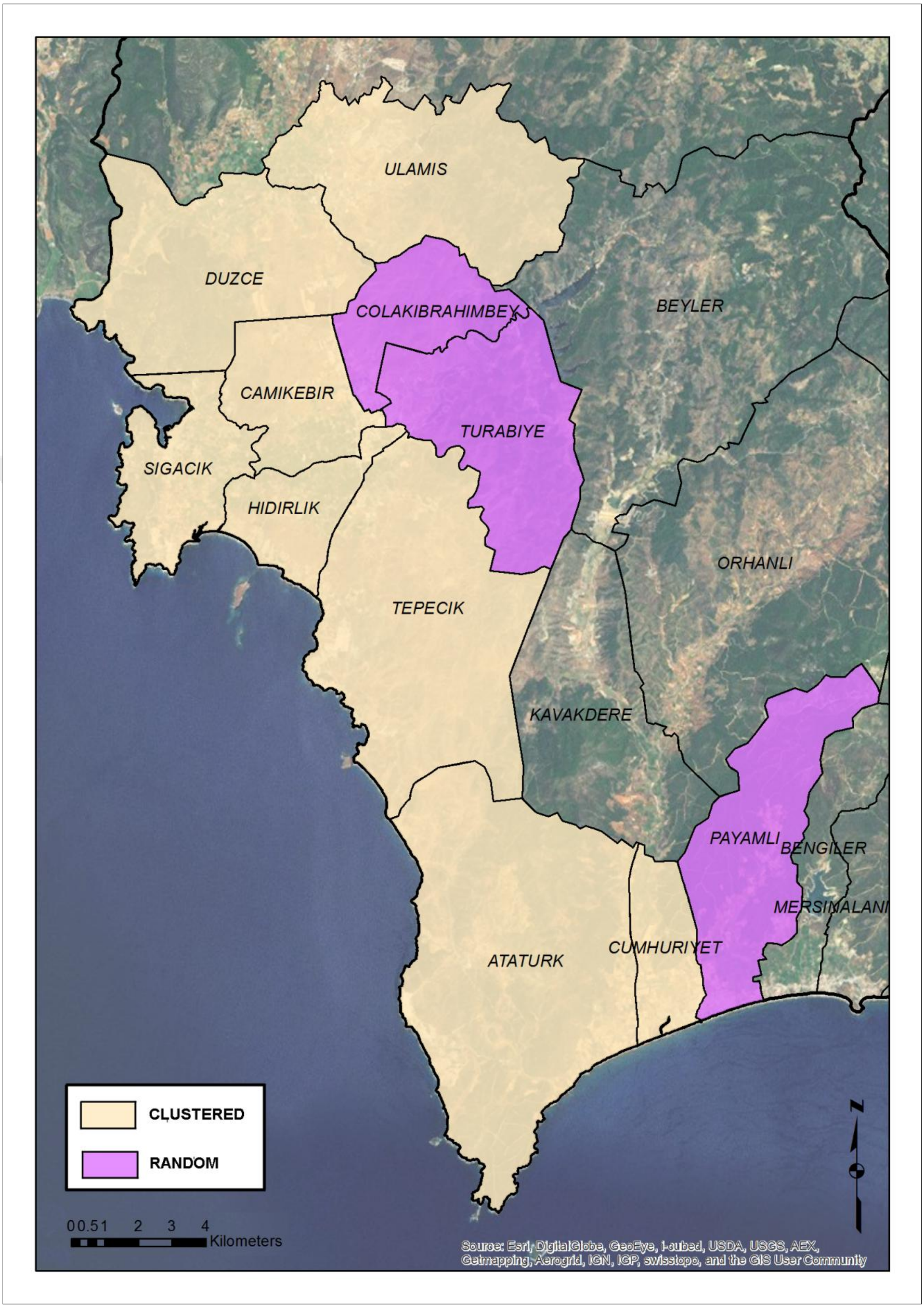

Figure 4.14 Distribution of urban green spaces which is calculated with euclidean distances.

4.2 Nearest Neighbor Analysis based on Network Distances

The nearest neighbor analysis based on network distances is not straightforward, and test of significance includes an additional process. The statistical significance of the obtained results is evaluated according to the confidence line indicated on the chart. Establishing confidence line for the nearest neighbor analysis is through the Complete Spatial Randomness (CSR) process. In this context, the important thing is that the observed curve which is outside the confidence interval line from the obtained results is statistically significant. The observed curve which is inside the confidence interval line means that the distributions are random. If the observed curve is above the upper envelop curve, it means that the distribution of open green spaces is clustered. On the contrary, if the observed curve is under the lower envelop curve, it means that the distribution of open green spaces is dispersed/uniform (Figure 4.15).

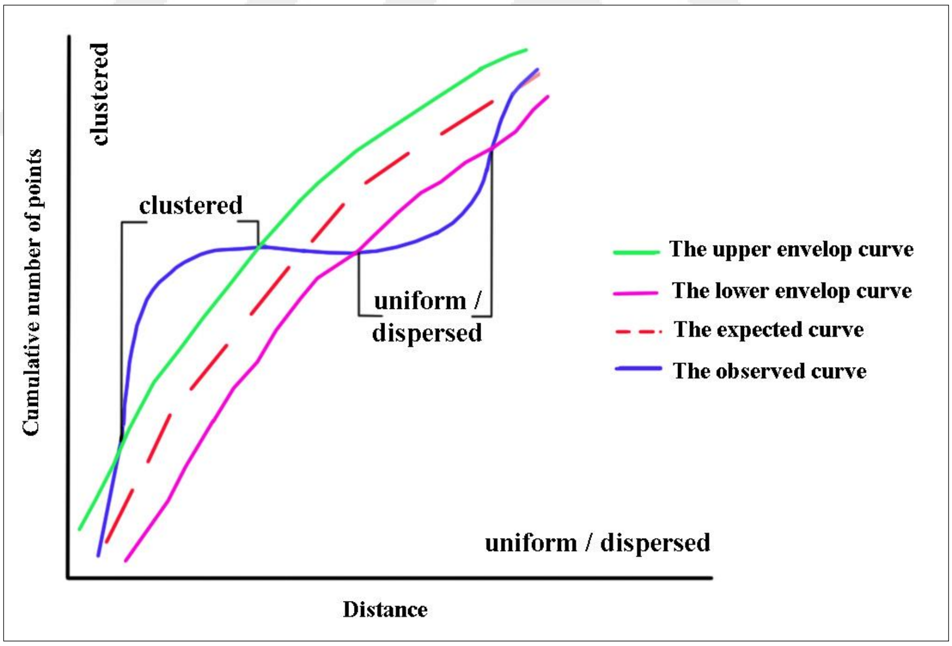

Figure 4.15 Observed and expected nearest neighbor curves.

For the case of neighborhoods, the results from the nearest neighbor analysis based on Euclidean distances are different from the results obtained from the nearest neighbor analysis based on network distances. Moreover, evaluating the dispersion of urban open spaces with the case of the neighborhood at Network Nearest Neighbour Distance Method, the results are different from the whole neighborhood calculation. As seen in Figure 4.16, the observed curve (blue curve) is above the upper envelop curve and hence we reject the Complete Spatial Randomness (CSR) hypothesis with α=0.95 (%5) confidence level in that distance range. Consequently, the distribution of urban open spaces is evaluated to be clustered in the whole neighborhood of Seferihisar.

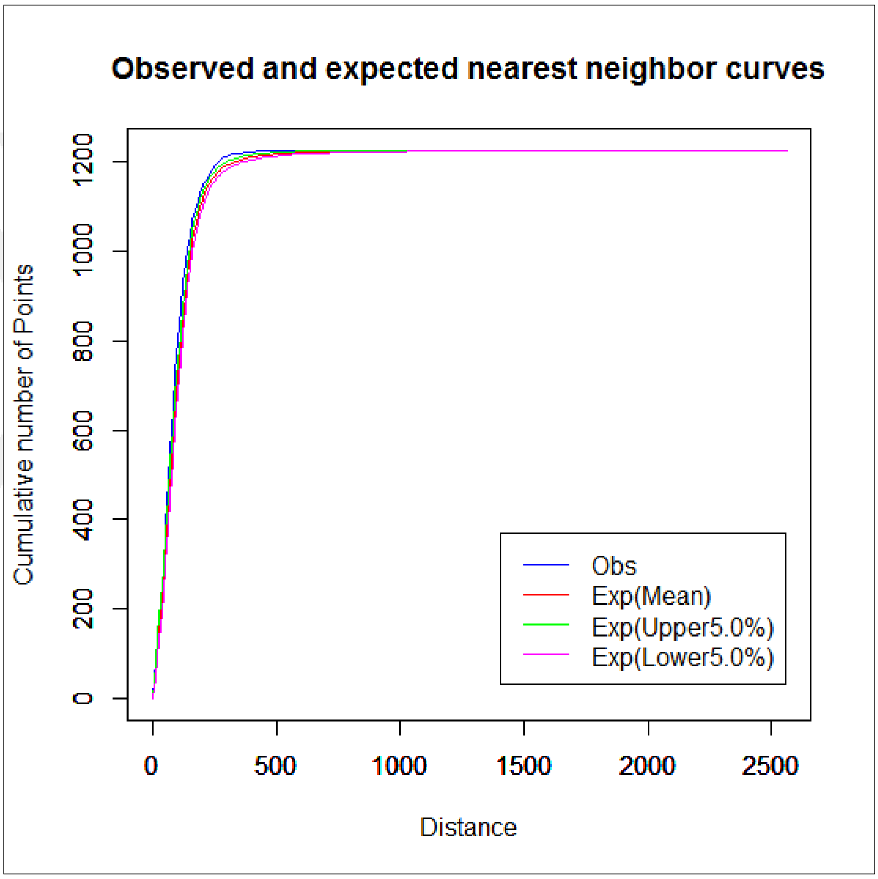

Figure 4.16 Observed and expected nearest neighbor curves, the whole neighborhood of Seferihisar.

Average of the observed neighbor distance : 89.285

Expected Values;

Lower: 98.203

Upper: 105.544

All Average: 101.879

Variance: 7374.188

4.2.1 Atatürk Neighborhood

The distribution of proposed urban green spaces in Atatürk neighborhood varies with the distance. In the chart below (Figure 4.17); the observed curve (blue curve) is above the upper envelop curve for distances about less than 100 m. and hence we reject the Complete Spatial Randomness (CSR) hypothesis with α=0.95 (%5) confidence level in that distance range. Consequently, the distribution of urban open spaces is evaluated to be clustered for distances about less than 100 m. On the other hand, the observed curve (blue curve) is in between the upper and lower envelop curve for distances between about 100 m. and 180 m. In this case, we cannot reject the Complete Spatial Randomness (CSR) hypothesis with α=0.95 (%5) confidence level in that distance range. Consequently, the distribution of urban open spaces is evaluated to be random for distances about more than 100 m. In addition to this, the observed curve (blue curve) is under the lower envelop curve for distances between about 180 m. and 350 m. The distribution of urban open spaces is evaluated to be dispersed for distances between about 180 m. and 350 m. and then it is observed to be random again for distances more than about 350 m.

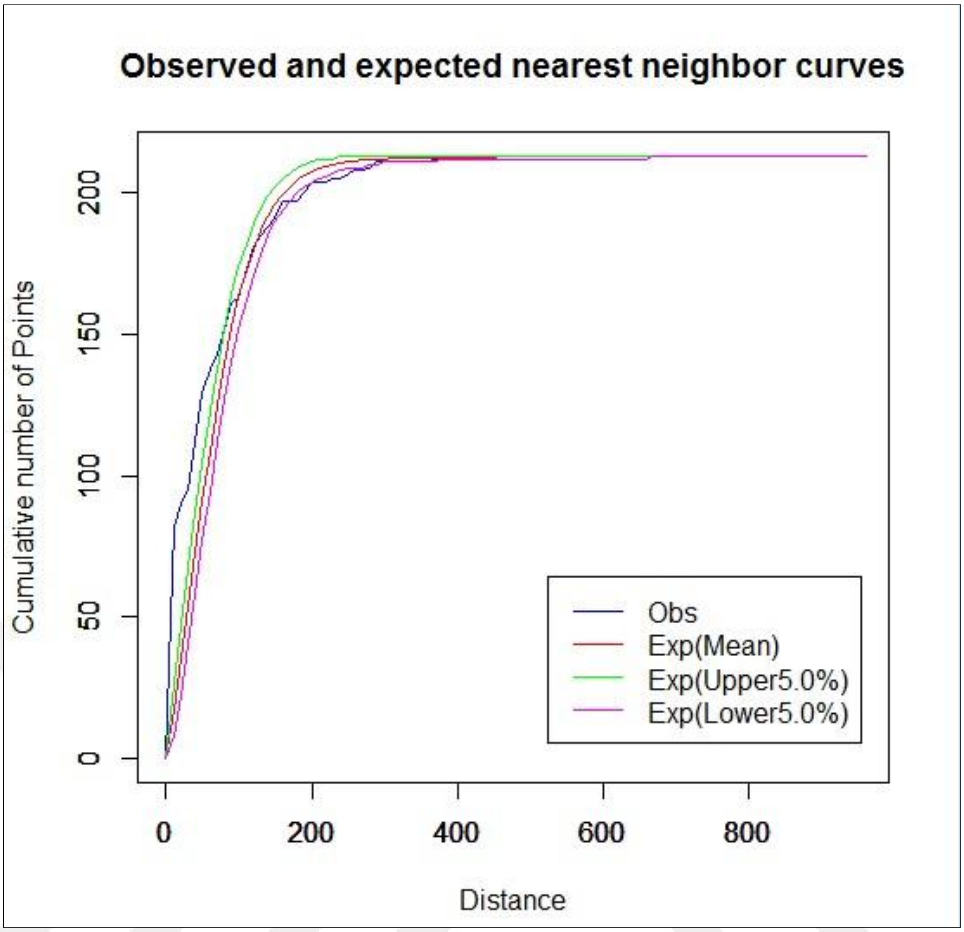

Figure 4.17 Observed and expected nearest neighbor curves, Atatürk neighborhood.

Average of the observed neighbor distance : 57.269

Expected Values;

Lower: 64.044

Upper: 75.771

All Average: 69.967

Variance: 3139.765

4.2.2 Camikebir Neighborhood

In the chart below (Figure 4.18); the observed curve (blue curve) is in between the upper and lower envelop curve. In this case, we cannot reject the Complete Spatial Randomness (CSR) hypothesis with 0.95 (%5) confidence level in that distance range. Consequently, the distribution of urban open spaces is evaluated to be random in Camikebir neighborhood.

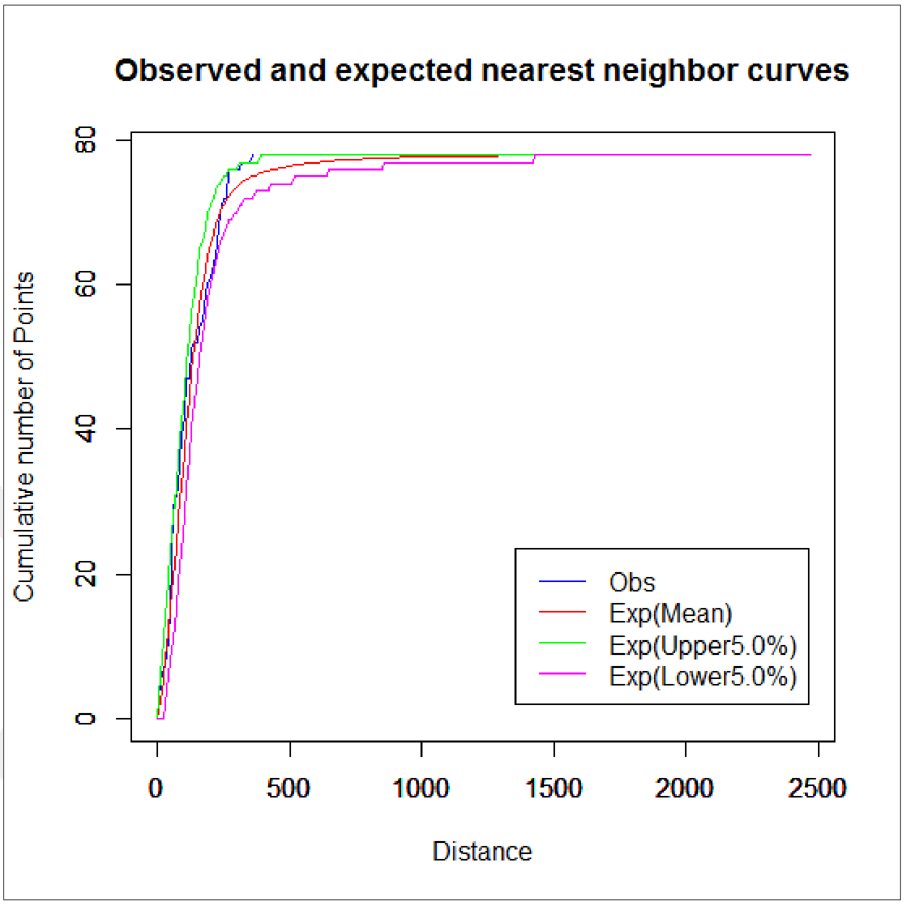

Figure 4.18 Observed and expected nearest neighbor curves, Camikebir neighborhood.

Average of the observed neighbor distance : 116.638

Expected Values;

Lower: 111.637

Upper: 150.571

All Average: 131.757

Variance: 16184.523

4.2.3 Çolakibrahimbey Neighborhood

In the chart below (Figure 4.19); the observed curve (blue curve) is in between the upper and lower envelop curve. In this case, we cannot reject the Complete

Spatial Randomness (CSR) hypothesis with 0.95 (%5) confidence level in that distance range. Consequently, the distribution of urban open spaces is evaluated to be random in Çolakibrahimbey neighborhood.

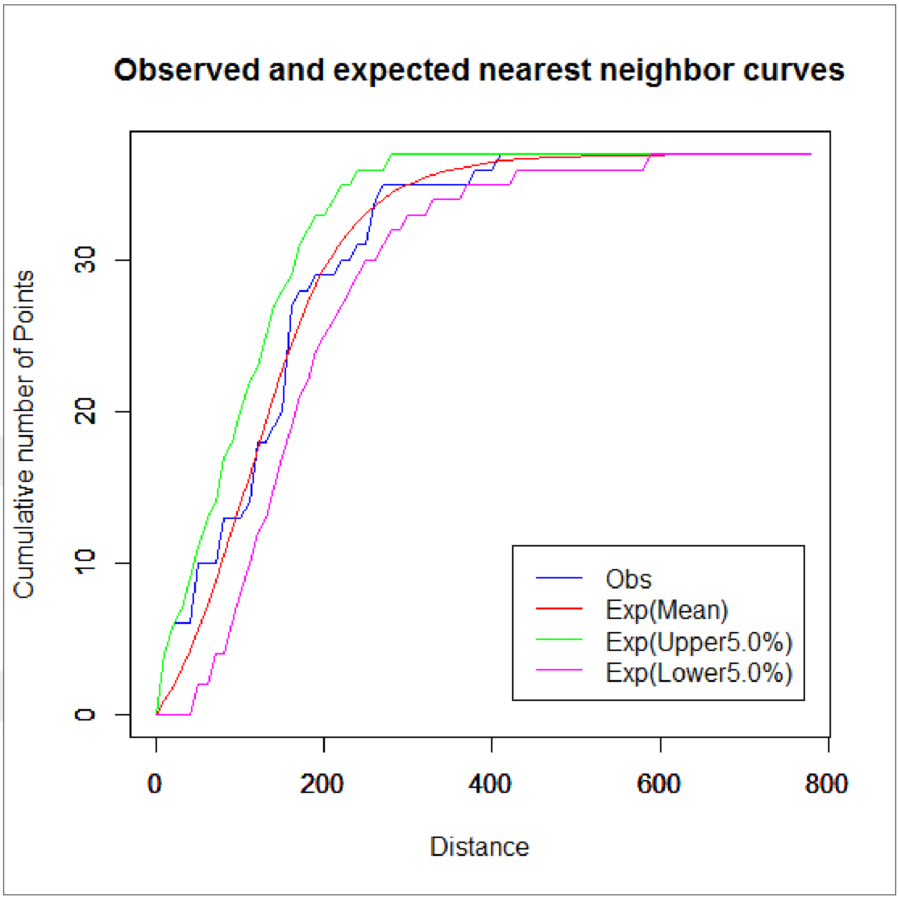

Figure 4.19 Observed and expected nearest neighbor curves, Çolakibrahimbey neighborhood.

Average of the observed neighbor distance : 134.180

Expected Values;

Lower: 113.489

Upper: 163.434

All Average: 138.216

Variance: 8177.990

4.2.4 Cumhuriyet Neighborhood

In the chart below (Figure 4.20); the observed curve (blue curve) is in between the upper and lower envelop curve. In this case, we cannot reject the Complete Spatial Randomness (CSR) hypothesis with 0.95 (%5) confidence level in that distance range. Consequently, the distribution of urban open spaces is evaluated to be random in Cumhuriyet neighborhood.

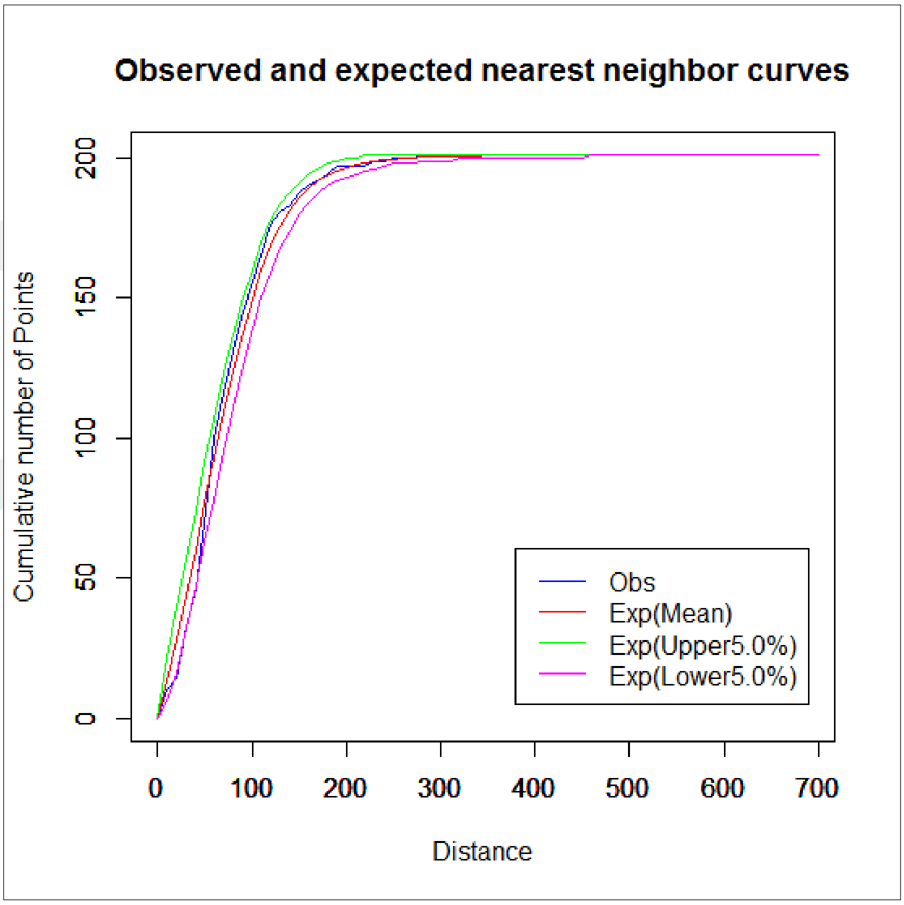

Figure 4.20 Observed and expected nearest neighbor curves, Cumhuriyet neighborhood.

Average of the observed neighbor distance : 72.340

Expected Values;

Lower: 66.430

Upper: 79.188

All Average: 72.917

Variance: 2674.474

4.2.5 Düzce Neighborhood

In the chart below (Figure 4.21); the observed curve (blue curve) is in between the upper and lower envelop curve. In this case, we cannot reject the Complete Spatial Randomness (CSR) hypothesis with 0.95 (%5) confidence level in that distance range. Consequently, the distribution of urban open spaces is evaluated to be random in Düzce neighborhood.

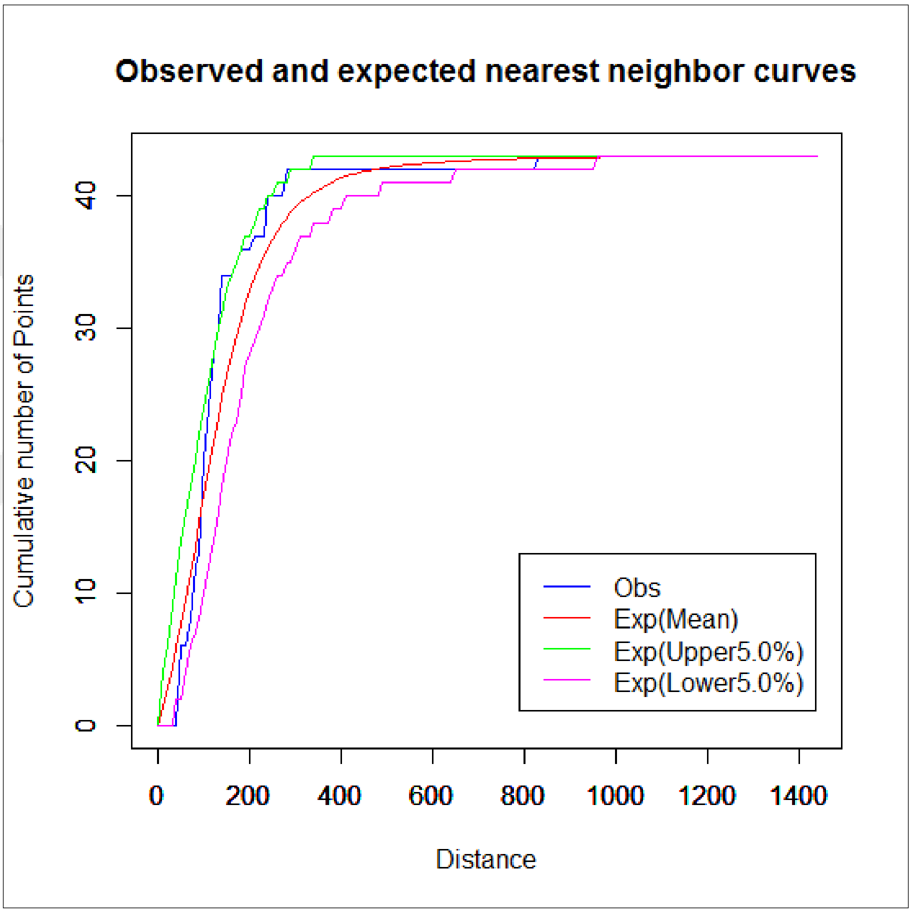

Figure 4.21 Observed and expected nearest neighbor curves, Düzce neighborhood.

Average of the observed neighbor distance : 134.030

Expected Values;

Lower: 118.349

Upper: 176.693

All Average: 147.872

Variance: 14903.284

4.2.6 Hıdırlık Neighborhood

In the chart below (Figure 4.22); the observed curve (blue curve) is in between the upper and lower envelop curve. In this case, we cannot reject the Complete Spatial Randomness (CSR) hypothesis with 0.95 (%5) confidence level in that distance range. Consequently, the distribution of urban open spaces is evaluated to be random in Hıdırlık neighborhood.

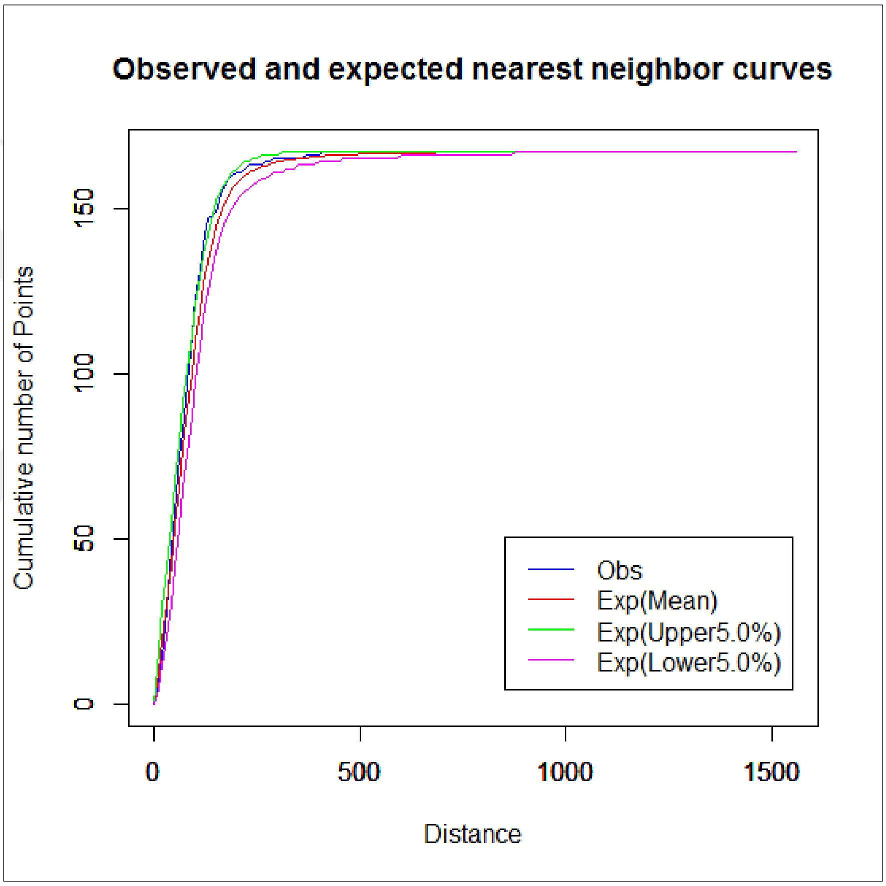

Figure 4.22 Observed and expected nearest neighbor curves, Hıdırlık neighborhood.

Average of the observed neighbor distance : 79.835

Expected Values;

Lower: 80.250

Upper: 97.756

All Average: 88.864

Variance: 5628.032

4.2.7 Payamlı Neighborhood

In the chart below (Figure 4.23); the observed curve (blue curve) is in between the upper and lower envelop curve. In this case, we cannot reject the Complete Spatial Randomness (CSR) hypothesis with 0.95 (%5) confidence level in that distance range. Consequently, the distribution of urban open spaces is evaluated to be random in Payamlı neighborhood.

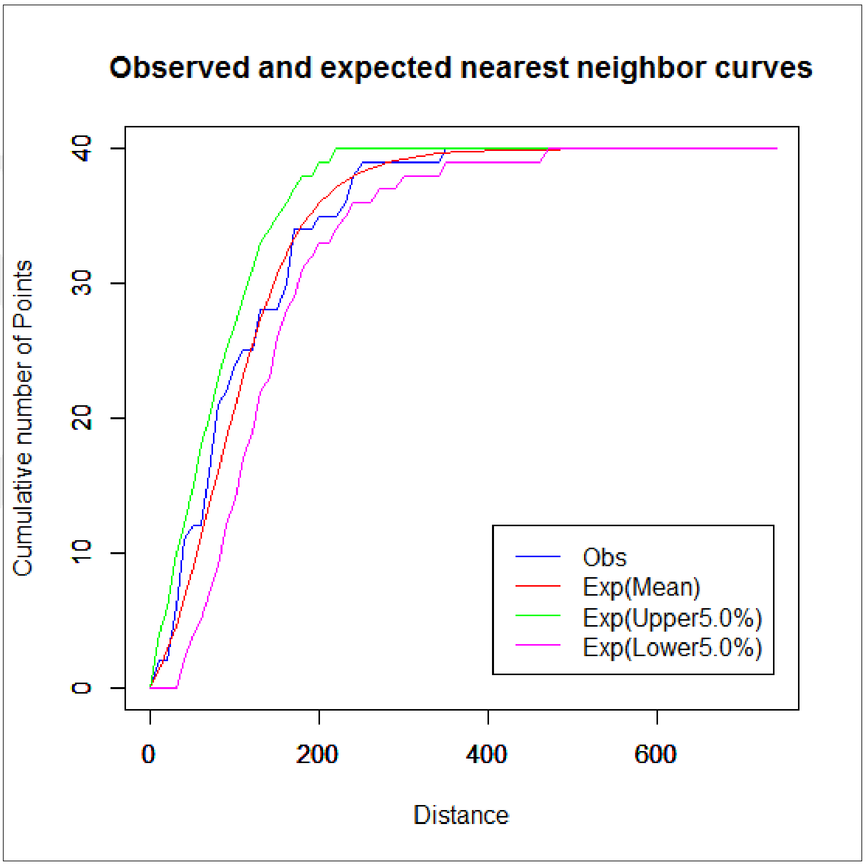

Figure 4.23 Observed and expected nearest neighbor curves, Payamlı neighborhood.

Average of the observed neighbor distance : 105.500

Expected Values;

Lower: 88.516

Upper: 126.970

All Average: 107.755

Variance: 5247.997

4.2.8 Sıgacık Neighborhood

In the chart below (Figure 4.24); the observed curve (blue curve) is above the upper envelop curve and hence we reject the Complete Spatial Randomness (CSR) hypothesis with 0.95 (%5) confidence level in that distance range. Consequently, the distribution of urban open spaces is evaluated to be clustered in Sıgacık neighborhood.

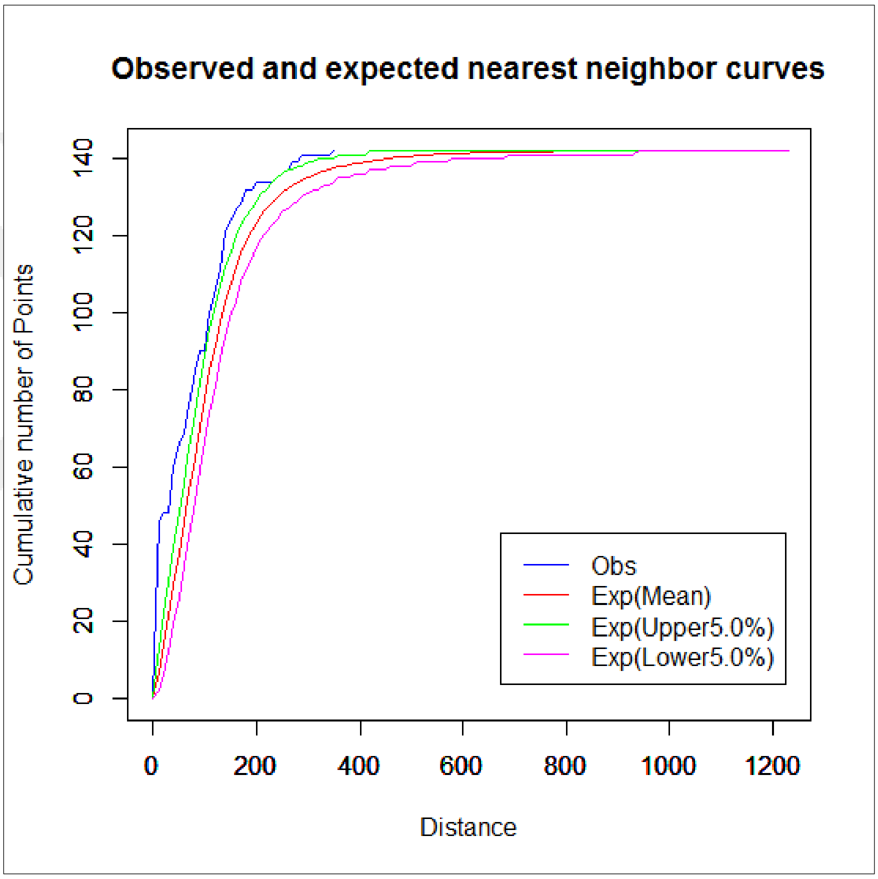

Figure 4.24 Observed and expected nearest neighbor curves, Sıgacık neighborhood.

Average of the observed neighbor distance : 73.576

Expected Values;

Lower: 101.196

Upper: 125.361

All Average: 113.417

Variance: 9885.341

4.2.9 Tepecik Neighborhood

The distribution type of urban open spaces in Tepecik varies according to the distance. In the chart below (Figure 4.25); the observed curve (blue curve) is in between the upper and lower envelop curve for distances about less than 100 m. In this case, we cannot reject the Complete Spatial Randomness (CSR) hypothesis with α=0.95 (%5) confidence level to the about 100 m. Consequently, the distribution of urban open spaces is evaluated to be random for distances about less than 100 m.

On the other hand, the observed curve (blue curve) is above the upper envelop curve for distances about more than 100 m. and hence we reject the Complete Spatial Randomness (CSR) hypothesis with 0.95 (%5) confidence level in that distance range. Consequently, the distribution of urban open spaces is evaluated to be clustered for distances about more than 100 m.

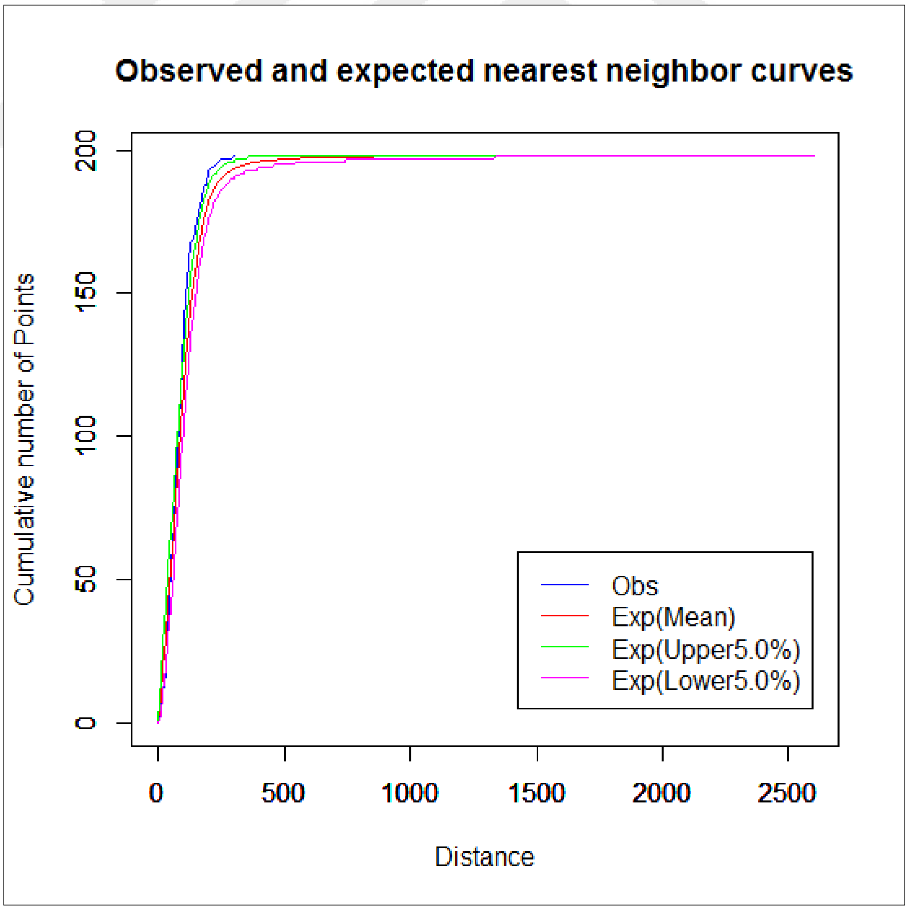

Figure 4.25 Observed and expected nearest neighbor curves, Tepecik neighborhood.

Average of the observed neighbor distance : 86.318

Expected Values;

Lower: 92.199

Upper: 109.579

All Average: 100.896

Variance: 7596.854

4.2.10 Turabiye Neighborhood

In the chart below (Figure 4.26); the observed curve (blue curve) is in between the upper and lower envelop curve. In this case, we cannot reject the Complete Spatial Randomness (CSR) hypothesis with 0.95 (%5) confidence level in that distance range. Consequently, the distribution of urban open spaces is evaluated to be random in Turabiye neighborhood.

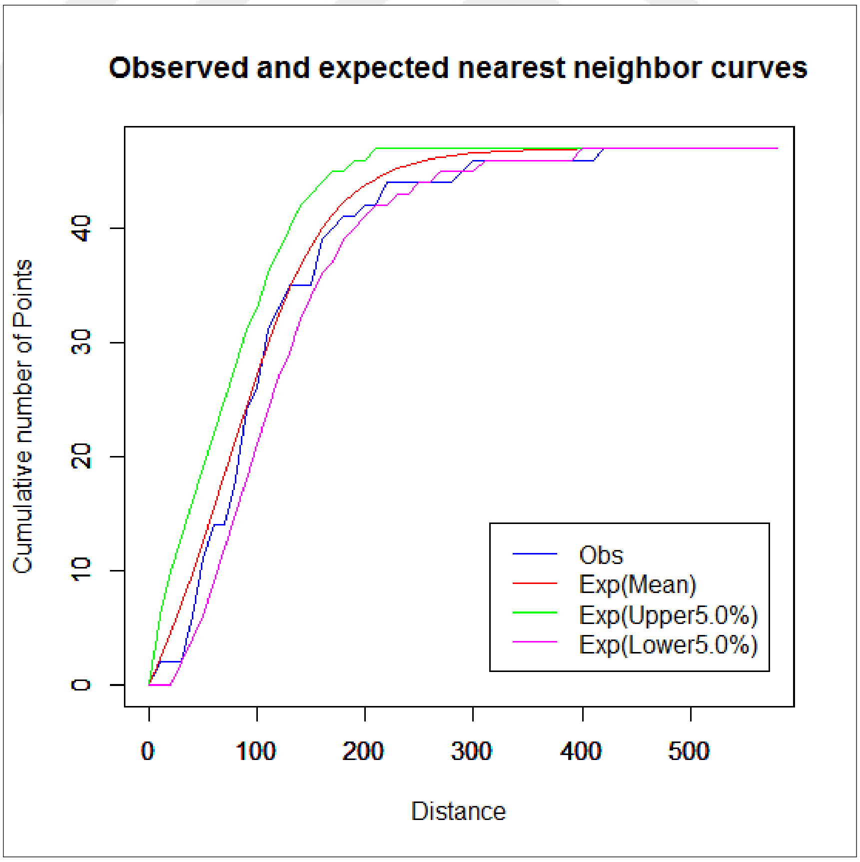

Figure 4.26 Observed and expected nearest neighbor curves, Turabiye neighborhood.

Average of the observed neighbor distance : 109.449

Expected Values;

Lower: 80.141

Upper: 111.295

All Average: 96.232

Variance: 4210.724

4.2.11 Ulamış Neighborhood

In the chart below (Figure 4.27); the observed curve (blue curve) is in between the upper and lower envelop curve. In this case, we cannot reject the Complete Spatial Randomness (CSR) hypothesis with 0.95 (%5) confidence level in that distance range. Consequently, the distribution of urban open spaces is evaluated to be random in Ulamış neighborhood.

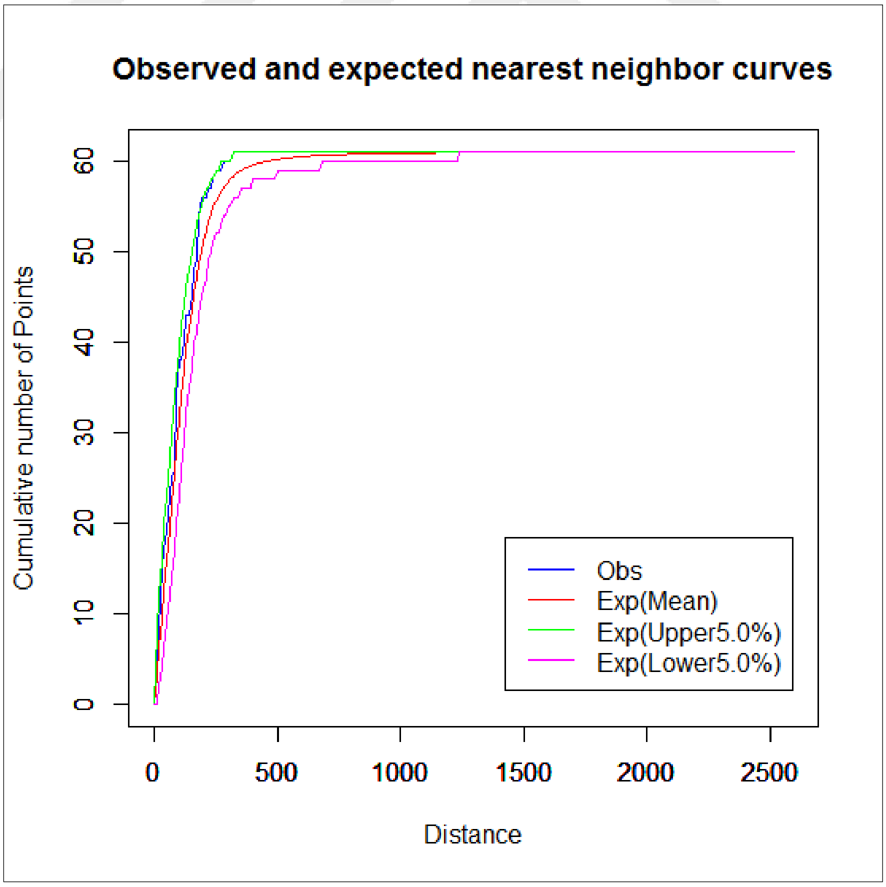

Figure 4.27 Observed and expected nearest neighbor curves, Ulamış neighborhood.

Average of the observed neighbor distance : 96.681

Expected Values;

Lower: 101.108

Upper: 143.777

All Average: 121.973

Variance: 13539.809

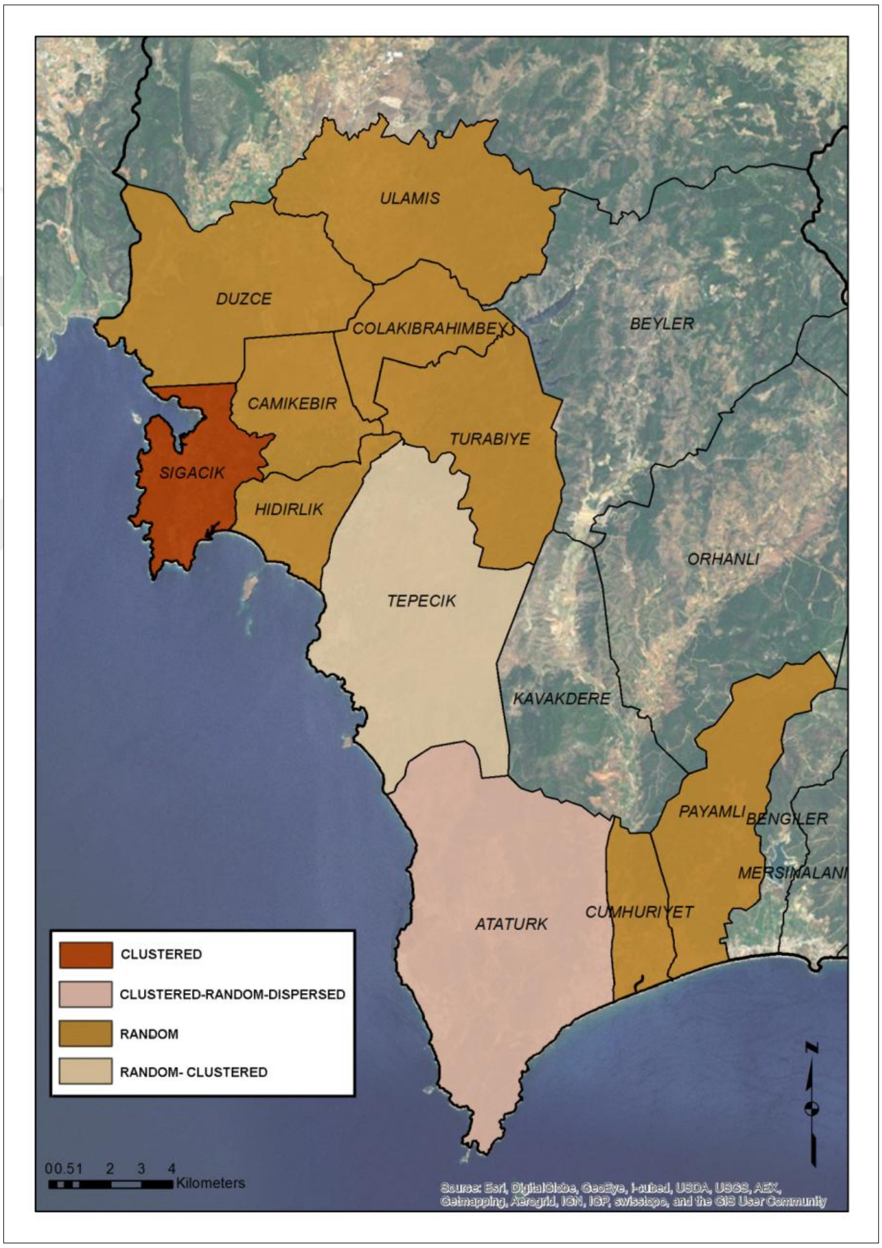

Figure 4.28 Distribution of urban green spaces which is calculated with network nearest neighbor distance .

4.3 Results

In this research, the results from the two nearest neighborhood analyses are compared: Euclidean distances based nearest neighborhood analysis and network distances based nearest neighborhood analysis. In Table 5.1 the results obtained from the two analyses are presented.

Table 5.1 The comparison between two methods

Neighbourhood	Euclidean Distance	Network Nearest Neighbor Distance
Atatürk	Clustered	Clustered- Random-Dispersed
Camikebir	Clustered	Random
Çolak İbrahim Bey	Random	Random
Cumhuriyet	Clustered	Random
Düzce	Clustered	Random
Hıdırlık	Clustered	Random
Payamlı	Random	Random
Sığacık	Clustered	Clustered
Tepecik	Clustered	Random - Clustered
Turabiye	Random	Random
Ulamış	Clustered	Random
The Whole Neighborhood	Clustered	Clustered

Evaluating the dispersion of urban open spaces with the case of at Nearest Neighbour Distance Methods based on on Euclidean distances, some results are different from the whole neighborhood calculation. Çolak İbrahim Bey, Payamlı and Turabiye have a random distribution and the other neighborhoods have a clustered distribution.

On the other hand, Camikebir, Cumhuriyet, Çolak İbrahim Bey, Düzce, Hıdırlık, Payamlı, Turabiye and Ulamış have random dispersion at Network Nearest Neighbour Distance Methods. Distribution of Atatürk and Tepecik varies from clustered to random and dispersed. In addition to this, Sıgacık have clustered dispersion

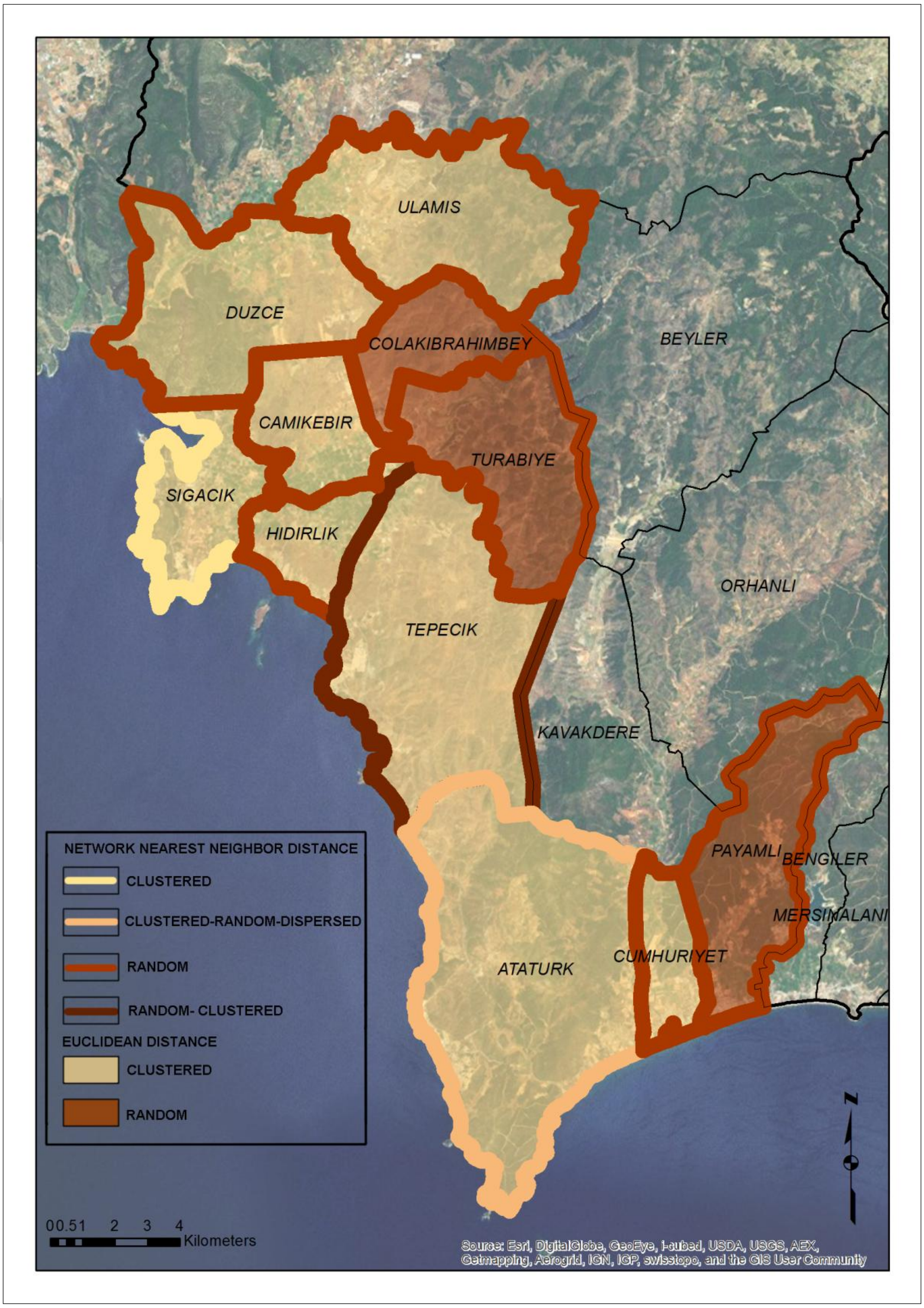

Figure 4.29 The comparison between two methods.

CHAPTER FIVE
CONCLUSION

In this study, the basic question is that how the urban green spaces are distributed over space. To answer this question properly, the methods to be used should be appropriate. In this research, the results from the two nearest neighborhood analyses are compared: Euclidean distances based nearest neighborhood analysis and network distances based nearest neighborhood analysis.

According to the results, when the whole neighborhood is discussed, distribution of the urban open spaces are clustered each other, but also calculation the case of neighborhoods, at Nearest Neighbor Distance Method (Euclidean distance) the results are different. Çolak İbrahim Bey, Payamlı and Turabiye have a random distribution. On the other hand, evaluating the dispersion of urban open spaces with the case of the whole neighborhood at Network Nearest Neighbour Distance Method, the result is the same of the first method, but the most results at the case of the neighborhood are different from the measured results by euclidean distance. Camikebir, Cumhuriyet, Çolak İbrahim Bey, Düzce, Hıdırlık, Payamlı, Turabiye and Ulamış have random dispersion this time. On the other hand, distribution of Atatürk and Tepecik varies from clustered to random and dispersed. Evaluating the dispersion of urban open spaces with the case of the neighborhood at both Nearest Neighbour Distance Methods, the results are different from the whole neighborhood calculation.

The results show that, the distribution of proposed urban green are not uniform or dispersed, which would be the ideal distribution over the cityscape. This finding is valid for both the nearest neighborhood analysis based on Euclidean distances and the nearest neighborhood analysis based on network distances. That can be accepted as a failure in planning decisions. It is revealed that the urban green spaces are planned independently from each other. By this way, it is understood that there is no concern about site selection of green spaces and accessibility in the development plans. Thus, people are not served equally. Limitations based on the built areas may be another explanation.

A second important finding of this research is that the results from the nearest neighborhood analysis based on Euclidean distances and the nearest neighborhood analysis based on network distances are different from each other. That is to say, findings based on Euclidean distances fail to replicate the results based on network distances. As people reach urban green areas using transportation networks, network distance methods seem to be more appropriate. Because, the real world is represented by a network embedded on a plane, events or facilities are represented by points on the network. The distance between two points is measured by the shortest-path distance in this method and the real world can be defined properly.

The nearest neighborhood analysis based on network distances should be used as decision support system when the development plans are prepared. It helps to form the decision of site selection and it can test the plan decisions. The development plans should provide feedback with this method absolutely. In this way, functionality and accessibility of the proposed planning decision can be tested before and after. The spatial analysis should be took part in the planning stage to make an effective planning decision.

In this study, the adequacy of urban green spaces in proposed planning decisions are evaluated in terms of distribution, but discussing the adequacy of urban green spaces with more parameter is possible. Some of parameters are not used to test the adequacy of green spaces in this study. There are some constraints and these are left something out of assessment. These can be sorted as follow; frequency of occurrence, distance from residence, residential densities, the minimum areal extent, functional properties and categories of the urban green spaces etc. However, having a limited duration is restricted to use all parameters of the adequacy of urban green spaces. For this reason, the adequacy of urban green spaces is evaluated by the help of only dispersion parameter. When distribution of green spaces are calculated, the area of green spaces are ignored and they are assumed the point data. On the other hand, it is supposed that people access to green spaces on foot, so "travel time" factor is ruled out in this study.

At the future study, before mentioned parameters will be able to be used for evaluating the adequacy of urban green spaces and neighborhood residents should be conducted a poll. In this way, the adequacy of urban green spaces can be discussed in depth. In the next research, the plans of active utilizable urban green spaces will be able to be prepared in line with request of neighborhood residents. On the other hand, the urban green spaces should be discussed in detail and planned separately. There are different urban green spaces planning approaches from the past, as the green belt, the green wedge, the green network and the green heart. These approaches can be used or developed a new one by the help of the Spatial Statistical Analysis Methods.

REFERENCES

Albayrak, B. (2006). *Çorum kenti mevcut alan kullanım kararları ve açık-yeşil alan verilerinin değerlendirilmesi üzerine bir araştırma*. Yüksek Lisans Tezi, Ankara Üniversitesi, Ankara.

Alkay, E., & Ocakçı, M. (2003). Kentsel yeşil alanların ekonomik değerlerinin ölçülmesinde kullanılabilecek yöntemlerin irdelenmesi. *A Mimarlık, Planlama, Tasarım*, *2* (1), 60-68.

Chrisman, N. (1999). What does GIS mean. *Transaction in GIS,3*(2), 175-186.

Chrisman, N. (1997). *Exploring geographic information systems.* New York; John Wiley and Sons.

Clark, P. J., & Evans, F. C. (1954). *Nearest neighbor as a measure of spatial relationship.* Ecology Society of America (ESA), 445-453.

Comber, A., Brunsdon, C., & Green, E. (2008). Using a GIS-based network analysis to determine urban greenspace accessibility for different ethnic and religious groups. *Landscape and Urban Planning, 86*, 103–114.

Çalışkan, A. M. (1990). *3194 sayılı imar yasası açısından kentlerimizde açık yeşil alan sisteminin geleceği ve Ankara-Çankaya İlçesi örneği*. Yüksek Lisans Tezi, Ankara Üniversitesi, Ankara.

Çulcuoğlu, G. (1997). *Ankara kenti yeşil kuşak çalışmalarının yabancı ülke örnekleri açısından irdelenmesi ve yeşil kuşak sistemi için öneriler*. Doktora Tezi, Ankara Üniversitesi, Ankara.

Değirmencioğlu, N. (1997). *Açık ve yeşil alanların mevcut kent planlama pratiğinde kent makroformuna yansıması ve peyzaj mimarlığı açısından Ankara ölçeğinde irdelenmesi*. Yüksek Lisans Tezi, Ankara Üniversitesi, Ankara.

Ergin, S. (1989). *Kentsel açık yeşil alan donanımının niceliksel değerlendirmesine yönelik matematiksel bir model önerisi*. Dokuz Eylül Üniversitesi Mühendislik - Mimarlık Fakültesi, MMF/ŞBP-89 EY 187, İzmir.

Gül, A., & Küçük, V. (2001*).* Kentsel açık yeşil alanlar ve isparta kenti örneğinde incelenmesi. *Süleyman Demirel Üniversitesi Orman Fakültesi Dergisi, A* (2), ISSN: 1302-7085, 27- 48.

Kahraman, C. (1998). *Kentsel mekanların sürekliliği/süreksizliği ve güvenlik ihtiyacı*. Yüksek Lisans Tezi, İstanbul Üniversitesi, İstanbul.

Lee, J., & Wong, D. W. S. (2001). *Statistical analysis with arcview GIS.* New York; John Wiley and Sons.

Liu, S., & Zhu, X. (2004). Accessibility analyst: an ıntegrated GIS tool for accessibility analysis in urban transportation planning. *Environment and Planning B: Planning and Design, 31,* 105-124.

Lwin, K. K., & Murayama, Y. (2011). Modelling of urban green space walkability: eco-friendly walk score calculator. *Computers, Environment and Urban Systems 35,* 408–420.

Mcharg, I. (1969). *Design with nature*. New York; Doubleday/Natural History Press.

Murayama, Y., & Thapa, R.B. (2011). *Spatial analysis and modeling in geographical transformation process*. Springer Science+Business Media B.V.

Müftüoğlu, V. (2008). *Kentsel açık yeşil alan karar ve uygulamalarının imar mevzuatı kapsamında Ankara kenti örneğinde irdelenmesi*. Yüksek Lisans Tezi, Ankara Üniversitesi, Ankara.

Okabe, A., Sugihara, K., & Shiode, S. (2006). *A toolbox for spatial analysis on a network*. Geographical Analysis, ISSN 0016-7363, 57-67.

Okabe, A., Yomono, H., & Kitamura, M. (1995). Statistical analysis of the distribution of points on a Network. *Geographical Analysis*, 152-175.

Rosa, D. L. (2013). Accessibility to greenspaces: GIS based indicators for sustainableplanning in a dense urban context. *Ecological Indicators*.

Sander, H. A., Ghosh, D., Riper D.V., & Manson S. M. (2010). How do you measure distance in spatial models? An example using open-space valuation. *Environment and Planning B: Planning and Design, 37*, 874-894.

SANET Team (2013). *The manual for SANET V4.1 beta runs on arcgis 10 & arcgis 10.1*. Retrieved November,2015, from http://sanet.csis.u-tokyo.ac.jp.

Senanayake, I. P., Welivitiya, W., & Nadeeka, P. M. (2013). Urban green spaces analysis for development planning in Colombo, Sri Lanka, utilizing THEOS satellite imagery – a remote sensing and GIS approach. *Urban Forestry & Urban Greening, 12*, 307–314.

Tazebay, İ. (1991). *Ankara kent merkezinin doğu-batı aksını oluşturan açık ve yeşil alan dizisinin işlevselliği üzerinde araştırma*. Yüksek Lisans Tezi, Ankara Üniversitesi, Ankara.

Yeşil, A. (2006). *Ankara metropoliten alanın yeşil alan sisteminin analizi*. Yüksek Lisans Tezi, Yıldız Teknik Üniversitesi, İstanbul.