

Investigation of the Effect of Transportation Network on Urban Growth by Using Satellite Images and Geographic Information Systems

Fatih ISCAN and Ceren YAGCI, Turkiye

Key words: Urban growth, Transport, Population

SUMMARY

The world's population is becoming increasingly in urban areas, rapid increase in urbanization exposed to urban growth. At the same time, urban growth affects transportation, understanding the transportation and urban dynamics are becomes a necessary condition for developing urban development strategies. Transportation and urban growth are strongly related with each other. To provide a better understanding of this relation, this paper is subjected to the correlation analysis of this relation and the relation levels of the urban areas and the roads according to years in Konya Province. The road networks and the urban areas were also compared according to years. Landsat imagery for 1999, 2005 and 2010 years have been used to calculate the urban areas and roads lengths. Land use classes such as urban area, agricultural area and other areas were classified and accuracy analysis was performed according to the controlled classification method. The obtained values are 79.48% for the year 1999, 85.77% for the year 2005 and 84.80% for the year 2010. The road network length develops according to urban development and population. The population data of 1999, 2005 and 2010 years are compared with road lengths and urban areas. As a result, the correlation coefficient between road length and urban areas is 0.9991. The correlation coefficient between population and urban areas is 0.664. It is determined that there is a positive linear relationship among population, urban areas and road lengths. According to these results, one of the important factors that are effective in Konya's development is transportation routes.

Investigation of the Effect of Transportation Network on Urban Growth by Using Satellite Images and Geographic Information Systems

Fatih ISCAN and Ceren YAGCI, Turkiye

1. INTRODUCTION

Urbanization is a significant problem in many parts of the world, particularly in densely populated territories. In countries like Turkey rapid increase in population are exposed to rapid urbanization; the destruction of agriculture and forest areas, pollution of the environment, transportation distress, noise pollution, deterioration of the ecosystem balance, and etc. Analyses of urban development and population distribution provide an opportunity to visualize and understand the human use of the landscape. They are useful for projecting trends in urbanization, assessing “smart growth” and conservation efforts, and for evaluating ecosystem impacts of human activities (Martinuzzi, 2007).

Urban growth is a difficult phenomenon to stop or limit in the direction of economic Dynamics. Because of this feature, urban growth continues to take place, as circumstances allow it to grow (Seydanlioğlu and Turgut, 2017) Zoning practices in developed country cities are usually carried out by local governments with broad authority. The authorities of the local governments are responsible for carrying out, implementing, implementing, enforcing and supervising all kinds of planning, projecting and programming activities related to the development areas within the responsibility areas. The role of central governments in this process is limited. In terms of developing countries, the issue of controlling urban development has not yet reached the level of creating a completely up-to-date field of interest. In these countries, zoning plans are not fully implemented or are subject to ineffectiveness in the face of ever-changing conditions and often become irrelevant documents (Nalkaya, 2001). In order to control urban growth, it is possible first to determine the current situation and to determine the parameters that guide urban growth such as population, road network. Most widely used technique to measure the extent of urban sprawl with the integration of remote sensing and GIS (Bhatta, 2009a; Bhatta, Saraswati, and Bandyopadhyay, 2010; Kumar, Pathan, and Bhanderi, 2007; Lata, Rao, Prasad, Badarianth and Rahgavasamy, 2001; Li and Yeh, 2004; Sudhira, 2004; Yeh and Li, 2001) For this reason, the relationship between the urban development of Konya and the transportation route, which is rapidly growing in this study, was investigated by means of Remote Sensing and Geographical Information System (GIS) methods and the relation between population and road network and urban growth was evaluated. It has become possible with the help of satellite images that the growth that takes place in Konya and its temporal treatment. While the land use change of three different species was examined, the effects of increasing population and transportation networks were also examined. From the Landsat satellite images of 1999, 2005 and 2010, land use maps of different years were obtained using the controlled classification method. Urban areas, agricultural areas and other areas were calculated from these maps created for Konya province. Years of land use changes have been put forward. At the same time, satellite images

were used to calculate lengths in the road network. Also; urban areas, road network length and population data, and the correlation scores between them were measured. As a result, the correlation coefficient between road lengths and urban areas 0.9991, coefficient between population and urban areas was found 0.664. It was determined that there is a positive linear relationship between population, urban areas and road lengths.

2. MATERIAL AND METHODS

2.1 Material

Konya Province is a province of Turkey in central Anatolia. It is the seventh most populous city in Turkey. As of 2014, Konya has a population of 1,174,536. Konya is an economically and industrially developed city. By area it is the largest province of Turkey. 76.2 % of the population in Konya Province lives in the city, while the remaining 23.79 % lives in the villages, sub-districts and districts (Figure 1). Konya Province has 31 districts, three of which are central districts: Karatay, Meram and Selçuklu.

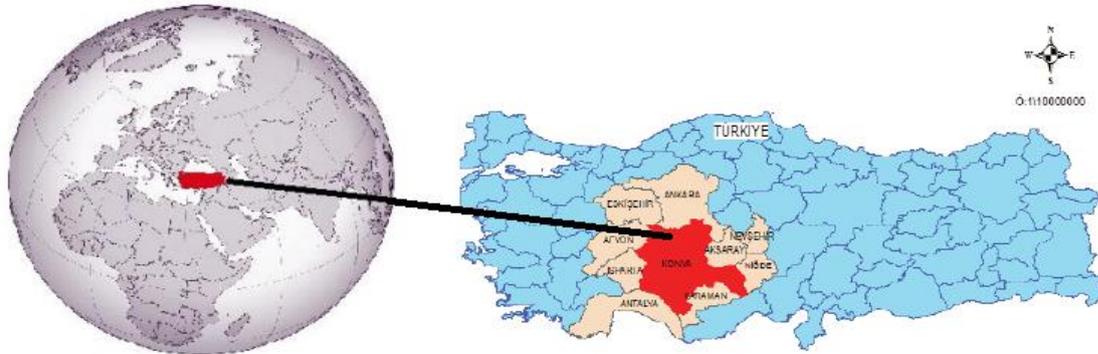


Figure 1: Study Area

Konya with a population of over 2 million, has more than 50 countries around the world. Among these countries, Slovenia, Estonia, Luxembourg, Malta, such as the European Union member countries as well as the European countries Iceland, Montenegro, Andorra, Liechtenstein, Monaco, San Marino and Vatican and countries such as Qatar, Gabon, Gambia, Bahrain, Bhutan, Suriname. Brunei and Belize are located. Population under 35 constitutes 59% of Konya's population, totaling 1.225.088 people (URL 1).

Examining Konya's population, people between the ages of 15-64 constitutes 67% of the population. 26% of Konya is between the ages of 0-14 and 8% is over the age of 65. Konya shows similar distribution of population regarding age structure. 68% Turkey's population is between the ages of 15-64. The numbers are 24% for people between 0-14 and 8% for people over 65 (URL2).

Landsat satellite images for 1999, 2005 and 2010 were used as a base for this study (Figure 2). Konya Municipality, founded in 1875, has reached the metropolitan status in 1989. Therefore, it is desirable to start the study period from this date in order to examine the effects

of the development and the population of the city. For this purpose, the satellite images required for the study were separately queried in the Earth Explorer. However, 1989 data were not available because the IKONOS satellite began using the WorldView-1 satellite in 1999, on September 18, 2007, and the images of Landsat satellites sent to the world in 1972 were not available for the first time. Instead, it began in 1999, the closest date for satellite imagery to work. In order for the required satellite images to be efficient, the images do not belong to the winter months, the air is open and the cloudiness rate is less than 10%, etc. attention has been paid to ensure that the criteria are met. For this purpose, satellite images of Landsat 7 of Konya province on 27.07.1999 and of Landsat 4-5 TM of 27.07.2005 were obtained on 01.07.2010. The Landsat images used are obtained from Tiff format digital media. The projection system of the images was selected the UTM (Universal Transverse Mercator) 36th Region and "WGS84 Datum" which are the most suitable for the location of the maps.

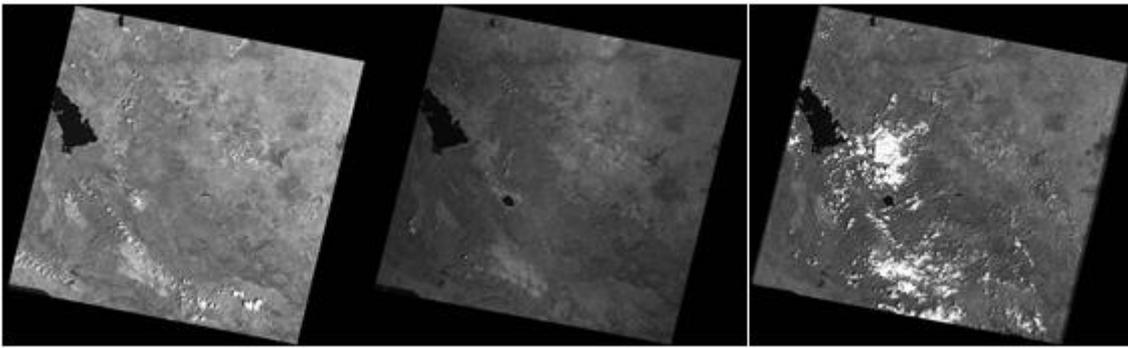


Figure 2. Band4 image for 1999, 2005 and 2010

In this study, ENVI 5.0 was used to process remotely sensed images, ENVI Classic to classify and evaluate, ArcGIS 10 for temporal analysis of the results obtained, and Google Earth Pro software as an aid tool for defining the classification training areas.

2.2 Method

In many agricultural applications and planning, GIS provides for the evaluation, updating, mapping and follow-up of data. The data obtained by remote sensing provide regular information about the working area. This information is not intellectual but is based on measurements in the field of work itself. Thus, detection and comparison of temporal changes is ensured (Aydođdu, 2008). In this study, GIS and Remote Sensing methods have been downloaded from the satellite viewer Google Explorer program which is necessary to investigate the effects of urban transportation on the urban development of Konya closed river basin. The necessary radiometric corrections have been made to improve the satellite images. Radiometric corrected satellite images were classified into three classes (agriculture, settlement, and other areas). The Maximum Likelihood method, which is a supervised classification method, has been preferred in the classification process. Accuracy analyzes were performed for classified satellite images (Figure 3).

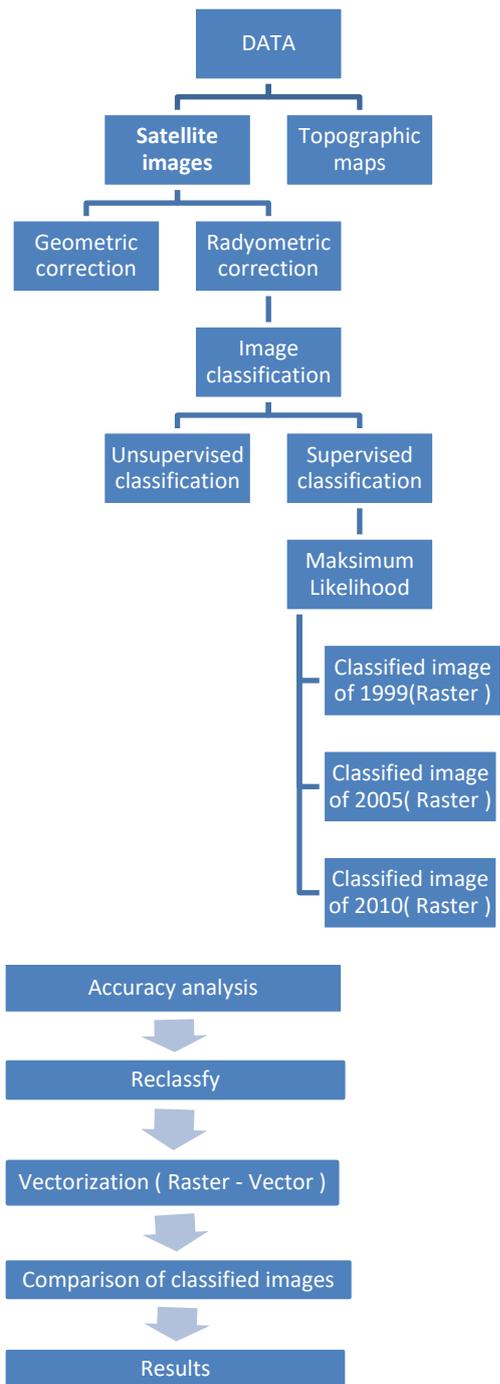


Figure 3. Flow Chart of Study

In order to improve Landsat satellite images, ENVI 5.0 software has made radiometric corrections to Band5, Band4, Band3, Band2, Band1 images every year. There are gaps in the image due to clouds, shadows or sensor errors in the Landsat 7 satellite images of 2005. These sensor faults have been corrected by ENVI Classic software with Gap filling. Educational classification was made on images.

Satellite images, controlled classification algorithms; Minimum Distance, Maximum Likelihood, Mahalanobis Distance methods have been applied. It has been observed that Maximum Likelihood is the most suitable algorithm in terms of desired accuracy and expected data sensitivity. The method used in land classification is based on three classes: land cover settlement, agriculture and other fields (Table 1).

Table 1: Specified Land Classes in Konya Province

Land Codes	Land Classes
1	Settlement Areas
2	Agriculture Areas
3	Other Areas

Each land class is assigned to a database by giving a different code number (1, 2, 3). The area values of each land class are calculated in hectares and percent (%) by subjecting these polygon data processed to the numerical database to the area account. The Map Comparison Kit program was used to determine the land change maps for different years (1999-2005, 2005-2010, 1999-2010).

3. RESULTS AND DISCUSSION

Correctness in remote sensing is the search for the correspondence between the label assigned to the pixel in the classified image and the real class of that pixel. The actual class can be obtained from aerial photographs, from existing maps and plans, or from GNSS data (Göksel, 1996). In this study, Landsat satellite images were used for accuracy analysis. The obtained accuracy analysis results are given in Table 2.

Table 2. Accuracy Analysis by Years

Years	Accuracy Rate
1999	%79.48
2005	%85.77
2010	%84.80

The thematic maps formed as a result of the classification are listed according to the category, the same classes are indicated with the same colors. As can be understood from the classified

images, agriculture areas gradually decreased with time as the settlement areas increased (Figure 4).

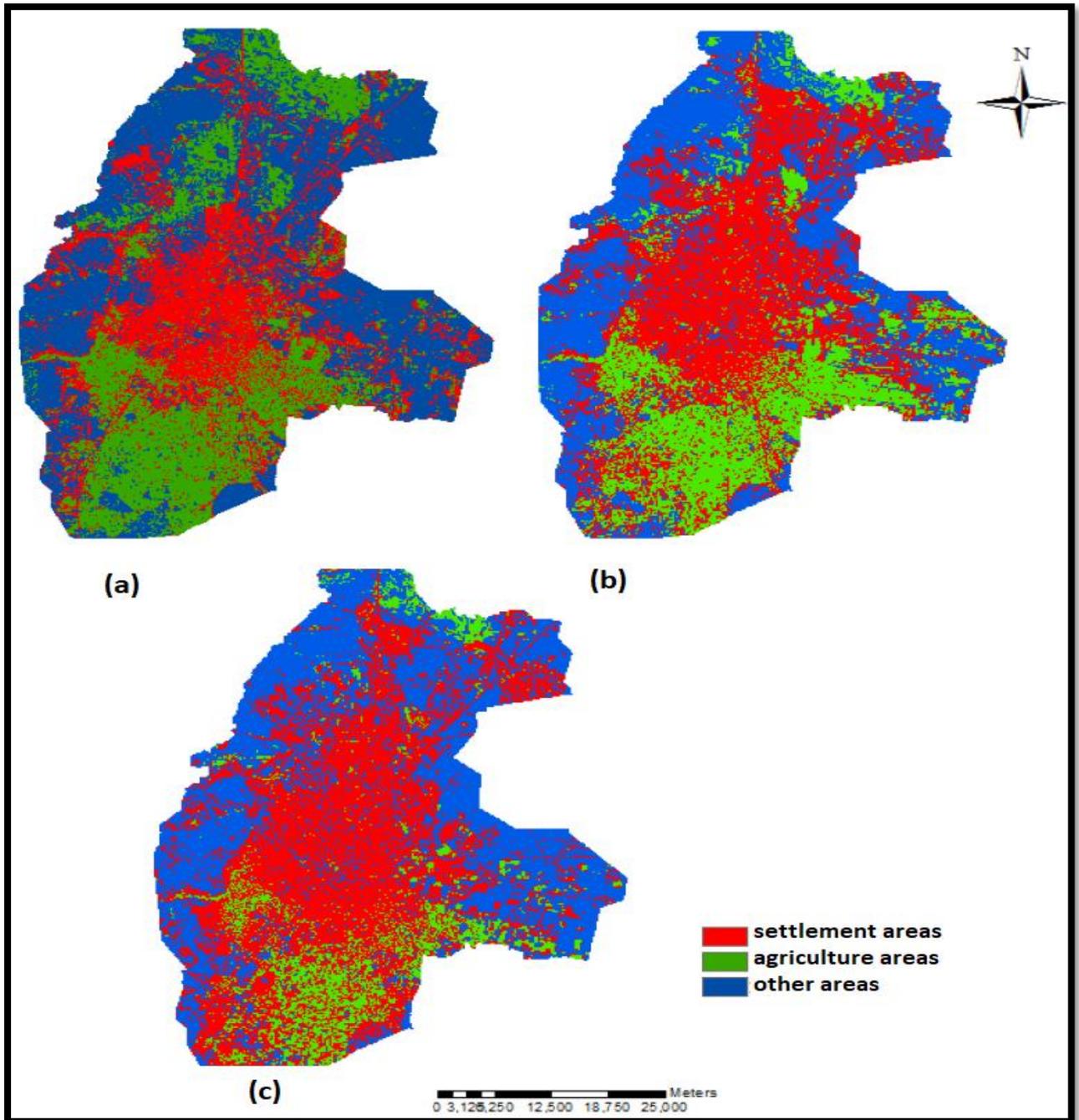


Figure 4. The land use of Konya Province, a. 1999: b.2005: c. 2010

The Kappa comparison method compares for each cell pair to determine whether the pairs are equal. There are two types of similarity in the Kappa statistic: Quantity similarity and location

similarity. The quantity similarity corresponds to the number of cells in each category, and the location similarity corresponds to the distribution of different categories on the map, expressed as KHisto and KLoc, respectively. The Kappa statistic is calculated by multiplying these two expressions (Bakırman, 2014). According to Kappa Method, Konya's land use changes according to years are seen in Figure 5.

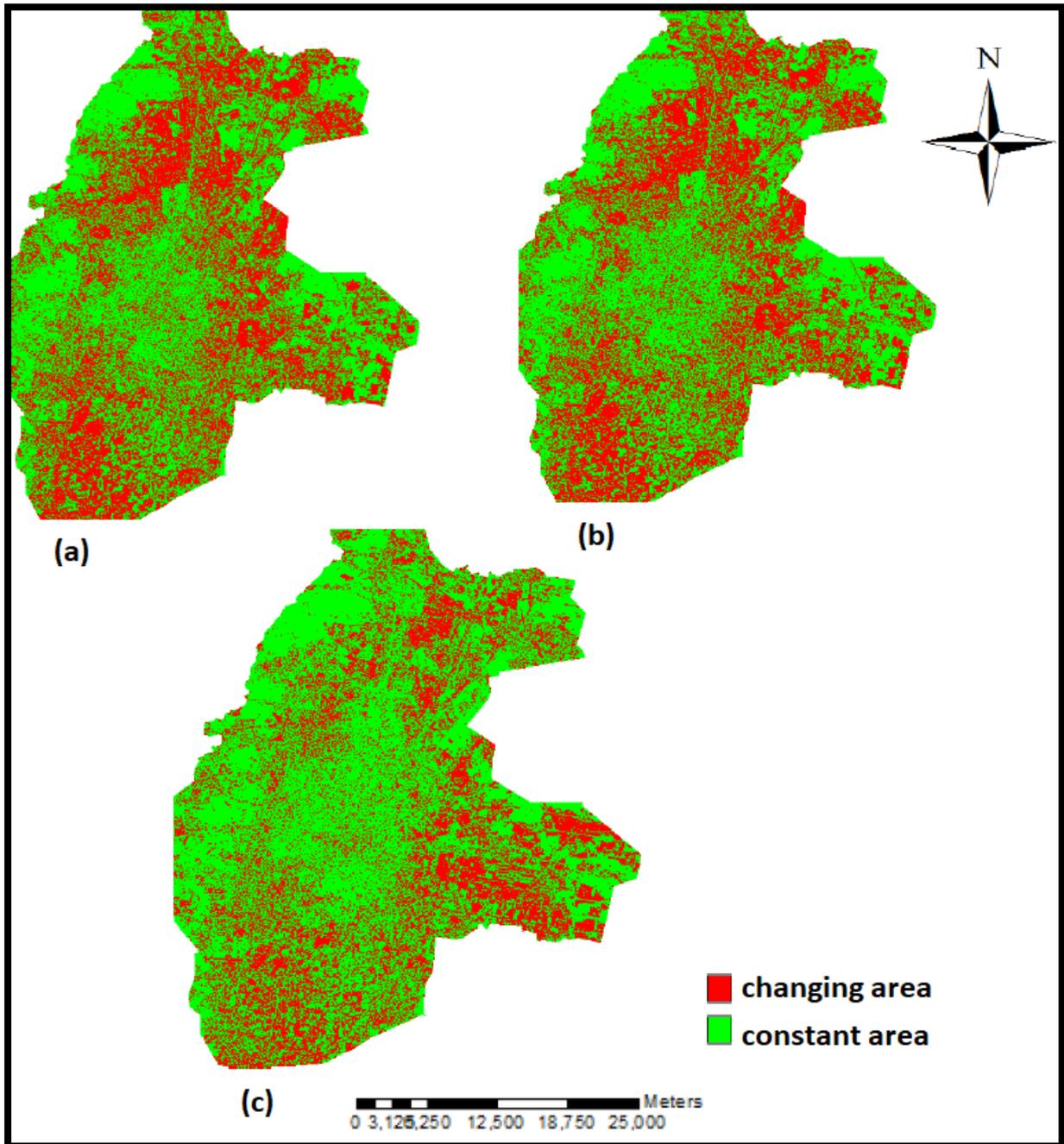


Figure 5. The land use map of Konya Province, a. 1999: b.2005: c. 2010 (Kappa Method)

In the Per Category method, the maps were examined in 4 different stages. These are both non-existent and non-existent areas on both maps, and non-existent areas on one map. While only changing and unchanging areas are examined in the Kappa method, more detail is provided in the Per Category method. The maps with the Per Category method are shown in Figure 6.

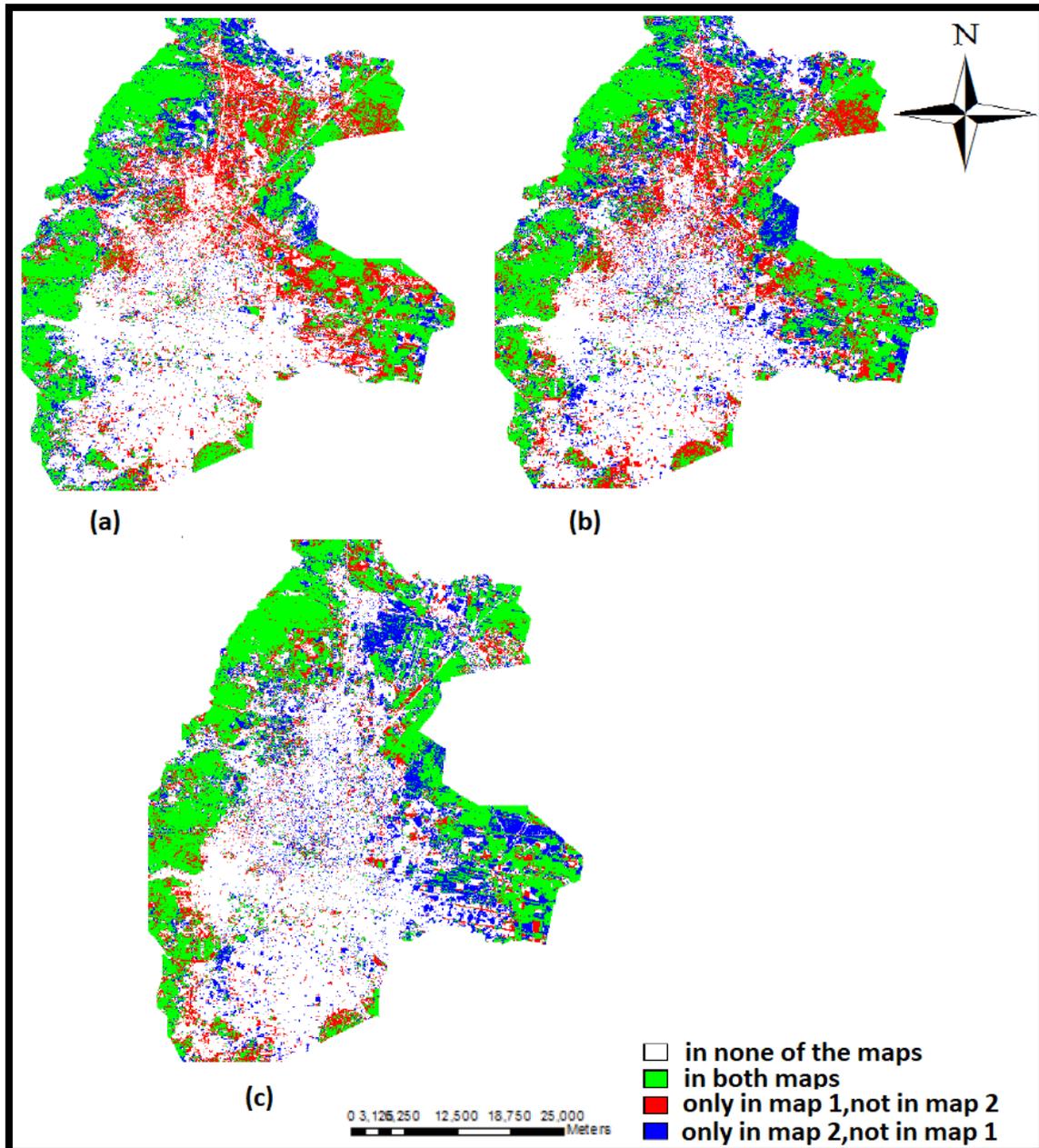


Figure 6. The land use map of Konya Province, a. 1999: b.2005: c. 2010 (Per Category Method)

The values of land use and exchange between 1999, 2005 and 2010 and years are given in Table 3 in this study. When the change between 1999 and 2010 was examined, it was observed that the settlement areas had 27.05% in 1999, it increased to 39.91% in 2005 and to 46.20% in 2010. Likewise, while the agricultural land area in 1999 was 27.68%, it decreased to 21.92% in 2005 and it decreased to 11.29% in 2010. Finally, it was observed that in 1999, while other areas had an area of 45.27%, it decreased to 38.17% in 2005 and increased in 2010.

Table 3: Land Changes Between 1999-2010 in Konya

LAND CHANGE DURING 1999-2005-2010 IN KONYA (MAXIMUM LIKELIHOOD METHOD)							
Land Use Classes	Total Area	Settlement Areas		Agriculture Areas		Other Areas	
		(ha)	%	(ha)	%	(ha)	%
1999	53408.31	14445.62	27.05	14784.70	27.68	24177.99	45.27
2005	53409.69	21314.23	39.91	11706.55	21.92	20388.90	38.17
2010	53407.79	24674.76	46.20	6030.48	11.29	22702.55	42.51
2010_2005 Land Change	-	3333.53	6.29	-5676.07	-10.63	2313.65	4.34
2010_1999 Land Change	-	10229.14	12.86	-8754.22	-16.39	-1475.44	-2.76
2005_1999 Land Change	-	6868.61	12.86	-3078.15	-5.76	-3789.09	-7.10

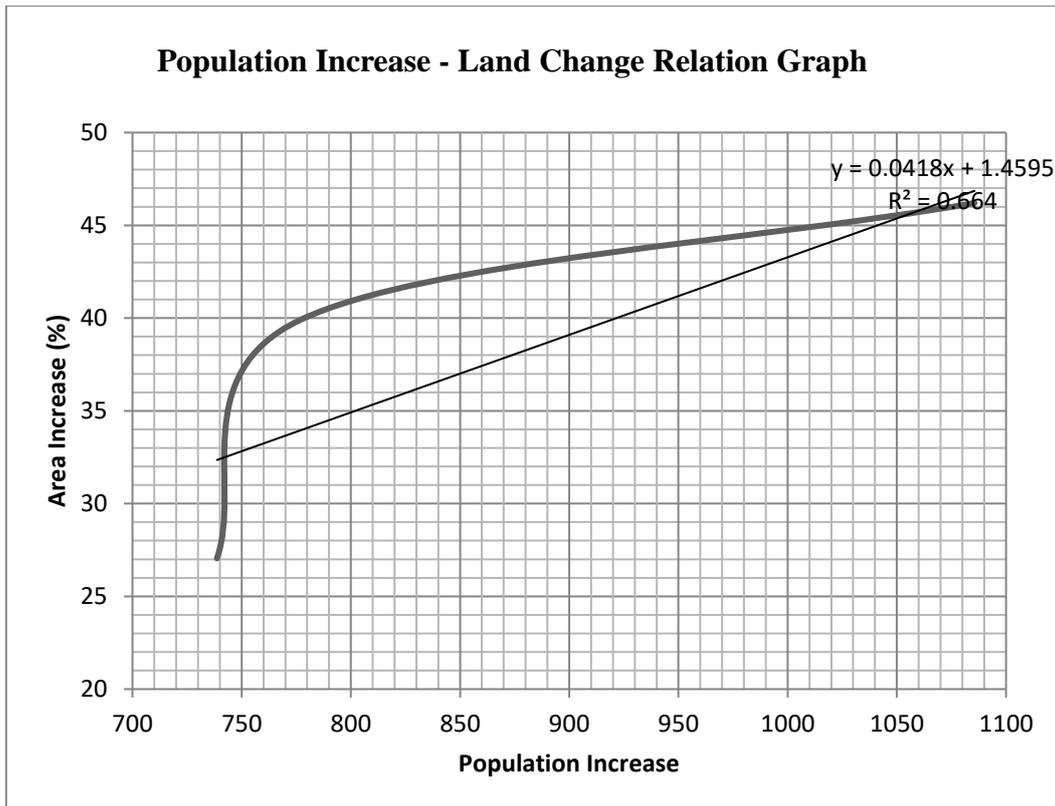
The population information of the central provinces of Konya Province (Karatay, Meram and Selçuklu) for the years of 1999-2005-2010 are given in Table 4. As can be understood from Table 4, the population between 1999 and 2010 increased by about 1.5 times. Especially in the Selçuklu, the population increase was more than in other provinces. This increase in the county is due to the presence of Selçuk University settlement in this district.

Table 4. Konya District (Karatay, Meram, Selçuklu) Population by Years

YEARS	Karatay	Meram	Selçuklu	Total Population
1999	182.677	230.386	325.627	738.690
2005	191.616	239.690	345.674	776.980
2010	263.071	314.421	508.102	1085.594

Correlation analysis is a statistical method used to test the linear relationship between two variables or the relationship of one variable to two or more variables, if any, and to measure the degree of this relationship. In this analysis, is to see how the dependent variable will change when the argument (X) changes. As a result of the correlation analysis, it is necessary that the correlation coefficient (r) of the linear relationship is -1 or +1. If the correlation value is 0, then there is no relation between the two variables. Correlation Analysis was performed to evaluate the data obtained in the research (Graph 1).

Graph 1. Population Increase – Land Change Relation Graph



As can be understood from the above chart, Correlation Coefficient is 0.664. The Correlation Coefficient (r) is close to +1 indicating a positive linear relationship between the variables. It is an important issue that if the transportation network affects the urban development or not. For this, a length of road is needed to determine how much Konya's transportation network affects urban development. Based on the Konya Province Central Districts (Karatay, Meram, Selçuklu), the digitization process was performed with the help of ArcMap program to determine the road network length in 1999, 2005 and 2010 (Figure 7).

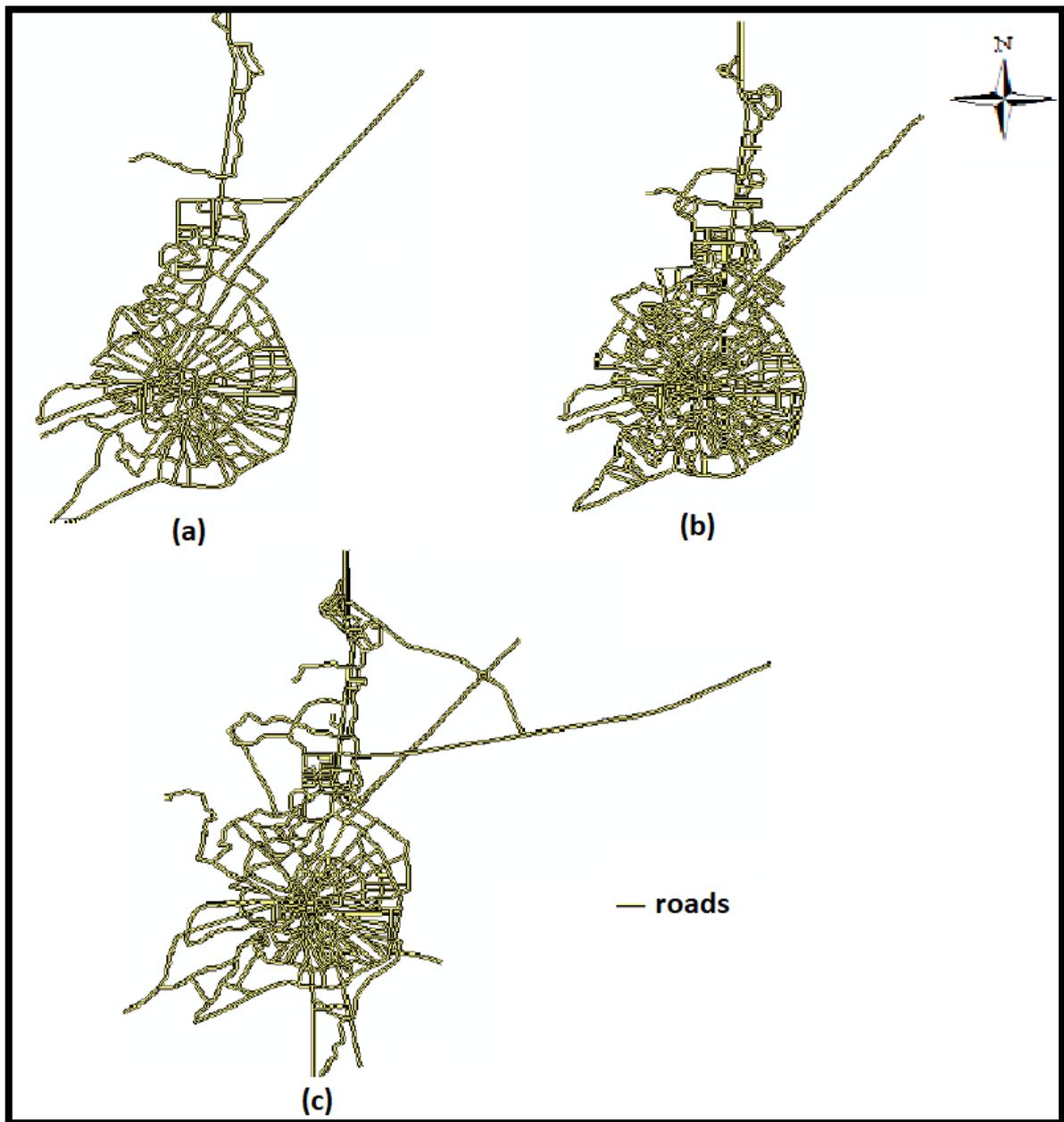
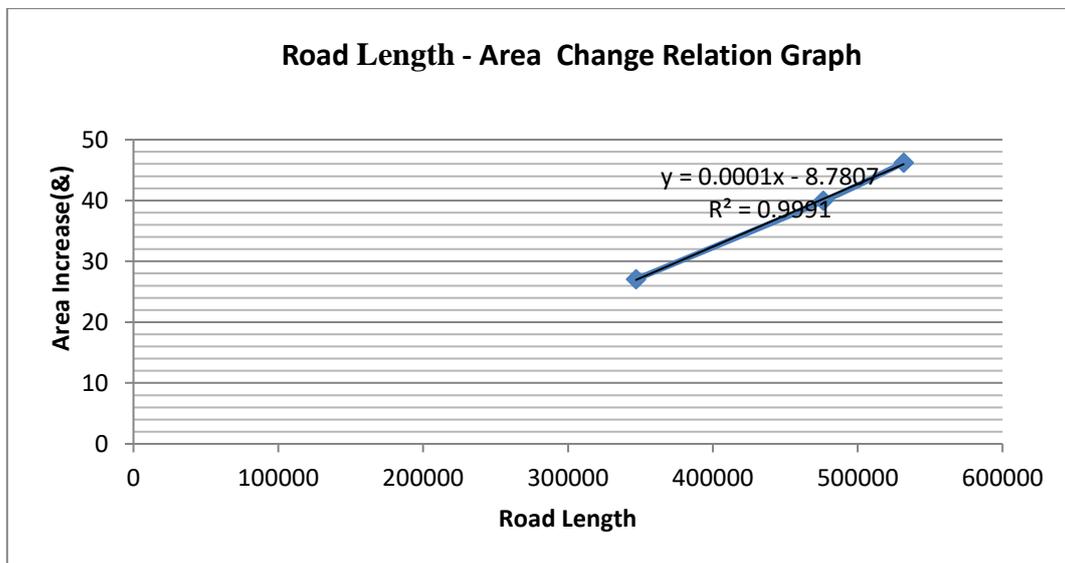


Figure 7. The road network of Konya Province, a. 1999: b.2005: c. 2010

In the city of Konya, the historical core became the scene for the formation of the bazaar. After 1980's rapid urbanization, industry, metropolitan city status, development of Selçuk University, etc. with the development plans prepared in 1999 with the aim of meeting the new requirements, the development of the city was aimed at the north and the development of the tram line was strengthened. As a result of the analyzes; In 1999, the total length of the main streets belonging to Konya Provincial Headquarters was found as 347001.38 m, 476173.67 m in 2005 and 531675.44 m in 2010. When the results of previous land change analysis are taken into consideration, it is observed that road network length and urban area growth increase in parallel with each other. A correlation analysis was conducted to determine the extent to which the increase in the length of the road and the increase in the urban area are related to each other. The correlation coefficient was 0.9991. The Correlation Coefficient (r) value is close to +1 indicating a positive linear relationship between the variables (Graph 2).

Graph 2. Road Length-Area Increment Graph



4. CONCLUSION

The city of Konya is one of the cities with fertile agricultural lands and the growth rate is high. In the last 50 years, there has been a large increase in the population, and there has been a tendency for the settlement area to grow further. The urban growth in Konya caused natural areas to be affected negatively. Although the plans have been made to protect fertile lands in the south, east and west, limited success has been achieved in this regard. This situation also affects the agriculture sector, which is an important economic sector for Konya city, in the negative direction.

Between 1999 and 2005, the population increased by about 1.5 times. While the total population was 738,690 in 1999, the total transportation network is 347001.38 meters. In

2010, the total population is 1085,594 while the total transportation network is 531675.44 meters. However, there has been a decrease of 16.39% (8754.22 ha) in agricultural land and an increase of 12.86% (10229.14 ha) in residential area. This result shows that population growth and the development of the transport network affect urban expansion.

GIS and Remote Sensing methods are the most important tools for planners to make decisions in a wide range of applications. These methods provide important facilities for administrators to follow the urban expansion, plan cities in the future and solve the problems that may arise.

REFERENCES

Aydođdu, M., 2008, Determination of the effect of cotton on different salt levels and farmer practices and correlation with satellite data, Harran Üniv. Institute of Science and Technology. Master of Science in Soil Science, Şanlıurfa 2008 (in Turkish).

Bhatta, B., 2009, Analysis of Urban Growth Pattern Using Remote Sensing and GIS: A Case Study of Kolkata, India, *International Journal of Remote Sensing*, 30(18), pp.4733–4746.

Bhatta, B., Saraswati, S., & Bandyopadhyay, D., 2010, Quantifying The Degree-Of-Freedom, Degree-Of-Sprawl, And Degree-Of-Goodness Of Urban Growth From Remote Sensing Data. *Applied Geography*, 30(1), pp.96–111.

Kumar, J. A. V., Pathan, S. K., & Bhanderi, R. J. 2007, Spatio-temporal analysis for monitoring urban growth – a case study of Indore city. *Journal of Indian Society of Remote Sensing*, 35(1), pp.11–20.

Lata, K. M., Rao, C. H. S., Prasad, V. K., Badarianth, K. V. S., & Rahgavasamy, V. ,2001, Measuring urban sprawl: a case study of Hyderabad. *GIS Development*, 5(12), pp.26–29.

Li, X., & Yeh, A. G. O. 2004. Analyzing spatial restructuring of landuse patterns in a fast growing region remote sensing and GIS. *Landscape and Urban Planning*, 69, pp.335–354.

Martinuzzi, S. ., William A. Gould a, Olga M. Ramos Gonzalez,2007, Land development, land use, and urban sprawl in Puerto Rico integrating remote sensing and population census data, *Landscape and Urban Planning* 79 ,pp. 288–297.

Nalkaya, S., 2001, Kentsel Formda, Kontrolsüz Büyümeyle Gelen Deđişim ve Sonuçları Dönüşüm Sürecinde Bir Kent: Sempozyumu, DAÜ, Gazimağusa, pp.133-142.

Seydanlıođlu A., Turgut S., 2017, Urban Growth Management System For Sample Cities of Turkey And İstanbul,Megaron,(12) pp. 3.

Sudhira, H. S., Ramachandra, T. V., & Jagdish, K. S., 2004, Urban sprawl: metrics, dynamics and modeling using GIS. *International Journal of Applied Earth Observation and Geoinformation*, 5, pp.29–39.

URL 1. <http://www.investinkonya.gov.tr/en/konya.asp?SayfaID=3> [Date of Access 15 May 2017]

URL 2. <https://tr.m.wikipedia.org/wiki/Konya> [Date Of Access 12 March 2017]

Yeh, A. G. O., & Li, X. 2001, Measurement and Monitoring of Urban Sprawl in A Rapidly Growing Region Using Entropy, Photogrammetric Engineering and Remote Sensing, 67(1), pp.83–90.

BIOGRAPHICAL NOTES

Fatih Iscan is an Assoc. Prof. Dr. of Geomatic Engineering at the Selcuk University of Konya, Turkey. He has been with Selcuk University since 2000. He completed his PhD study at Selcuk University (2009), in “Application of Fuzzy Logic in Land Consolidation Activities” subject. He has an MSc from Selcuk University, Department of Geomatic Engineering (2003), and a BSc from Yildiz Technical University (2000), in Geomatic Engineering. His research interests are Land consolidation, public works, cadastral survey law and GIS.

Ceren Yağcı was born in Eskişehir/Turkey. She received her BS degree in Geomatics Engineering from Selcuk University, and her MS degree in Geomatics Engineering from Selcuk University and also, she started her PhD studies in Geomatics Engineering from Selcuk University in 2014.

CONTACTS

Ceren YAĞCI
Selcuk University
Selcuk University, Geomatics Engineering, Selcuklu /KONYA
TURKEY
Tel. +9003322231891
Email:cerenavci@selcuk.edu.tr

Investigation of the Effect of Transportation Network on Urban Growth by Using Landsat Images and Geographic Information Systems (9441)
Fatih Iscan and Ceren Yagci (Turkey)

FIG Congress 2018
Embracing our smart world where the continents connect: enhancing the geospatial maturity of societies
Istanbul, Turkey, May 6–11, 2018