Modelling the Interaction Between Urban Sprawl and Agricultural Landscape Around Denizli City, Turkey

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Abstract: Urban sprawl is not merely a geographical expansion but also brings about a set of social and spatial changes such as the loss of human nature in urban life, the distortion of natural agricultural and archaeological landscapes and the transformation of natural landscapes into cultural landscapes. It is an obvious and crystal-clear fact that such changes are hard to control in developing countries. This study mainly aims at understanding the local scale variables leading the urban growth in Denizli, a city having a trend of fast settlement and urbanization, and analyzing how these variables would affect the way of urban growth in future. In this study, the spatial/positional variables on a local scale and the growth forms belonging to the years of 1987, 2001, 2013 and 2015 were correlated by using the Logistic Regression Analysis, and the urban growth in Denizli in 2025 was simulated. In the study, two models were created as the control model and estimation model in order to reach the simulation of 2025. In the control model, the urban growth belonging to 2015 was estimated by correlating the urban growth of 1987 and 2001 and an 80 % accuracy was attained for overlapping the outcomes of control model and the real-time urban growth in 2015. The valid accuracy rate in the control model was simulated via the estimation model (model 2) belonging to 2025. The primary aim should be taking control of construction and the city should be accordingly established upon a new model. In this regard, when analyzing the city models, it is thought that the model of a compact city is a sustainable model for Denizli.

Keywords: GIS, logistic regression analysis, remote sensing, urban growth model, urban sprawl

1 Introduction

In cities where rapid population growth and spatial change is uncontrollable, the management of the city becomes hard (LINARD et al. 2013, NDAWAYEZU 2015). In these cities, the absence of spatial policies and failing to organize urban growth are common and well-known issues. Good management of a city is provided through producing and sharing policies and knowledge supported by the shareholders. The most important issue here is to perceive the factors leading the dynamics of urban growth/development. From this viewpoint, it is the focus of this research study to determine the fundamental leading factors (of variables) in the growth of the city of Denizli via Logistic regression model. As a result of the applied model, the data obtained provides ideas about how the city will grow in 10 years.

As is known, urban growth and rapid urbanization are among the most serious global issues. In the Un-Habitat report (2011), it was predicted that the 52 % of the world population (3.6 billion) currently living in the cities will rise to 67 % in 2050. It is also reported that the city population will rise to 64 % in less-developed and developing regions. Given that Turkey is considered a developing country, it can be said that the urbanization will gradually increase and that urban growth will remain a constant problem. In a report by the United Nations

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(2015), it was reported that while in 1950 the population density in a kilometer square was 27,6 in Turkey, in 1987 it was 65,2; 83,4 in 2001; 99,0 in 2013 and 102,2 in 2015. For this reason, the prediction of urban population can be a tool for bringing a clearer perspective to Turkey where the population is increasing very rapidly and urban planning policies are lacking.

One of the most important reasons why urban planning policies are insufficient and unsuccessful is the limited techniques used for understanding and evaluating spatial-temporal designs and dynamics. Developing urban planning decisions will not make serious contributions by lifting the knowledge limitations with modeling urban growth (NDAWAYEZU 2015). Planning is a prudential action and so it needs to build strong bonds between the past and the future. By developing urban planning decisions, the responsible planners are required to make temporal analyses for urban dynamics in order to think analytically (EYOH & VIJAANORTO 2012) and make decisions.

Logistic regression (LR) is one of the experimental and statistical methods. LR is also a parametric model that is commonly used and models the change of spatial use (EYOH & VIJAANORTO). This technique/model questions the relationship between the data at certain times by encoding the dependent and independent variables (PULLAR & PETIT 2003). When used with Remote Sensing and Geographical Information systems, it is an effective tool for modeling the change of land cover and land use (DENDONCKER et al. 2007). LR provides an analysis of future growth designs based on the data and observations of the past years.

This study primarily deals with identifying the fundamental variables/factors in the growth of Denizli through the integration of RS, GIS and LR. Within the scope of this aim, the secondary aims are as follows: Producing maps of land cover and land use for the years 1987, 2001, 2013 and 2015; obtaining a growth model of the city of Denizli with LR, and predicting the urban growth design for the next 10 years; and predicting loss of agricultural land and evaluating the interaction of urban sprawl and urban politics.

2 Materials and Method

2.1 Study Area

The study area is at $37^\circ 46'$ N – $29^\circ 05'$ E coordinates and is 1135.92 km^2 covering the Merkezefendi and Pamukkale central districts affiliated with the Denizli Metropolitan Municipality. Menderes and Pamukkale, located in the Grand Menderes Basin, are comprised of the Golgeli Mountain Ranges, Esler Mountain and the Cokelez Mountain hills and the flat terrains between these mountains. The city of Denizli is situated in a geographical area where mostly plains exist, and is surrounded by mountainous areas. The settlements are generally established on plains and plateaus. The agricultural lands are found on the plains, plateaus and valleys (Figure 1).

The economic structure and location of Denizli contribute to its population increase. It is one of nine cities in Turkey that have been growing most over the last 30 years, in terms of economy and population. While the population was 251,418 in 1987, it rose to 407,156 and then to 574,321 in 2013. According to Address Based Population Registry System (ADNKS) records, the urban population makes up 70 % in Denizli, whereas the rural population is 30 %. It is seen that new urban areas needed as a result of population growth have been developed on agricultural, archaeological and natural landscapes which are significant for the economy and urban sustainability of Denizli. It was stated in interviews with Denizli local government representatives that this kind of settlement is related to political decisions and planning trends as well as population growth. It is seen that Denizli urban policy is based on the aim of becoming a metropolitan municipality and consequently intensive administrative boundary changes in the rural areas around the city centre of Denizli have been made.

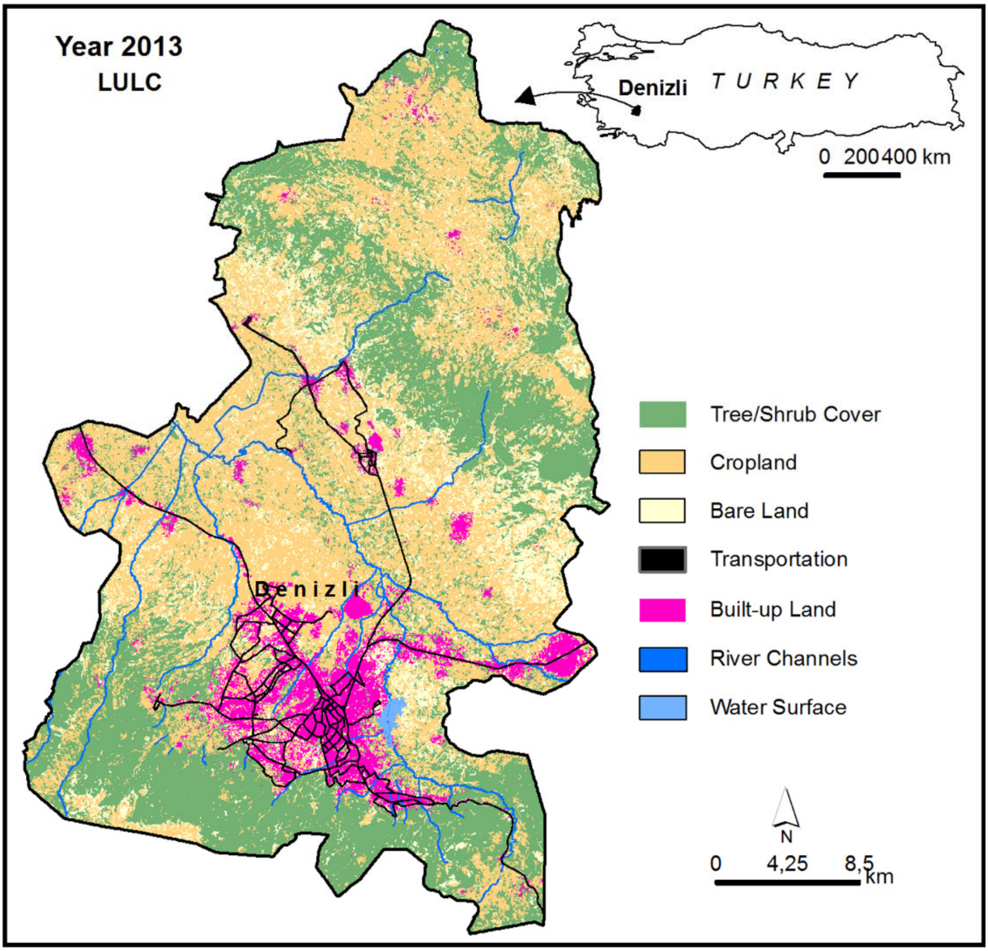

Fig. 1: Geographical location of study area and change of urban area

2.2 Modeling Urban Growth

Modeling urban growth in the study is processed in two phases as control model (2015) and estimation model (2025). In the control model, urban growth for 2015 was estimated by using data from 1987-2001 and the accuracy of the model was tested by comparing with the real urban growth (2015). In the estimation model**,** an urban growth for 2025 was estimated by using data from 2001-2013 and it was revealed how the variables used in the model would affect the urban growth. In creating models, the studies were respectively carried out under the following main titles: classification of satellite images, and determining/creating variables to be considered effective in urban growth and creating model.

2.1.1 The Classification of Satellite Images

Landsat 5 (08/1987), Landsat 7 (08/2001) and Landsat 8 (08/2013) images, taken as a reference geographically according to WGS 84 (35 N) projection, were utilized. The phases of classifications are as follows:

In the pre-treatments of classification: Image-to-image method was used on the images in geometric correction process and all the images were rectified to 2013 image. In this process, rms was taken as 0.5 pixel. Atmospheric correction was made by FLASH algorithm and then all the bands on the image were scaled between 0-1 by using the equation.

In the classification process: The meaningful patterns on the images were respectively determined with the process of multi-resolution segmentation. The nearest pixels or the ones with the most similar projection features were classified and thus, instead of working with millions of pixels, the segments were created with the combination of pixels being of common features.

Specific to this study, two-scale-factor was determined in the phase of segmentation. In order to create road details, the scale factor was weighted «1» and all the bands were scaled 1 (chess board segmentation). The scale factor and NIR band were weighted respectively as «25» and 2 for the fundamental land use categories.

In the next phase, threshold values were determined and classified by combining one or more features such as Landsat indices (build up index, GNDVI, OSAVI etc.) and brightness. As a result of classification, 7 land use/cover (LULC) categories were determined as agricultural land, barren and sparsely vegetation land, forest land, river, road, settlement and water body. For the year 2015, only settlements were classified.

In classification accuracy assessment, ground control points were determined for each land use/cover category after classification and an accuracy assessment was made for each year. According to this, overall accuracy was determined 82 %, 83 % and 88 % by years.

2.1.2 Determining and Creating Variables

With RS and GIS techniques, the urban growth was spatially identified through land cover and land use by years. Based on these identifications, urban growth maps and the variables leading the urban growth were also identified (Table 1). Having enumerated the variables of impact on urban sprawl, a transformation into raster grid format with 30 × 30 m cell was made through a set of standardization procedures. Binary maps for each variable displaying existence/non-existence (1 or 0) and fuzzy logic maps displaying the positions at a value between 0 and 1 were created. The method for modeling phases is given in the flow chart (Figure 2).

Table 1: Urban growth variables

Variables		**Contents**	**Variable structure**
Dependent variable	Y	0 = No Urban Growth, 1 = Urban Growth	Binary category
Independent variables	X_1	Agricultural Land Use 1 = Agricultural Land, 0 = Not Agricultural Land	Binary category
	X_2	Waste/Arid Land 1 = Waste/Arid Land, 0 = Not Waste/Arid Land	Binary category
	X_3	Distance to Important Centers	Continuous
	X_4	Distance to City Center (M)	Continuous
	X_5	Existence of Forest Lands 1 = Forest Land, 0 = Non Forest Land	Binary category
	X_6	1 = High Intensive Urban Area, 0 = Not High Intensive Urban Area	Binary category
	X_7	1 = Low Intensive Urban Area, 0 = Not Low Intensive Urban Area	Binary category
	X_8	Distance to Nearest Urban Cluster (M)	Continuous
	X_9	Other Land Cover/Land Use	Binary category
	X_{10}	Distance to Roads (M)	Continuous
	X_{11}	Distance to Centers of Urban Economy	Continuous

2.1.3 Creating the Model

Two models were created in the study.

Control Model: the effects of the variables leading to urban growth between 1987 and 2001 were determined via LRM and the urban growth area for 2015 was estimated.

Estimation Model: the effects of the variables leading to urban growth between 2001 and 2013 were determined via LRM and two scenarios were formed in order to determine the urban growth pattern belonging to 2025. While the first scenario estimated how urban growth would be with no limitations, in the second the interaction between the areas of protection status and urban growth was questioned.

The purpose of Logistic Regression Analysis is to model the relationship between one or more independent variable(s) and dependent variable (HOSMER & LEMESHOW 2000). In the logistic regression, while the dependent variable is binary, independent ones may be categorical or continuous. Logistic transformation is the natural logarithm of odds ratio of success or failure.

The variables whose odds ratio is close to 1 will be defined as the variables not being of significant contributions to the transformation of Y. If the coefficients of such variables are not found significant, the variables to be used in the study will be decreased, deducing that the related variable is not an important factor. Provided the coefficient is significant, the odds ratio higher than 1 means that the related variable is an important factor. It can be said that the odds ratio values close to 0 signifies that the variable is an important factor as long as the coefficient is significant but it is of a negative impact that causes Y to receive lower values (OGUZLAR 2005). Logistic regression uses the maximum likelihood estimation the most after the transformation of dependent variable into logit variable (OGUZLAR 2005).

The correlation between the independent variables is a significant criteria in the estimation of urban growth (CHENG & MASSER 2004, HU & LO 2007, MUNSHI et al. 2014). Thus, there should be no multi collinearity and similarities between the variables.

1. Model (Control model): in the period 1987-2001, the urban growth for 2015 was estimated through 11 variables (Figure 2). For the control model, the statistics for the LRM statistical reliability are as follows: McFadden 0.4164; Magelkerke 0.0446. In control model, Regression equation between the independent variables and the dependent one is given below (Table 2):

Urban Growth = –0,008505 + 0,318912*Agriculture + 0,331123*Barren And Sparsely Vegetation + 0,020835*Center Of Attraction To Distance-0,092369*Center Of Urban To Distance + 0,315676*Forestry + 0,081198*High Density Settlement + 0,109580*Low Density Settlement –0,000427*Nearest Urban Cluster To Distance + 0,210126*Other LULC – 0,112782*Road To Distance –0.181872*Center Of Urban Economy To Distance

Table 2: Regression coefficients of the variables (Control model)

	Variables (1987)	Coefficient	t_test (8308033)
Symbol	Intercept	–0.008505	–23.009583
X_1	Agriculture	0.318912	908.194031
X_2	Barren And Sparsely Vegetation	0.331123	897.529053
X_3	Center Of Attraction To Distance	0.020835	31.345898
X_4	Center Of Urban To Distance	–0.092369	–117.987495
X_5	Forestry	0.315676	852.873657
X_6	High Density Settlement	0.081198	55.408287
X_7	Low Density Settlement	0.109580	198.127975
X_8	Nearest Urban Cluster To Distance	–0.000427	–28.659225
X_9	Other LULC	0.210126	372.938904
X_{10}	Road To Distance	–0.112782	–339.323334
X_{11}	Center Of Urban Economy To Distance	–0.181872	–427.046295

2. Model (Estimation model): the urban growth for 2025 was predicted with 11 variables and 2 scenarios in 2001-2013 (Figure 3). In the first scenario, the growth was modeled without any intervention. In the second one, the urban growth was modeled in two ways through area protection statuses (absolute forest area, protected area, etc.). For the estimation model, the statistics stating LRM statistical reliability:

McFadden 0.3921; Magelkerke 0.0418 for 1.scenario

McFadden 0.3921; Magelkerke 0.0418 for 2.scenario

For scenario 1 in the estimation model, the regression equation between the independent variables and the dependent variable is as follows:

Urban growth = –0.2513 + 0.9054*Agriculture + 0.4285*Barren And Sparsely Vegetation + 1.3018*Center Of Attraction To Distance + 2.1375*Center Of Urban To Distance + 1.4156*Forestry + 25.5465*High Density Settlement + 25.4074*Low Density Settlement + 38.9582*Nearest Urban Cluster To Distance + 24.9267*Other LULC + 0.1909*Road To Distance –1.2314*Center Of Urban Economy To Distance

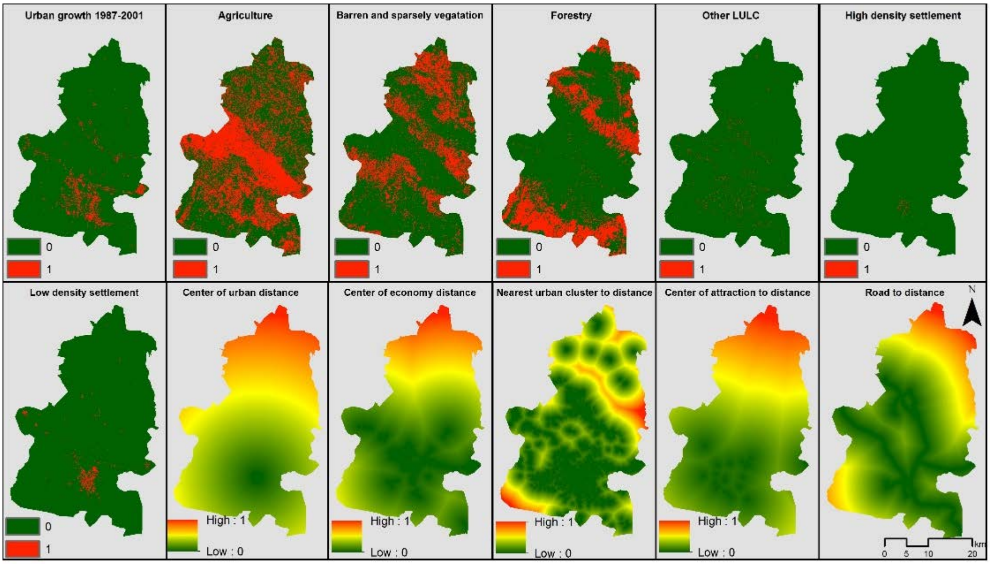

Fig. 2: The dependent and independent variables for 1987-2001

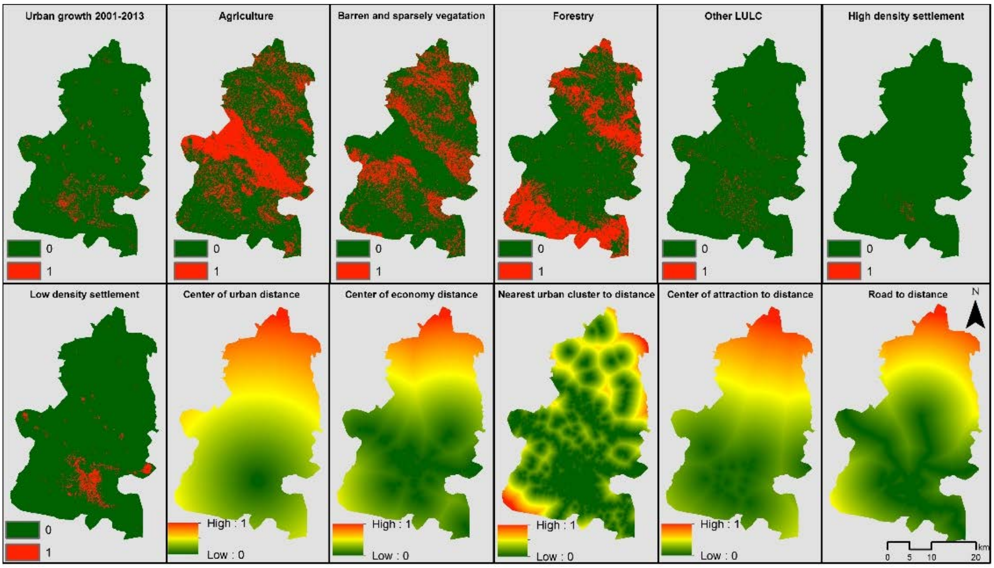

Fig. 3: Dependent and independent variables for 2001-2013

3 Results and Discussion

3.1 Urban Growth

In order to figure out the areal changes of urban land use, these changes in successive periods of time (1987-2001 and 2001-2013) were evaluated on the basis of lost, continuous, or gained areas. It was found that in the period of 1987-2001, the lost area was 10.3 km^2, the continuous area was 19.2 km^2 and the area gained was 51.6 km^2 for the city. On the other hand, in the period of 2001-2013 an area of 21.3 km^2 was lost, the continuous area was 49.5 km^2 and an area of 41.1 km^2 was gained (Figure 4). According to their areal distribution, the urban sprawl is seen to develop from the core of the city (continuous urban areas) outwards in all directions. It can be seen that the sprawl was through the road directions and it increased to the east, west and southwest in 2001-2013 (Figure 4). In the successive periods of time, the slope type where the urban sprawl is seen was determined examining its relation to the slope types for the gained urban areas, which are areas of sprawl. According to this, it was identified that the city developed intensely in the areas with 0-10 % slope at both periods of time.

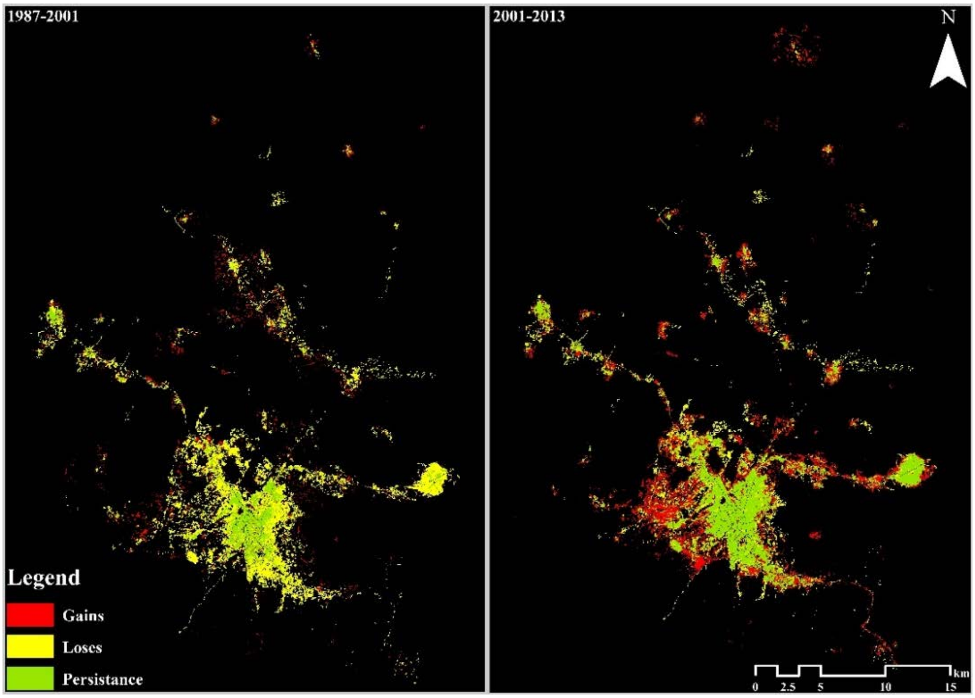

Fig. 4: The gained, continuous and lost urban areas according to successive time periods

Considering the periodic impact of population growth as the most serious factor for urbanization in the city of Denizli, it was seen that 155,738 people were added to the population between 1987 and 2001 and the rise of urban area per person is 264.5 m^2. From 2001 to 2013, the population increased by 167,165 people with a 118.4 m^2 rise of urban area per person. The mean rate of urban area growth for 1987-2013 was also determined at 188.9 m^2 per person. In addition to population growth, changes in the administrative boundaries and planning as other factors influencing the urbanization were discussed in four periods, being the period before 1987, 1987-2001, 2001-2013 and the period after 2013. In the period before 1987, with the effect of Law no. 1580, a legislative regulation of the municipalities as the urban management, the number of municipalities increased in the city centers and their surroundings especially after 1980. Along with the Construction Zoning Law no. 3194, granting the municipality authorization to construct or approve constructions led quickly to fragmentations in the administrative boundaries. As a result of these laws, each municipality made their own zoning plans and created new settlements. Considering the whole city, this also caused unplanned cities. Integrative upper scale planning studies in the early 1960s failed to be carried out because of the administrative fragmentation. When analyzing the periodic effect of this fragmentation in the city centre and its surrounding on the urban growth and sprawl, we see that the urban area increased especially in the main transportation corridors and around industrial sites.

In the period between 1987 and 2001, the effects of the previous period continued. Especially building code amnesty boosted shanty settlement and brought about the fragmentation of agricultural lands. Although the upper scale plans in this period aimed at providing integrity, urbanization was not able to be controlled because of rapid construction.

In the period 2001-2013, activities were carried out with the aim of integrating both the municipalities in the city centers, their surroundings and their plans. Environmental planning works for the plan integrity beginning after 2000 misfired because of the lack of coordination between the local and central governments and the inconsistency between the upper scale and subscale plans. However, the municipalities approved their own environmental plans with the Laws 5302 and 5393. This situation has allowed the disorganized and complex structure of the city of Denizli to continue to the date. The integrity of municipalities in the center and vicinity of cities was provided with the Demarcation Code 8352. Lastly, Denizli was made into Metropolitan Municipality with the Law no. 6360, in 2013. All the villages were made into districts by the law. This change poses a potential risk for agricultural lands. When analyzing the legislative regulations, the fragmentation in the administrative boundaries, the failure of plan integrity and the municipality plans independent from upper scale plans caused uncontrolled growth and sprawl. The uncontrolled developing cities have become serious problems in terms of their surrounding agricultural lands.

It was seen that the variables causing urban growth and sprawl affect agricultural lands in a negative way. As a result of the motorways through plain valleys and arable lands, new developing housing with the effect of settlements, trading and industrial areas around these ways has led to the loss of agricultural lands (Figure 8). Developing transportation opportunities increased construction and resulted in urban growth and sprawls around three main motorway routes to Ankara, İzmir and Antalya. In consequence of the analyses, when examining the total loss of agricultural lands between 1987-2013, the total loss in tenement districts is 510 ha, the loss in the campus area and 1 km around it is 94 ha, the loss in the industrial area and 1 km around it is 1704 ha, the loss 1 km around the motorway routes is 2207 and the loss in tourism areas and 1 km around is 314 ha. In both periods, the greatest loss in agricultural lands is seen to be around motorway routes and industrial areas. With the effect of the factors mentioned above, first circular, then linear and leapfrog sprawl are seen from the core of the city towards the periphery (Figure 5). The reason why the leapfrog sprawl increased in 2001 was the intensive administrative status change in Denizli as well as the self-authority of planning by the municipalities.

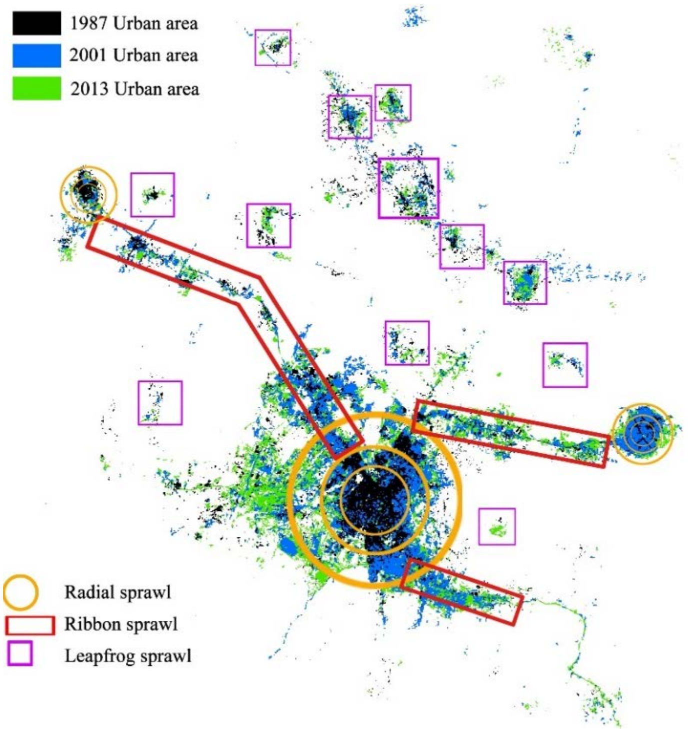

Fig. 5: The growth pattern of Denizli

3.2 Evaluation of the Variables Affecting Urban Growth via LRM

In control model (1987-2001), the primary variables that affect the urban growth in a positive way are “Barren and sparsely vegetation”, “agriculture”, “forestry”, “low density settlement” and “other LULC”. “Center of attraction to distance” and “high density settlement” affect it secondarily. The variables “center of urban to distance”, “nearest urban cluster to distance”, “road to distance” and “center of urban economy to distance” affect the urban growth in a negative way (Table 2). This shows that urban growth develops on ‘Barren and sparsely vegetation” and “agriculture areas” and that “low density settlement areas” are attractive for newly developing urban areas. As a result of this statistical analysis, no matter how much the urban areas in Denizli are clustered, it could be said that roads are not the greatest factor in urban growth. It is observed that the greatest factor in urban growth of Denizli is to make lands nonfunctional or that agricultural lands become building lands, losing their functions.

In the control model, when the estimated values of urbanization probability was classified as high probability, moderate probability and low probability once more, the general overlap of true urban growth in 2015 was determined as 86 %. This overlap is seen to be in high probability areas (47 %), moderate probability areas (25 %) and low probability areas (14 %). The model did not generate any data related to the existent area of 5.84 km^2 (14 %). When analyzing the 14 %, it was observed that these areas have been developed in a leapfrog growth (Figure 6). High overall consistency in the overlap shows that LRM generates satisfactory results in the urban growth modeling.

The urban growth model of 2025 was produced for Denizli. It was seen that the variables causing urban growth and sprawl in Denizli affect the agricultural lands in a negative way. The settlements, trading and industrial areas located around the motorways as a consequence of those motorways, built through plain valleys and arable lands, have brought about the loss of agricultural lands. Increasing transportation opportunities promote construction and cause urban sprawl in the vicinity of motorways to Ankara, Izmir and Antalya, as the three main routes (Figure 7).

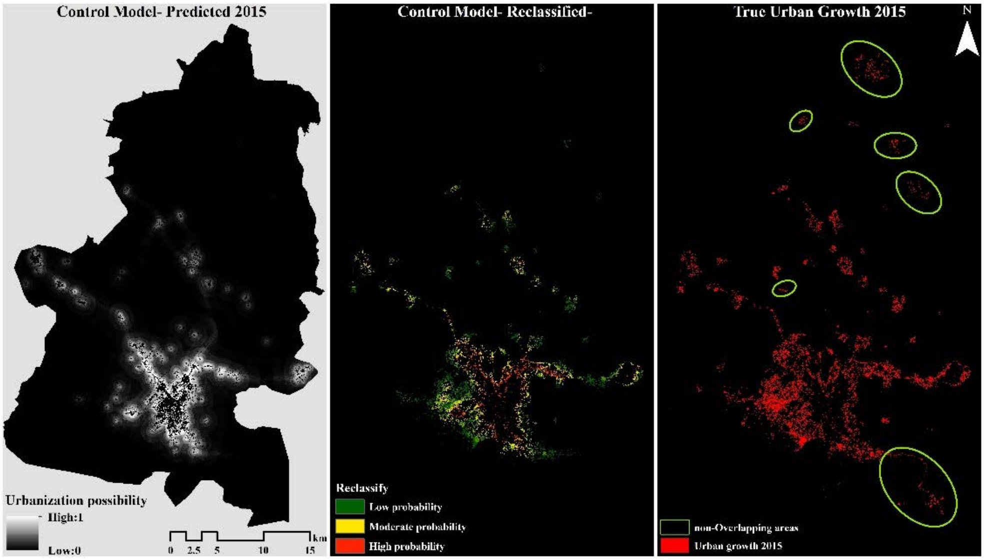

Fig. 6: Prediction of urban growth for 2015

According to the estimation model for 2025 (1. scenario), the city of Denizli continues the leapfrog and linear growth (Figure 7). The construction from the city center to the periphery is proceeding in all directions adjacent to the existent area; however, the linear growth is to the northeast (towards Saraykoy) and sets a border between the agricultural lands. Leapfrog sprawl occurs in the northern direction and results in a fragmentation and perforation in agricultural lands, also leading to pressure on archaeological settlements and archaeological protected areas. In the second scenario (Figure 7), the interaction between urban growth and protected areas is shown because there would be no construction on the areas of protected status. The urban growth is rapidly developing to the areas of protected status. It is known that urban rent is of impact on changing the status of protected areas. For this reason, the protected areas around Denizli are under pressure of urban growth. In the future, protection strategies should be developed for these areas whose characteristics will be changed and included in urban growth areas. It could be said that the main reason of the change in municipal borders and adjacent areas is management confusion and lack of coordination. The planning lags of the local government stem from the fact that the authority of making environmental plans belongs to the ministry. Increasing numbers of the municipalities, especially in 1980-2000, prevented the understanding of integrated planning. Environmental plans, upper scale plans, were repeatedly changed due to the fact that each municipality had the authority of making and approving their own plans. Although the aim was to control planning and urbanization within the borders of adjacent and municipal areas, there was a failure to avoid the rent concern and increasing urbanization especially around industrial lands, which resulted in urban growth.

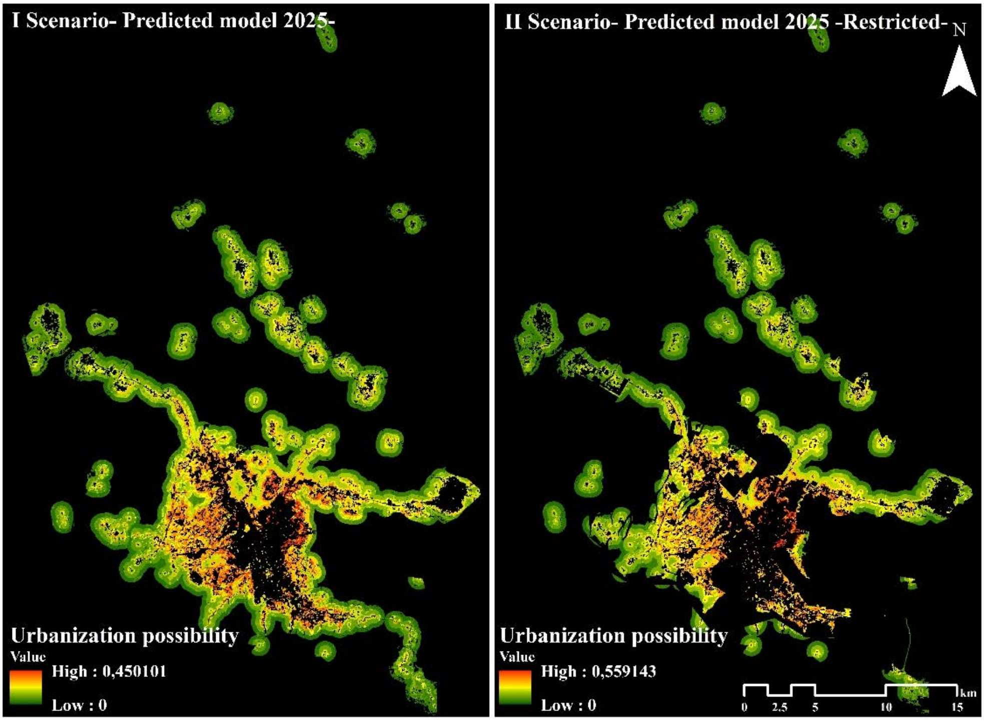

Fig. 7: Prediction of 2025 urban growth

4 Conclusion and Outlook

It is possible to make ecological decisions in urban planning and management by using RS, GIS and LRM techniques providing urban growth models. It is also important for a healthy urban life to extend such research studies in Turkey where urban policies are insufficient. Urban growth needs monitoring since it is a global issue triggered by urbanization (KARSIDI & WIJANARTO 2011). Based on this requirement, urban growth models have recently become widespread with RS, GIS and LRM techniques (CHENG & MASSER 2004, HU & LO 2007, DUBOVYK et al. 2011, MUNSHI et al. 2014, NDAWAYEZU 2015). The variables used in this study vary according to the regional urban planning policies and the phenomenon of urban growth in the related region.

It can be seen, according to RS, GIS and LRM results, that many factors affect urban development. Along with the effects of the variables such as population growth, are urban policies, central and local governments, subscales and upper scale plans, work for preventing the loss of agricultural lands, and disordered settlement in the city center and its surrounding. The primary aim should be taking the control of construction and the city should be accordingly established upon a new model. In this regard, when analyzing the city models, it is thought that the model of a compact city is a sustainable model for Denizli.

When modeling results are evaluated together with urban politics, it is more appropriate to think that "urban sprawl follows urban politics" rather than "urban sprawl follows roads". The main factor causing urban expansion in Denizli is the inadequacy and confusion of national spatial and social planning policies. Urban expansion continues to evolve over urban areas like a cancer cell. UA, GIS and various statistical models are of course very important to show this situation. However, the lack of a planning/evaluation system to evaluate these estimates demonstrates that urban sprawl will continue to adversely affect agricultural areas and urban ecosystems.

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References

CHENG, J. & MASSER, L. (2004), Understanding Spatial and Temporal Processes of Urban Growth: Cellular Automata Modelling. Environment and Planning B: Planning and Design, 31, 167-194. doi:10.1068/b2975.

DENDONCKER, N., ROUNSEVELL, M. & BOGAERT, P. (2007), Spatial Analysis and Modeling of Land Use Distributionsin Belgium. Computers, Environment and Urban Systems, 31 (2), 188-205. doi:10.1016/j.compenvurbsys.2006.06.004.

DUBOVYK, O., SLIUZAS, R. & FLACKE, J. (2011), Spatio-Temporal Modelling of Informal Settlement Development in Sancaktepe District, Istanbul, Turkey. ISPRS Journal of Photogrammetry and Remote Sensing, 66 (2), 235-246. doi:10.1016/j.isprsjprs.2010.10.002.

EYOH, A., OLAYINHA, D. N., NWILO, P., OKWUASHI, O., ISONG, M. & UDOUDO, D. (2012), Modelling and Predicting future urban Expansion of Lagos, Nigeria from Remote Sensing Data Using Logistic Regression and GIS. International Journal of Applied Science and Technology, 2 (5), 116-124.

HOSMER, D. W. & LEMESHOW, S. (2000), Applied Logistic Regression. Second Edition. John Wiley, New York, 375 p. http://dx.doi.org/10.1002/0471722146.

HU, Z. & LO C. P. (2007), Modeling Urban Growth in Atlanta Using Logistic Regression. Computers Environment and Urban Systems, 31 (6), 667-688. doi:10.1016/j.compenvurbsys.2006.11.001.

KARSIDI, A. & WIJANARTO, A. B. (2011), Urban Growth Prediction Using Logistic Regression Model: Case Study in Bogor, West Java Province, Indonesia. Globë, 13 (2), 165-174.

LINARD, C., TATEM, A. J. & GILBERT, M. (2013), Modelling Spatial Patterns of Urban Growth in Africa. Applied Geography, 44, 23-32.

MUNSHI, T., ZUIDGEEST, M., BRUSSEL, M. & VAN MAARSEVEEN, M. (2014), Logistic Regression and Cellular Automata-Based Modeling of Retail, Commercial and Residential Development in the City of Ahmedabad, India. Cities, 39, 68-86. doi:10.1016/j.cities.2014.02.007

NDAWAYEZU, G. (2015), Modeling Urban Growth in Kigali City City Rwanda. MSc Thesis, The Faculty of Geo-Information Science and Earth Observation, University of Twente.

OGUZLAR, A. (2005), Lojistik Regresyon Analizi Yadimiyla Suclu Profilinin Belirlenmesi. International Journal of Economics and Administrative Sciences, 19 (1), 21-35.

PULLAR, D. & PETTIT, C. (2003), Improving Urban Growth Forecasting With Cellular Automata: A Case Study For Hervey Bay: The Modeling and Simulation Society of Australia and New Zealand Inc. (MSSANZ). In International Congress on Modelling and Simulation (Vol. 04). Townsville, Australia.

UN-HABITAT (2011), World Population Prospects: The 2008 Revision Methodology of the United Nations Population Estimates Projections. New York.

UNITED NATIONS (2015), United Nations, Department of Economicand Social Affairs, Population Division. World Population Prospects: The 2015 Revision. https://esa.un.org/unpd/wpp/Download/Standard/Population.