GÜFBED/*GUSTIJ* (2021) 11 (2): 497-509
DOI: 10.17714/gumusfenbil.685894 Araştırma Makalesi / *Research Article*

Analysis of car park etudes with different statistical methods and modeling with GIS: Erzincan province case

Otopark etütlerinin farklı istatistiksel yöntemler ile analizi ve CBS ile modellenmesi: Erzincan ili örneği

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• Geliş tarihi / *Received*: 06.02.2020 • Düzeltilerek geliş tarihi / *Received in revised form*: 15.02.2021 • Kabul tarihi / *Accepted*: 11.03.2021

Abstract
Rapidly changing lifestyles, rising expectations, and increased private vehicle ownership have caused increases in the number of urban trips. All these changes that have appeared in time have made the parking requirement more important every day. Parking surveys have been required to determine what actions to be taken leadingly during the location selection and building processes of the parking areas to be built. The failure on planning parking areas correctly reveals environmental and economic problems as well as social problems. In this study, parking surveys were carried out primarily in order to determine location, types and capacities of existing car parks. The capacity and locations of the new parking areas have been determined considering five-year traffic increases. The points where parking needs were most needed were determined counting the vehicles parked at 44 separate on-road parking areas in the city center of Erzincan, where parking fees are charged by the municipality. In determined parking areas, statistical analyses were performed with spatial analysis outputs, artificial neural networks and time series analysis methods counting the vehicles parked regularly during daylight hours for one year. Solutions were offered to reduce parking load in traffic identifying new correctly located car parking areas in Erzincan city center. In the light of the analysis results, the location and capacities of the new parking areas suggested to be built identifying 6 different points in the city center were determined. In conclusion, an additional 1420-vehicle parking capacity in suggested new parking spaces was proposed as a solution-oriented approach for the parking problem in the city center.

Keywords: Artificial neural networks, Location selection, Parking survey, Spatial analysis, Time series analysis

Öz
Hızla değişen yaşam tarzları, yükselen beklentiler, özel araç sahipliğinin artması, kentsel yolculuk sayılarında artışlara neden olmaktadır. Zaman içinde meydana gelen tüm bu değişiklikler otopark gereksinimini her geçen gün daha da önemli kılmaktadır. Yapılacak olan otopark alanlarının konum seçimi ve kurulum süreçleri içerisinde başlangıç olarak yapılması gerekenlerin neler olduğunu belirlemek için otopark etütlerinin yapılması gerekmektedir. Otopark alanlarının doğru planlanmaması, çevresel ve ekonomik sorunların yanında sosyal problemleri de ortaya çıkarmaktadır. Bu çalışmada öncelikle mevcut otoparkların konum, tür ve kapasitelerinin belirlenmesi amacıyla otopark etütleri yapılmıştır. Beş yıllık trafik artışları da dikkate alınarak yeni otopark alanlarının kapasite ve konumları belirlenmiştir. Erzincan ili şehir merkezinde bulunan ve belediye tarafından park ücreti alınan 44 ayrı yol üzeri park alanı noktasında park eden araçların sayımları yapılarak otopark ihtiyacının en çok olduğu noktalar tespit edilmiştir. Belirlenen park alanlarında, bir yıl boyunca düzenli olarak gündüz saatlerinde park eden araç sayımları yapılarak mekânsal analiz çıktıları, yapay sinir ağları ve zaman serileri analizi yöntemleri ile istatistiksel analizleri yapılmıştır. Erzincan kent merkezinde bulunan doğru konumlandırılmış yeni otopark alanları belirlenerek trafikteki otopark yükünü azaltmaya yönelik çözüm önerileri sunulmuştur. Ortaya çıkan analiz sonuçları ışığında il merkezinde 6 ayrı nokta belirlenerek yapılması önerilen yeni otopark alanlarının konum ve kapasiteleri belirlenmiştir. Sonuç olarak önerilen yeni park alanlarındaki 1420 araçlık ek otopark kapasitesi il merkezindeki otopark problemine çözüm odaklı bir yaklaşım önerilmiştir.

***Anahtar Kelimeler**: Yapay sinir ağları, Konum seçimi, Otopark etüdü, Mekânsal analiz, Zaman serileri analizi*

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1. Introduction

Rapidly changing lifestyles, rising expectations, increasing interest in purchasing private vehicles and the rise in country's population have increased the daily trip rates per capita causing increases in the number of urban trips. All these changes have prioritized the need for parking more and more important every day. Location selection for urban parking area is essential for making efficient, on-site, and accurate decisions increasing the survey benefit as well as designing outdoor spaces. Further traffic surveys should be carried out before attraction centers such as shopping malls, hospitals, industrial zones that increase traffic density have been built. Determining what needed to be done initially for location selection and building processes of the parking areas to be built and enriching the contents of the car park survey ensure making more accurate decisions (İskender, 2010). In addition, it has also aimed to produce a solution in order to ensure standard on-site implementation of survey, reporting, real-time visualization and accelerating the process of ensuring the integration of traffic load in the near future. Urban outdoors indicates a whole created by the constructions and refers areas where all urban events are experienced. Proper construction of these outside environments is remarkable for cities (Özbuğday, 2009). Insufficient infrastructure, on the other hand, makes the parking problem inextricable. Determination of parking policy by local governments and carrying out necessary surveys are compulsory for offering solutions (Haldenbilen et al., 1999). The efforts of people to leave their vehicles in safe and correct places during their daily trips have also brought the problem of parking, which is part of the traffic problem, to the agenda (Gökdağ and Yarbaşı, 2014). When previous literature studies were reviewed, it was noticed that the researches on parking problems in city centers were mostly carried out for large cities; although the studies reporting small-scale cities were also noticed, it was determined that solutions for many applications could not be reached, and spatial analysis methods and statistical analysis methods were not used together. In reviewed literature studies, it was specified that the observations lasted for no more than six months. In this study, the counts for 44 separate on-road parking points were carried out for one year.

In order to organize randomness in parking management in Abu Dhabi, Abu Dhabi City started implementing a new paid parking system inside the city, named Mawaqif. This new system helps reducing the parking problem in congested areas but transferred the problem to less crowded areas in the city (Alkheder, S. A., Rajab, M. M. A., and Alzoubi K., 2016). Ecosystem architecture including interconnected service platforms was created so that the parking services can be explored universally and used to reduce the traffic problems related to the park (Strasser M., Mauser D. and Albayrak S., 2016). In order to minimize traffic congestion and provide efficient parking facilities in Dhaka city, a prototype of the reservation-based parking system was designed and simulated by developing a smartphone-based parking model (Dey, S. K. et al., 2019). It was a systematic project for fundamentally solving the curb parking problem in city. It temporarily worked to increase parking management enforcement, perfect road parking sign, or strengthen travelers' thought education. From perspective of demand management for curb parking, this paper put forwards five fundamental solutions including making the city transportation system perfect, improving travelling structure, and taking advantage of technological intelligence to curb parking problems (Wang D., Han X., and Xing G., 2016).

The problems for parking planning and projecting phases investigated by architects, engineers, students, official institutions, and organizations in terms of private cars have been profoundly examined (Kargı, 2013). Increasing parking needs arisen from increased population density and transportation problems in city centers due to the reasons such as rapid urbanization and easy vehicle owning were analyzed (Gökdağ and Yarbaşı, 2014). With the need for parking spaces in Denizli city center, the results of off-street parking survey were presented emphasizing the decrease in road capacity due to the difficulty in parking outside the car park areas (Haldenbilen et al., 1999). Adana city transportation system and management problems were examined considering spatial, environmental and socioeconomic developments and the views of the individuals who were resident in the city on transportation problems were revealed with questionnaires and various statistical methods (Sandal and Traş, 2012). A practical system was suggested to administer the concept of parking planning and management at the level of small-scale cities (Özen, 2014). Capacities, usage rates and frequency of parking spaces, purposes of use and parking times were analyzed (Kaplan and Yıldız, 2002). Parking problems in Eskisehir city center were investigated in an approach based on sustainable transportation system (Yalnız and Bilgiç, 2006). Depending upon year-by-year developments in transportation systems and

reasons for the occurrence of parking problems, the demands of parking especially due to the way of using urban land was investigated (Çıkman, 2003). For ensuring a sustainable transportation system, the dimensions and types of parking problems were analyzed with main headings highlighting parking management strategies, and the problems were tried to be identified (Barhani, 2007). Parking problems were examined for the city center of Konya (Güngör, 2006). The general definition and types of car parks were analyzed in detail depending upon the concept of parking possible to be integrated into transportation systems in a way reducing vehicle ownership and supporting public transportation systems (Özdemir, 2006). Evaluations were suggested on the current status of parking areas throughout İstanbul and the way they were used (Aslan, 1998). Emphasizing the urban planning of parking spaces, the types and shapes of parks based on standards and regulations were mentioned (Özel, 1996).

Disordered growth in residential areas and lack of infrastructure have caused structures to be dense in certain areas of settlements and appearance of significant transportation problems in everyday life. Random parking of vehicles on roadsides causes narrowing of the roads and, therefore, traffic density and congestion (Özdemir, 2006; Çiçek, 2015). Car parking areas are needed at destination points of trips by car. In addition to the environmental and economic problems appearing when these parking areas are not planned correctly, these also reveal social problems negatively affecting the activities of the society. This effect has been noticed in a large area in large cities, whereas being noticed in a narrow area in small cities. When regarded in this sense, parking and transportation problems will be largely overcome with correct parking design to be planned in the city center. Whereas it is difficult to plan parking areas in big cities due to the number of cars and difficulty in creating parking spaces, this problem is possible to be overcome more simply and quickly in small cities. Survey is essential for the solution of the parking problem. In accordance with the information above, this study was carried out using the parking data obtained for a year as result of a detailed and comprehensive research, unlike the existing studies carried out so far in order to reveal parking problem in Erzincan as a small-scale province. This study included four chapters, and the first chapter was the introduction. This part was the one introducing the subject and explaining the previous studies. The second section included material and method and included data collection and analysis methods used in the study. The third section included the findings and discussion part, and the findings and data related to the results obtained as result of the study were briefly expressed in written form. In the final section of the conclusion and recommendations, solutions were offered explaining the transfer of the information found as result of the study, the significance of the results and what these results indicated. In this study, it was aimed to make realistic, on-site, accurate decisions for the new car parks planned to be built using spatial analysis outputs and statistical analysis methods on GIS system of parking surveys conducted in the provincial center.

2. Material and method

While analyzing the data obtained in the study, time series analysis and artificial neural network methods were used statistically, and geographic information system (GIS) was used for spatial analysis.

2.1. Time series analysis

A time series is a sequence of data points typically measured at uniform time intervals. The samples occur in a variety of fields ranging from economics to engineering, and methods of analyzing time series create an important part of statistics. Time series analysis includes methods for analyzing time series data in order to extract meaningful characteristics of the data and predict future values. The Autoregressive Integrated Moving Average (ARIMA) models, or Box-Jenkins methodology, are linear models that represent stationary as well as nonstationary time series ARIMA models relying heavily on autocorrelation patterns (Green, 2011). A stochastic transaction provides a framework for directing uncertainty into predictions (Ahmad et al., 2002, Wang et al., 2014). One of the most popular models used for this purpose is Box-Jenkins autoregressive integrated moving average (ARIMA) model. It is used to create synthetic series with the same persistence structure as an observed series and also to predict the behavior of a time series regarding past values (Cadenas & Rivera, 2010). The main purpose of Box-Jenkins ARIMA model time series modeling is to predict future trend depending upon past behavior. One of the most frequently used models for this purpose is Box-Jenkins Autoregressive Integrated Moving Average (ARIMA) model (Chattopadhyay & Chattopadhyay, 2010). Time-dependent changes of the data are observed while performing time series analysis. For example, traffic accidents happening on the roads are more common during the holidays

rather than the traffic in the normal time, namely, the accident rates change depending upon time. Time series analysis is benefited for noticing inconsistent data, making predictions, completing the missing data and correcting the mistakes. Time series analysis methods are moving average, relative strength index, momentum and rate of change.

2.2. Artificial neural networks

Artificial neural networks were created and developed influencing from the biological nervous system. Biological nerve cells communicate with each other through synapses. A nerve cell conveys the information it processes to other cells using axons. Similarly, artificial nerve cells collect external information with a gathering function and send the information to other cells of the network producing the output. The elements creating the structure have different addition and activation functions. The values of the connections that connect artificial neural networks are called weight values. Process elements come together in 3 layers parallel to each other and create a network. These three layers are input layer, intermediate layers, and output layer. The information is delivered to the network through the input layer. They are sent to the output layer as being processed in intermediate layers. The network's ability to produce correct outputs for the inputs depends on entering correct values of the weights.

2.3. Geographic information system (GIS)

The GIS system used as the spatial analysis method in the study is a system including hardware, software, personnel and methods performing the functions of collecting, saving, processing, evaluating, associating, updating, questioning, analyzing and presenting all kinds of graphic and non-graphic spatial information in order to assist users in decision-making processes depending on location related to the solution of social, economic, environmental, etc. problems in the world. In other words, GIS is a system that has the function of collecting, saving, processing and presenting all graphical and non-graphical data obtained with observations depending on location (Yomralıoğlu, 2000). Geographical information systems provide powerful tools that allow data to be analyzed, visualized, and make conscious decisions (Hanchette C., 2014). GIS is a decision support system that fulfills the process of collecting, saving, analyzing, and presenting spatial and non-spatial geographical data in accordance with the purposes of the study. GIS is effectively used for determining the route used in navigation applications with various analyzes and presenting the results to the users (Durduran et al., 2018). Using the network analysis tool of GIS, solutions are offered to problems such as analyzing the shortest path with any road network, accessing to fire stations, police stations, hospitals, determining product delivery routes, and analyzing service networks (Varol et al., 2010). GIS provides an opportunity for analyzing spatial data using both multi-scalar and diachronic approaches, and, quite importantly, in a digital and quantitative manner (Remoaldo, P. C. A. Ribeiro V., Lopes H. S. and Silva S. C. G., 2018). In the study, ArcGIS software developed by ESRI was used for the analyzes based on geographic information system. In the study, maps illustrating the number of parking vehicles were created using the Kernel Density method which was one of the important analysis methods of GIS processing current parking spaces in the city center and 44 on-road parking spaces charged by Erzincan Municipality on the map. This process was used to reduce the number of vehicles parked on the road and accessibility for the distribution of the proposed parking areas.

2.4. Data collection and analysis

Screening model was used to recognize the parking problems, examine solution suggestions, and determine the efficiency of systems put forward with the advancing technology. General screening models indicated screening arrangements made on the whole universe or a group of samples taken from the population in order to make a general judgement about the universe including various elements (Karasar, 1994). Using the general screening method, all kinds of information about the parking areas were collected, and a common compliance and implementation integrity was achieved. The 44 parking areas Erzincan Municipality allowed on-road parking with fee in the city center were mapped with Google Earth program (Figure 1). Then, the parking areas serving as parking lots in the city center were determined and their capacities and locations were determined.

Figure 1. 44 road parking areas used in the city center and charged by the municipality

The number of vehicles that parked in parking lots was counted with the hand terminals used by the parking officers of Erzincan Municipality. The number and parking time of the vehicles in the parking areas were determined obtaining the data from the hand terminals of the parking staff. The obtained data covered a one-year permanent period. The parking space occupation period which started at the same time as the license plates of the vehicles parked instantly via electronic hand terminals were entered into the system was recorded. Combining these parking times in computer environment, hourly, daily, monthly, and annual total times and average parking times were calculated. In addition, the data were grouped in three different time periods as morning, noon, and evening. According to this, the morning group included 7a.m., 8a.m., 9a.m., 10a.m., and 11a.m. Noon hours included 12p.m., 1p.m., 2p.m., and 3p.m. Hours after 4p.m. were called the evening group.

Three columns were created for 44 observation points and the total number of cars parked in the morning, noon and evening and the average number of vehicles were entered. Subsequently, the maps presenting the average values of these three groups were created and the thematic map created with the Kernel Density method using the spatial data in ArcGIS 10 software was presented in Figure 2. The created thematic map was used to observe the distribution of parking in the city center and to determine the areas where the new parking lots in addition to the existing structure should be planned.

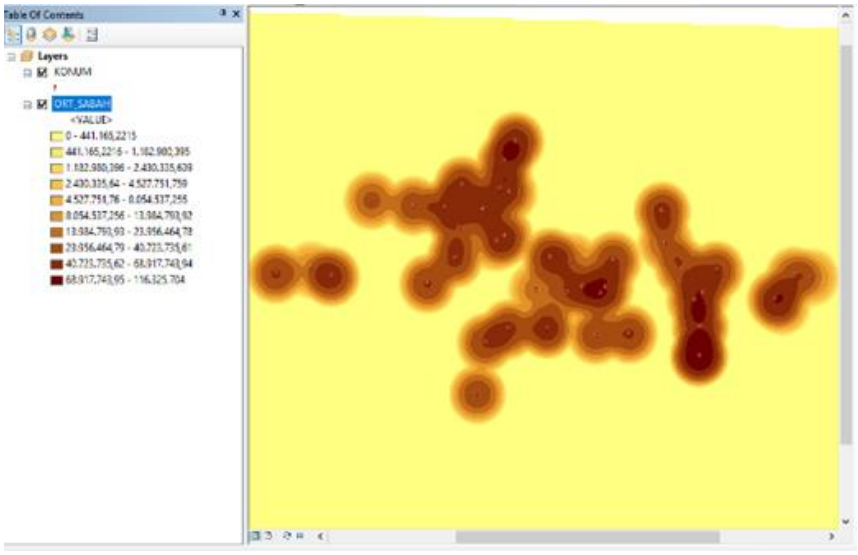

Figure 2. Kernel density analysis (analysis of on-street parking areas)

44 road parking areas in the city center where observations were made are named as in Table 1.

Table 1. Charged on-street parking spaces of Erzincan municipality

Erzincan city center on-street parking observation points			
Point No	**Name of Point**	**Point No**	**Name of Point**
1	in front of Metinler Bazaar	23	in front of Manifaturacilar
2	Selimoğlu Commercial Complex	24	in front of Yildiz
3	in front of Mado	25	in front of Fatih Bazaar
4	in front of Uzun Bazaar	26	west Gülistan Hotel
5	Bariş Manço Park	27	in front of Emniyet Bazaar
6	in front of Ordu Bazaar	28	in front of Lambaci
7	in front of Ari Firini	29	east of Buğday Square
8	north of Gemi Commercial Center	30	south of Buğday Square
9	south of Gemi Commercial Center	31	in front of Asist
10	next to Ziraat Bank	32	in front of Hiraoğullari
11	Eğinlioğlu Commercial Center	33	in front of Polat Commercial Center
12	in front of Sony Service	34	in front of Kizilay Centre
13	in front of Camii Kebir	35	in front of Ermar Shopping Mall
14	in front of Ing Bank	36	in front of Erzingaz
15	in front of Şekerbank	37	back to Büyük Bazaar
16	east road of Ermerkez	38	in front of Tozlu Shopping Mall
17	in front of Halkbank	39	in front of Mazda
18	in front of Vakifbank	40	next to Manifaturacilar
19	in front of Milli Eğitim	41	in front of v.savaş
20	in front of Karakaya Hotel	42	in front of 1st health care center
21	in front of Büyük Bazaar	43	in front of Boyacilar Cami
22	in front of Fevzipaşa	44	in front of Adalet Sarayi

In Table 1, the list of the on-road parking areas used extensively in the city center was listed and after the coordinates of the given parking areas are determined, KML (Keyhole Markup Language) as a format used for storing geographic data and related content was created entering in Google Earth. Then, KML Folder was transformed into Shape (storing the geometric locations and quality information of geographical features) as in Figure 3. To add new fields to the exported file, the field calculator operation was performed applying the add field-batch command (adding a new field to a table or to the raster of a property class, property layer and attribute tables).

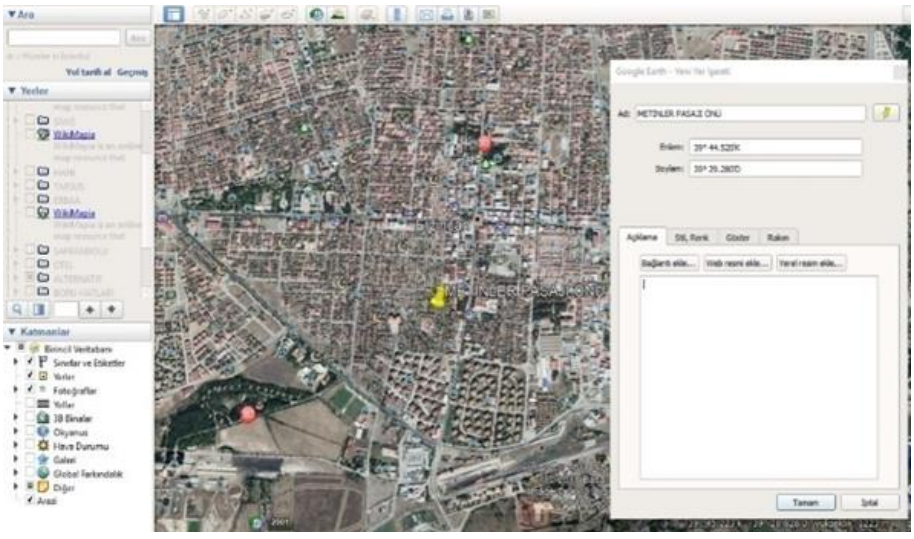

Figure 3. Creating KML

3. Findings and discussion

Parking has been a problem in Erzincan where there is a highly planned urbanization. It was observed that the parking problem in and around Dörtyol which had the busiest traffic of the city where due to shopping areas, restaurants and banks caused drivers to get annoyed and caused parking violations. It was determined that the existing road-long parking areas were occupied by the owners of the workplaces due to their long-term parking and therefore the individuals who came for business follow-up and shopping did not find a place to park their vehicles for a short time. In addition, it was observed that the sincere relationships between the park staff of Erzincan Municipality and the workplace owners created an obstacle for collecting the parking fees. For this reason, it was observed that the disincentive pricing aspect of long-time parking did not provide any benefit.

There were totally in-service 37 parking lots in the city center. Twenty-six out of these car parks were in-service and 11 were out-of-service. Regarding the capacities of the existing car parks, the average capacity of the parking spaces was calculated to be 24 vehicles per car park. It was observed that many places serving as parking lots had a car-wash license instead of obtaining a parking license. During the face-to-face interviews with the parking lot owners, it was learned that female customers did not prefer parking areas located in the basement or descended by a ramp. The reason for this was said to be the steepness and narrowness of the descending ramps. In addition, in the price comparisons, it has been observed that the municipality's road parking fee is more appropriate than the normal parking fees. Furthermore, in terms of comparing the fees, on-street parking fees were observed to be lower than normal parking lot fees. The fact that the parking lots in the back streets caused on-street parking spaces more beneficial. When the occupancy rates of the car parks in the city center were examined, it was observed that low-capacity open parking lots were preferred more than closed parking lots as they were more practical and economical.

Considering the observations and counts made in the city center, the morning, noon and evening hours were categorized in 3 groups. The maps showing the number of cars parked in the city center were created thematically in Figure 4, Figure 5, and Figure 6 processing the counting information collected from the road parking areas in the city center for a year in Arcgis software, and the average number of parked vehicles was presented in Figure 7.

Figure 4. Thematic map for morning hours

Figure 5. Thematic map for noon hours

It was determined that the number of vehicles parked in the morning was the most between 7a.m. and 9a.m. The distribution map of the number of vehicles parked in the morning was presented in Figure 4. It was observed that the number of cars parked at noon hours was the most between 12p.m. and 2p.m. The map with the noon-hour was presented in Figure 5.

Figure 6. Density map for evening hours

Figure 7. Parking space fit map

It was determined that the number of vehicles parked in the evening hours was the most between 5p.m. and 7p.m. The distribution map of the number of vehicles parked in the evening hours was presented in Figure 6. The parking fit map suggested to be created was obtained combining the maps of the number of vehicles that parked in the morning, noon and evening hours as presented in Figure 7.

Thematic parking number maps were obtained as result of the analysis performed with ArcGIS software. Time series analysis was used to predict the number of cars to be parked in the future. ANN analysis was used to compare the obtained estimation results. Which one of these two methods revealed closer outputs to the real series was analyzed to obtain prediction results. The graphical outputs as result of the analysis were as follows:

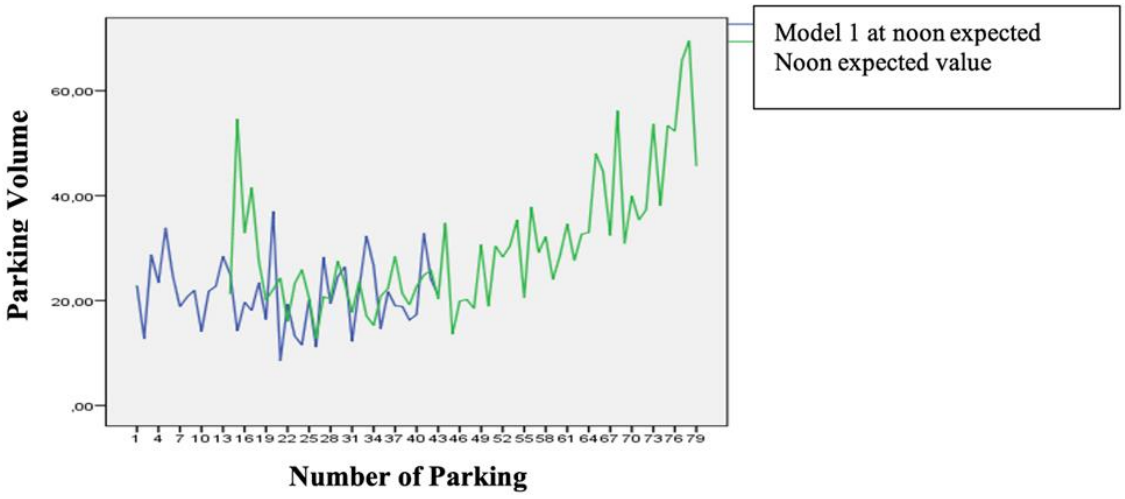

Figure 8. ANN fit graphic

ANN analysis fit graphic of the model was presented in Figure 8. It was observed that there was a seasonal fluctuation in the graphic. In addition to the fit in the graph, it was observed that parking peaked at certain minutes of noon times. Moreover, it was also observed that the number of parking in noon times was consistent with the prediction series. The time series analysis fit chart of the model for the noon hours was presented in Figure 9.

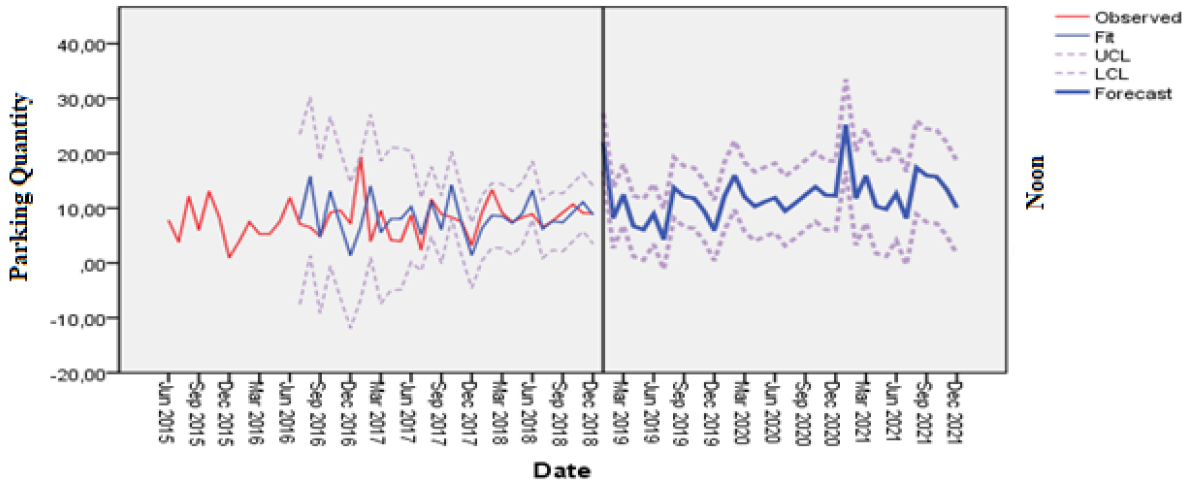

Figure 9. ARIMA (1,1,1) (1,1,1) model prediction series

It was observed that there was a seasonal fluctuation in the chart. In addition to the fit in the graph, it was observed that parking peaked at certain minutes of noon times. It was also observed that parking at noon hours was between the upper and lower confidence intervals. In the parking time series analysis model performed in the evening hours, the graphs of the confidence interval prediction series and the original series were drawn together and the graphic in Figure 9 was obtained. The fact that the fit and series within the confidence intervals in the graphic indicated how much the model was statistically significant. It was noticed that the ACF and PACF graphs the error terms of the time series analysis model appeared as result of parking in evening hours were within the confidence intervals, the delays were found to be fit, and the model was tested statistically significant. The model results were observed to be significant In Figure 10 indicating the prediction series, original series and confidence intervals.

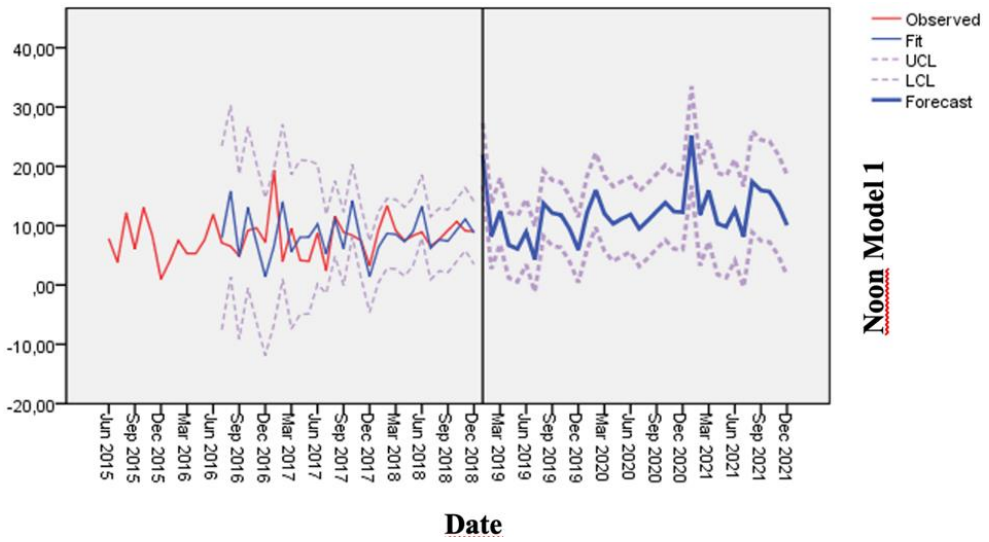

Figure 10. Prediction series graphic for ARIMA (1,1,1) (1,1,1) model

In Figure 11, the fit graph of the prediction series and original series according to the analysis results of the parking in the evening hours was drawn, and the compliance was possible to be observed. It was observed that the most suitable model was ARIMA (1,1,1) (1,1,1) model, and this was also the most statistically significant model.

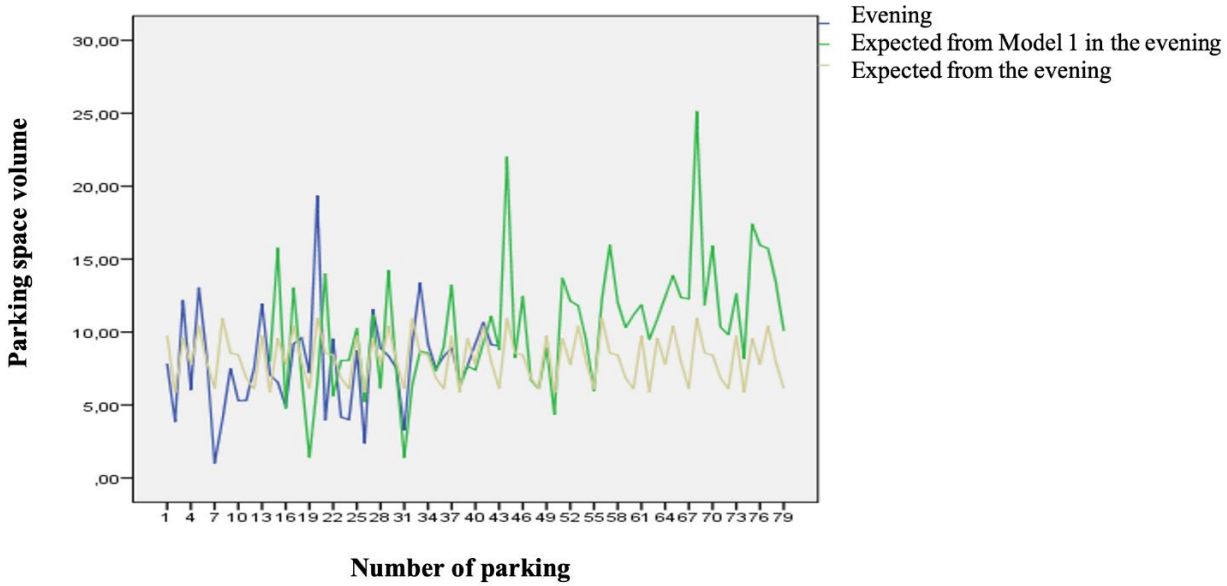

Figure 11. ARIMA (1,1,1) (1,1,1) model prediction series for evening hours

Time series and ANN estimation results are compared in Figure 12.

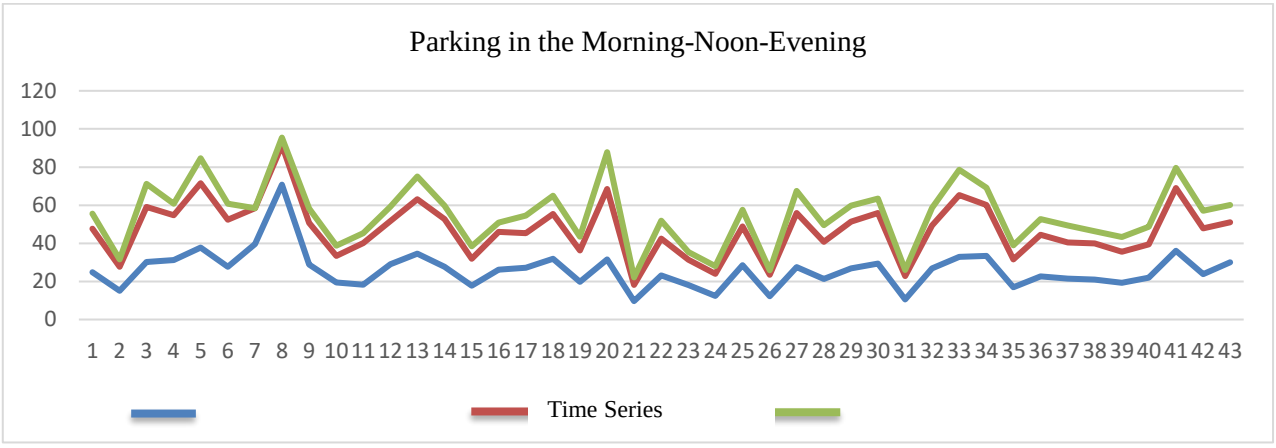

Figure 12. Comparison of time series and ANN prediction results with the original series

In Figure 12, the fit graph of the total parking in the morning, noon, and evening hours according to ANN and time series prediction model was drawn and the compliance was observed.

4. Conclusion and recommendations

In the study, the number of cars that parked in 44 different parking spaces in three time zones as the morning, noon and evening were statistically analyzed with time series Box-Jenkins model and ANN model. Prediction series were created for the following 5 years, and the trend in parking numbers was analyzed.

According to the number of car parks in the morning, noon and evening hours, ARIMA (1,1,1) (0,0,0), ARIMA (1,1,1) (1,0,0), ARIMA (1,1,1) (1,1,1), ARIMA (2,2,2) (1,1,1) models were created, and it was noticed that the most suitable model was ARIMA (1,1,1) (1,1,1). Since the lags were within the confidence intervals in ACF - PACF graphs with the highest coefficient of determination R^2=0.62 and the lowest AIC (Akaika Information Criteria), it was accepted as the most statistically significant model when compared to the others.
When ANN was compared with time series, ANN revealed statistically more significant results due to the success of ANN method in solving more complex structures. R^2=0.83 AIC information criterion was lower and fit graphics (Figure 11) were found to be more significant. Since hourly time series data were used, a seasonal fluctuation was immediately noticeable in the graphics, and, the seasonal difference was obtained in the model due to this fluctuation's reflecting fit in the model results. According to the predictions related to the future, a 32.8% increase was expected in the number of parking for the following two years. If the parking suggestions were not taken into consideration by the local administrators, it would be obvious that the traffic of looking a parking space caused by the drivers who could not find a parking space in the following two years would increase and cause greater transportation problems.

Besides the existing car parks were insufficient in the city center, it was determined that the existing car parks were not used efficiently due to the lack of sufficient control of the vehicles that parked on the road. It should be ensured that a pricing system deterring long-term parking in the roadside parking areas should be established and fees should be collected more seriously. The side streets opened by the Erzincan Municipality to reduce the traffic congestion of the city center, alternative roads, charged parking system, taking car dealerships outside the city were among the studies possible to be carried out to create solutions.

In addition, when the start and increase of parking in the city center in the morning hours was analyzed, it was determined that the parking traffic had regular customers. It was observed that on-street parking areas were occupied from the early hours of the morning until the evening hours, and the drivers looking for parking spaces could not find a place and created a kind of searching traffic in addition to the existing traffic. It was determined that one of the traffic lanes was completely occupied by parked cars in the road parking areas in the city center during peak hours, and the total length of the occupied lane was calculated to be 6420m. The total lane length to be occupied for the following two years was considered to be 8520m with the increase in the number of vehicles to park that calculated to be 32.8%. The lane length a

vehicle occupied when parked was approximately 6m. In this case, it was predicted that the parking lots suggested to be built at determined points would reduce the parking load in the center with an additional capacity increase of 1420 vehicles in total. The parking standards for Turkey were specified in parking regulations updated in 2018. According to this regulation, 20m^2 area was needed for each vehicle including the maneuvering area. For this reason, approximately 24.800m^2 parking area was calculated to meet the need for a new car park capacity of 1420 vehicles. For reducing the parking density in the city center, 6 new parking areas were determined with the help of spatial analysis outputs determining the points where the parking lot requirement was the most in the light of vehicle counts and collected information. In addition to the spatial analysis outputs in determining new parking areas, it was determined that the city center was the busiest, and the Dörtyol and its surrounding where a large part of the trade areas took place needed more parking lots. Furthermore, expropriation and construction costs were also regarded for choosing new parking areas. Three out of 6 chosen new parking areas (2, 3, 5) were the locations of the business center, hospital and stadium where the construction process would be started, and at these points, the parking areas to be included in the existing construction plans would provide a great advantage in terms of cost. Similarly, in the light of the information taken from Erzincan Municipality for areas of 1, 4 and 6, it was considered that new and modern constructions would be made within the framework of urban transformation in near future and a great advantage would therefore be provided in terms of construction cost including parking lots in planned urban transformation projects. In conclusion, new parking areas suggested to be built in the city center, especially in the main arteries and narrow streets and alleys close to the center would eliminate parking traffic and lead to a great relief.

These points are as follows and are marked on the map in Figure 13:

1- Construction of a closed 4-storey parking lot for 200 vehicles for a total of 4000m^2 in the empty part of the existing garden of the Science and Art School.
2- Creating a parking garage for approximately 120 vehicles in an area of 2400 m^2 in the basement of the new building of the Kızılay Commercial Center.
3- Constructing a parking area including a parking lot of 350 vehicles in the project of the state hospital to be renovated with a total of 7000m^2 closed and open area.
4- The construction of the open field in Buğday Square as a 2-storey basement car park with a capacity of 150 vehicles with 3000m^2 total capacity going down to -2 floor from the basement.
5- Constructing a 300-vehicle car park area with a total of 6000m^2 indoor and outdoor parking areas planned to be built for the newly built city stadium.
6- Due to the lack of available space in the Merkez Çarşı and the need for urgent parking, planning a 300-vehicle parking lot constructing a 4-storey car park with a total of 6000m^2.

Figure 13. 6 new parking lots planned to be built on the existing parking density areas

In reference to all these, the information obtained at the end of inventory studies was collected in the form of Geographical Information System (GIS), and it was predicted that the new parking areas proposed to be built close to the areas with parking density would provide a great solution for the parking problem. In conclusion, the study revealed that the traffic problems could be solved determining the right areas for new parking lots with a correct development study.

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