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RESEARCH ARTICLE

Determination of New Deveplopment Area in Kırklareli by GIS Based Weighted Overlay Analysis

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Abstract

In today's world geography, the migration from rural area to urban areas continues and the increasing urban population causes vertical and horizontal urban growth. Many factors, such as spatial growth of cities due to population growth, orientation of high level income group towards outskirts of cities, large scale mass housing projects, and higher education facilities attached to cities, realization of large scale public investments because of low land cost cause urban sprawl. In the historical process, the urban settlements have been shaped by a variety of factors such as the needs of the society, the security, the natural environment, the proximity to the agricultural areas, the proximity to the water bodies and the landscape. At the present case, cities are widening towards unsuitable areas. It is important to take control of expansion of cities and to canalize it towards the most appropriate sites. Similar to other cities in Turkey, orientation of urban expansion in Kırklareli city is a necessity for sustainable urban development. The purpose of the study is to determine the most suitable new development areas by using weighted overlay method considering the slope, aspect, land use, soil classes, erosion status, geological structure, proximity to natural drainage systems, proximity to transportation connections, proximity to urban facilities and urban settled area criteria. In the study Geographic Information Systems (GIS) technology was used. The dataset was overlaid predominantly and the settlement suitability level was determined according to the scores of the each cells.

Keywords: Site Selection, Weighted Overlay, GIS, Kırklareli

Introduction

In recent years, the rapidly increasing world population has brought population growth in urban areas. The increasing population in urban areas has caused urban sprawl, which is a type of urban growth that is known to have negative consequences on limited natural resources. Functionality of the natural resources, desirable level of habitability in urban areas are possible to achieve if urban development can be controlled through meeting new land use demand on properly selected site. This will help to promote sustainable urban development. The concept of sustainable urban development, which first became popular in the 1972 Stockholm Conference, is to ensure that a community, ecosystem, or any system with continuity maintains its function without interruption, without corruption, without overuse, or without overloading with vital resources (Stockholm Conference, 1972). This concept widely discussed in several world-wide organization (Habitat I-1976, Brundtland Report (Common Future Report) -1987, Rio Conference and Agenda 21-1992, European Urban Charter 1992, Aalborg Charter-1994, Habitat II-1996, Johannesburg Summit-2002, Bristol-2005, Leipzig Charter-2007, European City Charter 2-2008 (United Nations, 1976, 1987, 1992, 1994, 1996, Council of Europe, 2008)).

Although there is no commonly agreed on definition for sustainable development, the notion mainly explained with fulfil the needs of present without consume the next generation's livelihoods (Brundtland Report (Common Future Report), 1987). It is express in other terms that ensuring economic development without self-sacrifice, in the sense that environmental values and natural resources are

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used in a rational manner, which will not lead to waste, considering the rights and benefits of present and future generations. Three headlines must be provided in order to ensure sustainable urban development. These headlines are physical, social and cultural characteristics (Haighton and Hunter, 1994). Whenever the concept of sustainable development is debated, many factors need to be considered. These factors are; natural factors such as slope, aspect, geological structure, stream beds, agricultural areas; artificial factors such as transportation networks, land use, proximity to urban areas, proximity to urban facilities, and social factors such as socio-cultural structures, habits, ethnic structures and income levels of the urban residents.

Creating sustainable settlements requires many different elements to be evaluated together as mentioned above. At this point, in decision making process, Geographical Information Systems (GIS) provide convenience for the interpretation of large-scale and complex data (Duran et al., 2006, Demir et al., 2016). The most important feature of GIS is the spatialization of existing data and the acquisition of new data depending on location. GIS is used for natural hazards, land use planning, transportation planning, groundwater vulnerability assessment, site selection for landfills, industries, health facilities, educational facilities and new development areas. In general terms, many different geographically referenced layers can be overlapped with each other with the help of GIS and the resulting products can easily be obtained (Musaoğlu et al., 2004, Kaya & Gazioğlu, 2015).

Multicriteria decision making method is commonly used in studies which more than one layer is used for selecting multiple functions to achieve integrated data. Weighted Linear Combination (Dai et al., 2001; Moeinaddini et al., 2010), the Weighted Potential-Constraint Method (Zong et al., 2007), the Ideal Point Method (IPM) (Ekmekçioglu et al., 2010), Analytic Hierarchy Process (AHP) (Ersoy ve Bulut, 2009; Sener et al., 2010; Park et al., 2011; Guiqin et al., 2009; Vasiljevic et al., 2011), Ordered Weighted Averaging (OWA) (Gorsevski et al., 2012; Malczewski, 2006), EVIAVE (Zamorano et al., 2008), Simple Additive Weighting (Sener et al., 2006), the Land Suitability Index Model (Marull et al., 2007), and the Ecological Niche Suitability Model (Ouyang and Wang, 1995), Fuzzy Multi Criteria Desicion Analysis (Akbari et al., 2008) are some of the examples which used multi-criteria decision making method in a variety of ways (Liu et al., 2014).

Suitable site selection for functions, with the help of GIS, is one of the most convenient applications for spatial planning (Romano et al., 2015; Malczewski, 2006). Multi-criteria decision analysis (MCDA) and GIS can be defined as a process that integrates and transforms geographic data and value to obtain an overall assessment for choosing the most suitable locations for various functions (Romano et al., 2015; Boroushaki & Malczewski, 2008; Özcan & Musaoğlu, 2010).

The growing interest in associating GIS technology with MCDA processes is beacause of the GIS potential of managing, processing, upgrading and storing large amounts of complex geo-referred data from various sources at multi-spatial, multitemporal and multi-scale levels, providing a time-efficient analysis and digital database for long term monitoring (Romano et al., 2015; Moeinaddini et al., 2010; Vaghela, et al., 2018).

The integration of GIS-MCDA procedures is advanced map overlay approaches to select most suitable site (Sumathi et al., 2008). The decision rules can be divided into multiobjective and multiattribute decision making methods. In the multiobjective method the alternatives are generated by taking the factors and the constraints into consideration. Criteria are commonly measured by a numerical scale which is continuous (slopes, distances, altitudes, climatic factors) or discontinuous (land use, physical or administrative boundaries) (Malczewski, 2004; Romano et al., 2015).

The relative importance of the criteria is represented by using weights and the performance of the land use under consideration for each criterion represented as a score or suitability class. Weights can be

assigned subjectively or objectively by using expert opinion in a pairwise comparison method or a basic component analysis of yield-determining factors (Giap et al., 2005; Nguyen et al., 2015).

The most suitable site selection for any urban facility, residential area or industrial facility is possible by evaluating various criteria together. Functions that do not select suitable places cause economic problems for the urban and urban users eventually, as well as the situations where the environment does not participate, negatively affecting ecological sustainability. Functional location choices that are not considered economically, socially and environmentally sustainable are frequently encountered in current urbanization practices. The economic, social and environmental sustainability coverage of the criteria taken into consideration is one of the factors that should be considered in the most appropriate location selection work.

Many studies which used multicriteria based site selection methods for sustainable urban development have formed with geology, elevation, slope, aspect, land cover, land use capability, land slide status, proximity to streams, proximity to highways, proximity to urban facilities like shopping centers, green areas, education and health, population density, employment intensity value, groundwater dept, restrictive soil properties, vegetation, noise level analysis, ecological structure etc. (Ouyang and Wang, 1995; Gazioğlu et al., 1997; Dai et al., 2001; Musaoğlu et al., 2002; Burak et al., 2004; Ayten et al., 2005; Yılmaz, 2005; Malczewski, 2006; Sener et al., 2006; Zong et al., 2007; Marull et al., 2007; Akbari et al., 2008; Reis et al., 2008; Zamorano et al., 2008; Ersoy ve Bulut, 2009; Moeinaddini et al., 2010; Ekmekçioglu et al., 2010; Yalçın and Batuk, 2010; Sener et al., 2010; Park et al., 2011; Vasiljevic et al., 2011; Gorsevski et al., 2012; Özşahin & Kaymaz, 2015; Gazioğlu, et al., 2016; Engin & Şengün, 2016; Göksel et al., 2018; Karakuş & Cerit, 2017;)

In this study, it was aimed to determine the most suitable new development area for Kırklareli city which does not have a planned and regular urban image despite the fact that it is a small-medium sized settlement (Gülnerman et al., 2017). Historical research was carried out primarily to learn the dynamics of the urban space within the historical development process. As a concequence of research topography, highways, large-scale public investments, large-scale housing projects have emerged as the determinants of the urban expansion in the city.

In order to create sustainable urban areas, the urban development areas need to be assessed in the context of the sustainability of natural, artificial and social elements. It is relatively easy to acquire data and associate it with urban space on natural and artificial elements. On the other hand, it is not easy to acquire geocoded data on social and economic elements. Due to various difficulties in spatialization of the data, social factors were not included in the evaluation in the scope of this study. Therefore, the study is inadequate in decision making process while it can be a guide for planning sustainable settlement. In parallel with the literature researches and the urban researches made in Kırklareli city, various criteria were selected to determine the most suitable new development areas. These criteria are slope, aspect, land use, erosion, hydrology, geology, land use capability, proximity of built up environment, proximity of transportation and proximity of urban facilities. The dataset consists of specified criteria were obtained from public institutions, online maps and printed sources. Dataset was spatialized with the help of the GIS based computer environment. To determine the weights of each criteria in decision making process to select new development area, a survey was applied to the urban planners. Finally, all criteria were superimposed by determined weights, and the most suitable areas for urban development were identified. This study was conducted in order to guide the urban expansion in accordance with the principles of sustainability in Kırklareli city center.

Material and Method

Study Area

Kırklareli province is a sort of bridge from Asia to Europe and a neighboring border with Bulgaria. It is surrounded by Bulgaria in the

north, Black Sea in the east, Istanbul in the south east, Tekirdağ in the south, and Edirne in the west (Figure 1).

As a result of the researches made with available resources and maps it was stated that the historical development of the city started from Yayla Quarter and Kırklar Hill located in the Kocahidir Quarter (Yıldız & Yüksek, 2008; Erginal, 2017).
The development in this region, especially with the immigrant exchanges in the first years of the Republic, began to expand to the western and eastern directions (Aysu et al., 1984; Tuncel, 2002; Uludağ, et al., 2018).

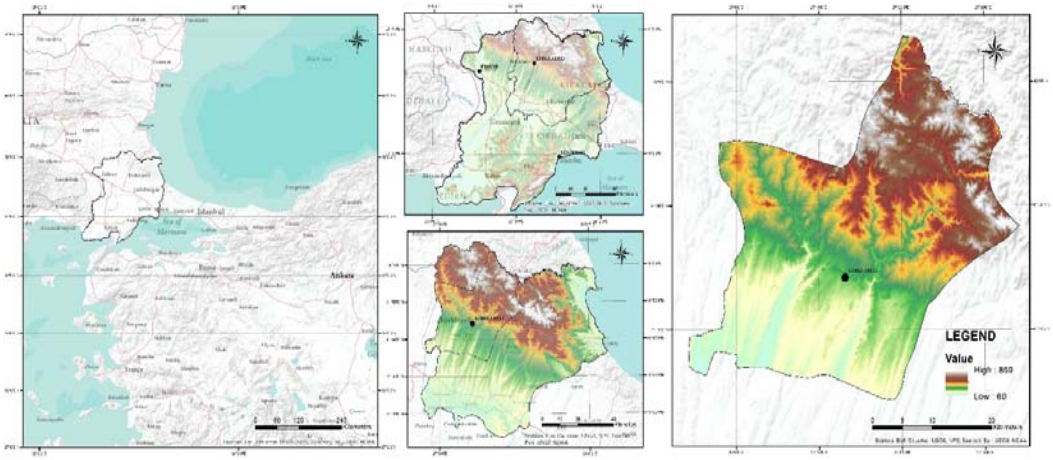

Fig. 1. Geographic Location of the Study Area

When the borders of the city in 1976 were examined, it is seen that the development proceeded towards the western and southern directions of the city. The first master plan made in 1948 and second master plan made in 1968 canalize the spatial expansion towards the Kurtuluş Street, Fevzi Çakmak Street, Atatürk Street and Istiklal Street (Aysu et al., 1984; Tuncel, 2002). Especially after 1980, the site selection of military areas, the construction of the E87 highway connecting the Kırklareli-Dereköy border gate and Kırklareli - İstanbul connection orient spatial growth to the south. In addition to these, the site selection of the facilities such as education, mass housing, public institution and health in the Karakaş district has also triggered the development in the west direction. A third development plan was made in 1986, but relevant plans were revised by the municipality in 1988 and 1991. When the revised development plans of 1991 were considered, new development areas were proposed towards to the north, south and west directions. After 2000s, city borders in the north, west and south directions continue to expand in line with the 1991 plan decisions. The biggest change is TOKI Mass Housing Project in north of the city. The impact on the relevant projects and regions led to the exclusion of the limits envisaged in the 1991 plan (Özkök & Kuru, 2015) (Figure 2,3,4).

The population of the city has been increasing since 1965 (Figure 5). When the population change in Kırklareli is subjected to a general evaluation of the neighborhood scale, it is observed that the Istasyon neigborhood has separated significantly from the other neighborhoods. Pınar and Bademlik are other neighborhoods collecting population on the periphery of the city. In the eastern part, Akalar and Cumhuriyet are slightly losing population (Figure 6).

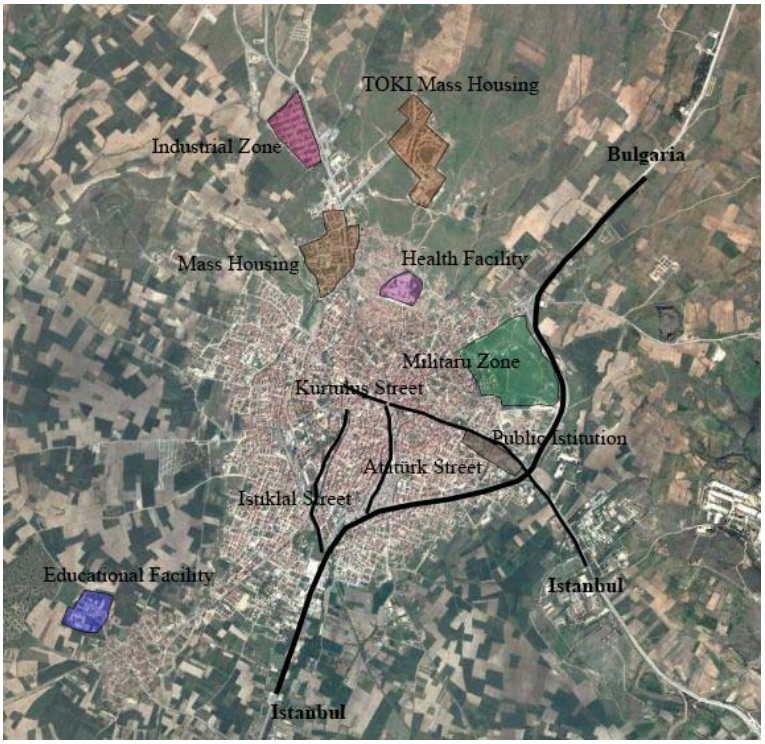

Fig. 2. Some Reasons of the Spatial Growth

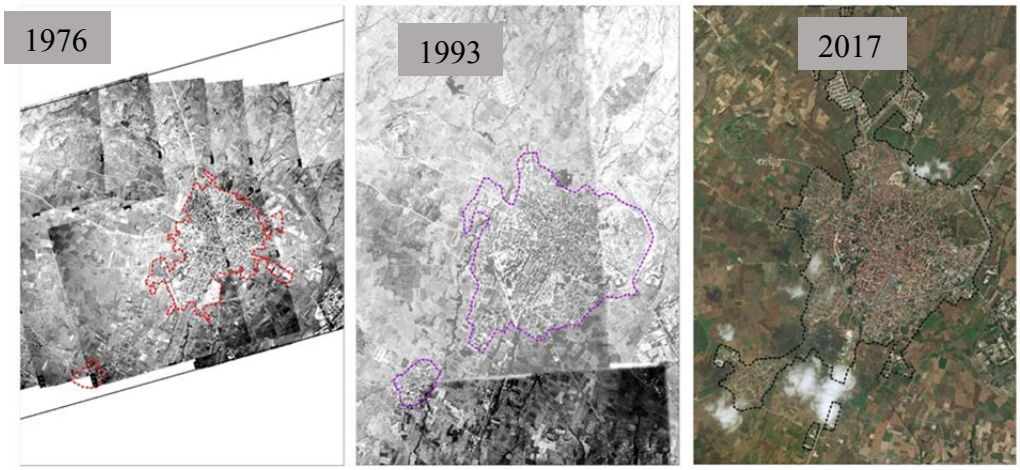

Fig. 3. Spatial Growth of the Study Area

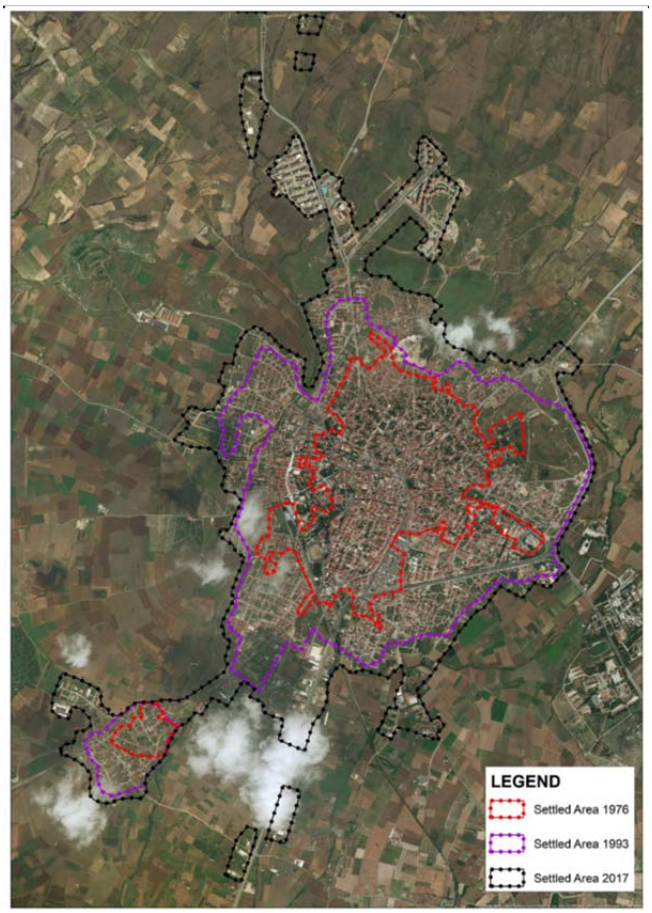

Fig. 4. Urban Growth Boundaries Between 1976-2017

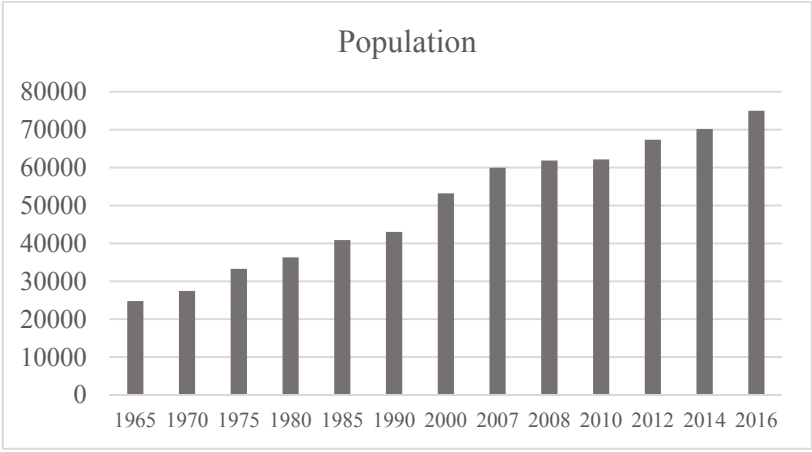

Fig. 5. Population Growth in the Study Area

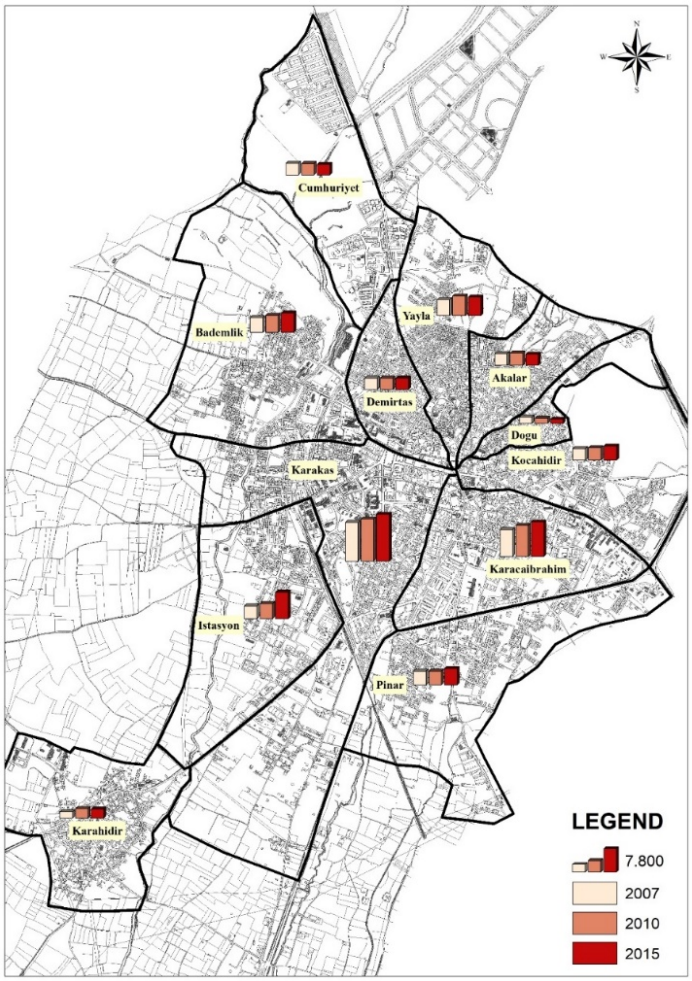

Fig. 6. Population Growth of Neigborhoods for the Study Area

Methodology

In the study, GIS based weighted overlay process was applied. The criteria and subcriteria that affect urban expansion were identified as a result of the literature researches and studies made specifically for the study area. Weights of determined criteria and scores of subcriteria were obtained by the help of expert opinions (Table 1). The visualization of the study process is given in Figure 7.

Proximity to the built-up area, proximity to the urban facilities and proximity to the transportation were considered as artificial criteria and slope, aspect, proximity to the stream beds, erosion status, land use capacity, land use status and geological condition were considered as natural criteria. Firstly, all the data obtained from various sources in various file formats have been converted to raster format data with 26 * 26 meters pixel units in ArcGIS environment. The Euclidean distance feature was applied for proximity analysis. At later stage, these analysis were reclassified using scoring values obtained from expert opinions and they were adapted to overlay. At the final stage, reclassified analysis were subjected to weighted overlay analysis in ArcGIS environment using weights from expert opinions. As a result of the process, the most suitable areas for urban expansion were identified and visualized (Figure 8).

Table 1. Scores and Weights for Used Criteria

	Criteria	Subcriteria	Average Score	Average Weight
Natural Criteria	Slope	%0-%5	4	10%
		%5-%10	5	
		%10-%25	3	
		%25-%40	1	
		%40-%100	0	
	Aspect	S	5	8%
		SE-SW	4	
		E-W	3	
		NE-NW	2	
		N	1	
	Land Use	Strict Protected Agricultural Zone	0	13%
		Priority Protected Agricultural Zone	0	
		Limited Agricultural Zone	4	
		Forest	0	
		2B	2	
		Lea	0	
	Erosion	I	1	7%
		II	2	
		III	4	
		IV	5	
	Hydrology	0-100	0	10%
		100-500	2	
		500+	5	
	Geology	Solid Foundation	5	11%
		Avarage Solid Foundation	3	
		Soft Foundation	0	
	Land Use Capability	I	0	10%
		II	0	
		III	0	
		IV	1	
		V	2	
		VI	3	

		VII	4	
		VIII	4	
Artificial Criteria	Proximity of Built-Up Environment	0-500	5	8%
		500-1000	4	
		1000-1500	3	
		1500-2000	2	
		2000+	1	
	Proximity of Transportation	0-500	5	14%
		500-1000	4	
		1000-2000	3	
		2000-5000	2	
		5000 +	1	
	Proximity of Urban Facilities	0-500	5	10%
		500-1000	4	
		1000-1500	3	
		1500-2000	2	
		2000+	1	

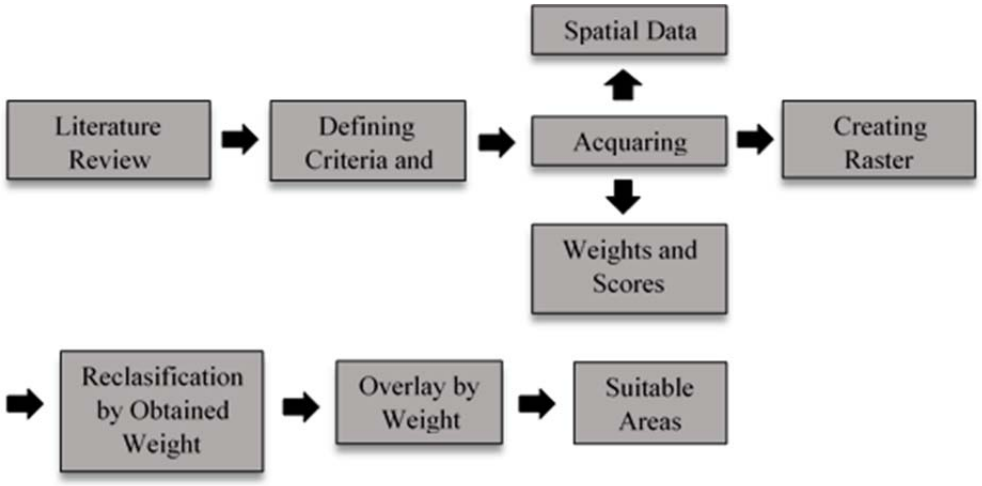

Fig. 7. Flowchart of the Study

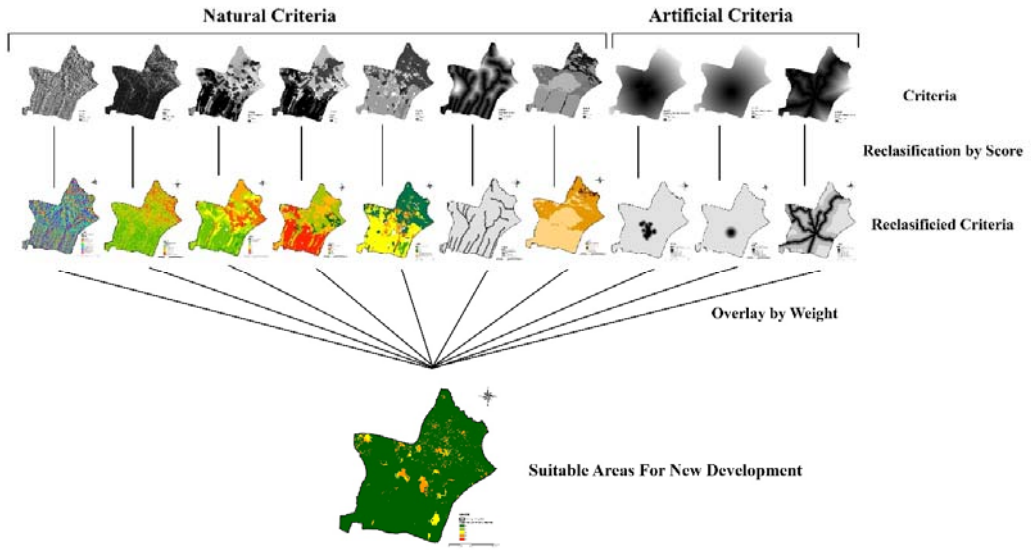

Fig. 8. Flowchart of the Methodology

The south, southeast and southwest orientation of topography is quite dominant in the study area. A southward viewing of the natural landscape is a positive factor for urban settlements. Similarly, the vast majority of the area has a slope range of %0 to %5. Besides, small amount of area has %25 and much more slope. The city is located in the transition point of the Yıldız Mountains and Ergene fertile agricultural basin. It is surrounded by forest area in the north and agricultural area in the south. The northern part of the study area has low erosion level with stable geological base while southern part has high erosion level with soft geological base. The deep stream beds in the east and west of the city, the mountains of Yıldız and the Ergene lowland are the main elements that shapes the natural macroform of the study area (Figure 9).

Results and Discussion

The land use status of Kırklareli is composed of approximately 56% (88 035 ha) of agricultural land and approximately 36% (57557 ha) forest land. At the same time, the agricultural areas located in the region consist of approximately 70% (111 123 ha) highly efficient 1st, 2nd, 3rd and 4th class soil capacity. On the other hand, the great majority of the geological situation is composed of soft and moderate solid base.

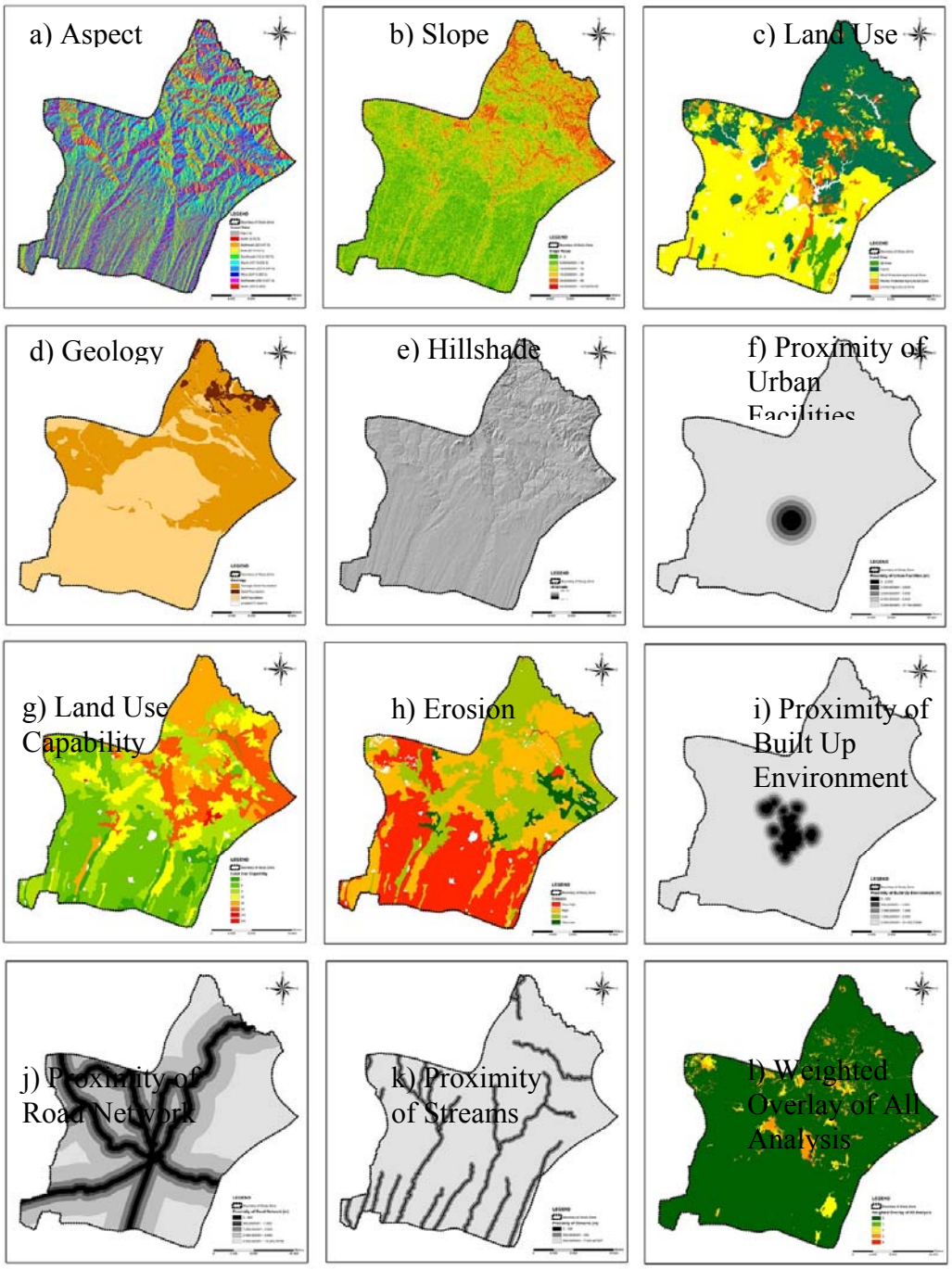

Fig. 9. Criterias

The weighted overlay model which is set according to explained criteria in the methodology section, indicates that the suitable new development areas are located in the northeast and northwest parts of the city centre. Beside that, the study area with 157 153 ha has 146 681 ha (approx. 93%) unsuitable area. The area with the highest level of suitability with 4 points is 62 ha wide. 2nd degree suitable area with 3 points is 615 ha wide and with 2 points 3rd degree suitability 3976 ha wide. Lastly 4th degree suitable area with 1 point is approximately 1 ha (Figure 10).

It is possible to say that the city of Kırklareli is in a very sensitive ecosystem according to evaluated data. In the decision making process adequate attention must be paid to the sensitive ecosystem for a sustainable urban development.

Information technologies that have developed in recent years have provided considerable ease in understanding the dynamics of urban development and future oriented decision making process. The role of the developed computer software in mapping and collocation of various and spatially independent data is great. The multi-criteria decision making method used in this study can easily be realized with existing computer software.

In this study, firstly literature review and study area analysis were carried out to determine the dynamics of urban development specific to the city of Kırklareli. Determined dynamics are mainly composed of natural and artificial environment data. However, social and economic criteria that are often ignored or considered not as important as their competence in decision making processes are also not used in the study. In this regard, the study is inadequate to use in decision making processes directly. The chosen criteria for natural and artificial environment are considered as the criteria that guide the spatial development of the Kırklareli City or should be used to guide spatial development in the context of sustainable urban development concept.

Secondly, the sub-criteria for the each criteria and the impacts of these sub-criteria on the sustainable urban development aim were determined by using expert opinions. For this purpose, the opinions of the investigators were utilized in the field of urban and regional planning. Nevertheless, the opinions of urban and regional planners are inadequate in terms of urban development, which has a wide variety of dynamics, and many other disciplinary experts are needed in decision making processes. Some of the other disciplines involved in ecology, economics, sociology, architecture, history, public administration, local governance and political science are required to maintain sustainable urban spatial development. Future work requires multidisciplinary, multi-participatory assessments.

Although it is directly related to various internationally accepted standards for sustainable urban development, it is necessary to make different evaluations for each city subject to the study. Considering the concept only as the provision of conservation and useage balances of natural values and ignoring the social structure and cultural habits of urban users will result in a lack of understanding of urban dynamics. In this context, it is important that the gathering of indigenous data and the natural, artificial and social dynamics specific to the place are of great importance. However, it is not always possible to relate each acquired data with space. The multi-criteria decision-making method, which is carried out with the help of space based analysis in this study, makes it difficult or impossible to use some social and economic criteria.

Generally, this study shows a negative aspect in terms of neglecting the social dimension when spatial data shows a positive aspect in terms of providing cooperative use of each other.

Conclusion

Because of the rapidly increasing population in urban areas, cities tend to grow horizontally and vertically. Growth in medium and small-scale cities like Kırklareli is largely horizontal. In this context, various natural, artificial and social elements need to be evaluated together to determine the new urban development areas for sustainable urbanization. In this study, deciding the most suitable new development areas for Kırklareli city within the scope of natural and artificial elements was made by weighted

overlay method. The study may form a basis for the planning studies to be carried out, and is important from the perspective of directing urban development but it is necessary to carry out a more comprehensive evaluation at the implementation stage since social elements are not included in the study.

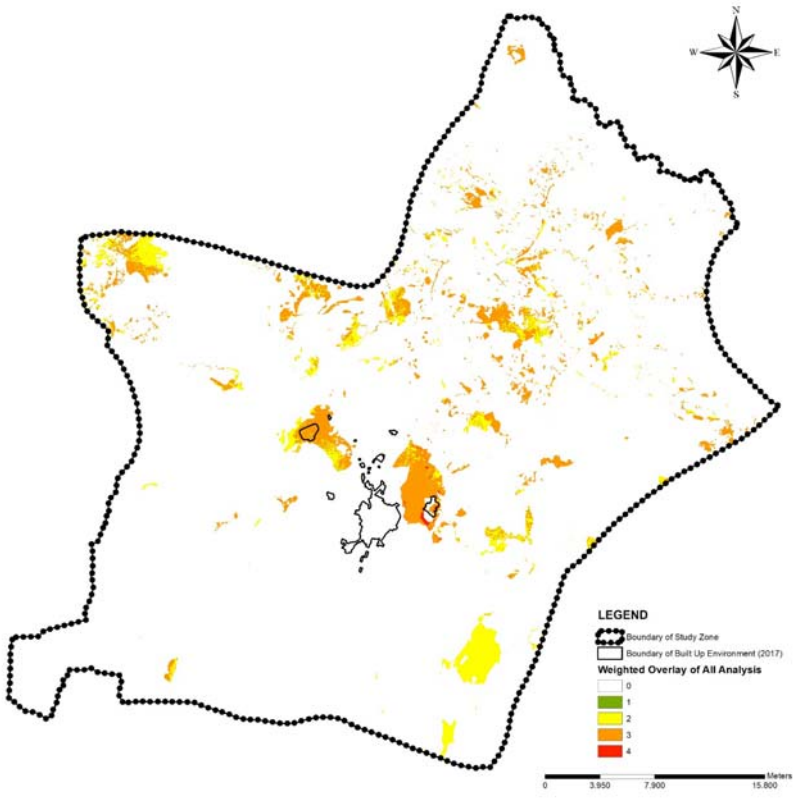

Fig. 10. Suitable Areas for New Development

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