Environmental Research & Technology, Vol. 4 (2), pp. 117-125, 2021

Environmental Research & Technology

http://dergipark.gov.tr/ert

RESEARCH ARTICLE

A study on evaluation of site selection in sanitary landfill with regard to urban growth

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ABSTRACT

Sanitary landfill is a widely used waste disposal method worldwide due to its safe and economic. The most important issue in this storage method is the process of selecting the landfill. This process is one of the critical issues in the urban planning process due to its enormous impact on the region's economy, ecology, and environmental health. At the same time, it is also a great importance for public health. Urban growth is a phenomenon that is difficult to stop or limit in line with economic dynamics and demographic changes. For this reason, site selection in solid waste sanitary landfill is a great importance in terms of ensuring a sustainable urban future. The site selection in sanitary landfill is made conventionally taking into account environmental, social and economic criteria. In this study, the waste disposal facility, which was built according to the mentioned criteria and still in operation, was evaluated in the context of urban growth. In this context, Landsat TM 1989 satellite image for the determination of urban boundaries of the central settlement area of Sanliurfa before the irrigation of the GAP project, and Sentinel-2 satellite image enrichment to determine the urban development boundaries after irrigation was mapped by Screen digitizing. Its spatial evaluation and mapping were performed utilizing ArcGIS software.

Keywords: Sanitary landfill, site selection, socio-economic pressures, urban growth, Sanliurfa

1. INTRODUCTION

Many countries have started to pay more attention to the selection of landfills with the increase in urbanization in recent years. Searching for a new waste site can be a time-consuming process when existing waste disposal sites are full. For this reason, a new field must be determined before these fields are filled. The landfill has been used for years as the most common method of removing solid waste almost worldwide.

Suitable hydrological, geological, and environmental conditions are required for a suitable solid waste sanitary landfill site. For these reasons, waste sanitary landfills should be specially designed and built, and managed strictly to keep them safe during their operation. Scientific studies need to be done to properly select the applicable areas for landfill. In this way, the cost of landfills can be reduced, and possible pollution can be controlled [1]. Many methods such as diagramming, gray clustering, expert systems, geographic information systems (GIS), and analytical hierarchy processes (AHP) are used in the selection of landfills [2]. GIS techniques are a method used effectively to provide solutions for landfill selection [3,4]. The geographic information system (GIS) is a digital database management system designed to manage spatially distributed data from various sources in large volumes. They efficiently retrieve store, analyze and display information according to user-defined indications. In this way, it is an ideal method for advanced site selection studies. GIS is widely used to facilitate the landfill selection process and to reduce its cost [5,6].

In developing countries such as Turkey, landfill or multi-criteria analysis using GIS significant progress was made way relates to the election [7]. However, this method is an advantage for developing countries

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Received 16 December 2020; Received in revised form 31 March 2021; Accepted 18 May 2021
Available Online 25 May 2021
Doi: https://doi.org/10.35208/ert.841200

This paper has been presented at EurAsia Waste Management Symposium 2020, Istanbul, Turkey

since it does not include financial and economic restrictions. Technological development, globalization, and unavoidable population growth have accelerated the urbanization process in developing countries. Therefore, the selection of suitable solid waste sites should match the rapid urbanization process [8,9].

In this study, the waste disposal facility, which was built according to the mentioned criteria and still in operation, was evaluated in the context of urban growth. In this context, Landsat TM 1989 satellite image for the determination of urban boundaries of the central settlement area of Sanliurfa before the irrigation of the GAP project, and Sentinel-2 satellite image enrichment to determine the urban development boundaries after irrigation was mapped by Screen digitizing. Its spatial evaluation and mapping were performed using ArcGIS software.

2. MATERIALS AND METHOD

2.1. Study area

The province of Sanliurfa is in the center of the Southeastern Anatolia Region, Gaziantep is located in the west, Adiyaman in the northwest, Diyarbakir in the northeast, Mardin in the west, and Syria in the south. It is located between 36° 40'- 38° 02' North latitudes and 37° 50'- 40° 12' East longitudes (Fig 1). Its altitude is 518 m.

Sanliurfa is located on the southern skirts of the central part of the Southeast Taurus Mountains. Mountains and high hills in the north of the province descend towards the south. The great plains are in the southern half. Row hills are quite common. Suruç, Harran, Viransehir plains, which are lined from west to east, are among these mountain ranges. The area of Sanliurfa land is 18,584 km². 98.3% of the provincial lands, 61.7% of which are covered with plateaus, 22% by mountains, and 16% by plains, are arable land.

2.2. Methodology

In the analysis of the urban changes of the city of Sanliurfa, Landsat-5 TM and Sentinel-2A satellite data were used in 1989 and 2019, respectively. Landsat-5 TM 1989 satellite image and Sentinel-2A satellite to determine the boundaries of urban development after irrigation was mapped by image enhancement screen digitizing (Fig 2). The Landsat-5 TM sensor, which has been used since 1984, has 6 bands with 30 m resolution and a thermal band with 120 m resolution in the near and middle infrared region. Each Landsat TM image covers an area of approximately 185x185 km² [10].

Fig 1. Study area and existing solid waste storage facility

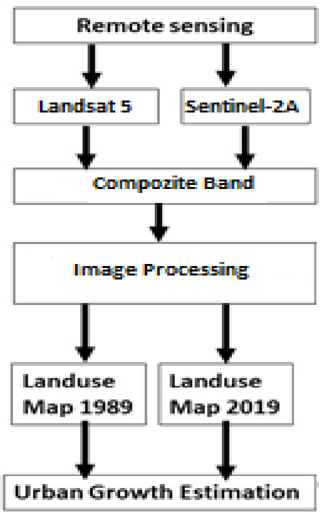

Fig 2. Methodology and flow chart of the study

Studies were carried out on the WGS84 UTM Zone 37N projection system. Image processing and evaluation of multi-time satellite images were carried out using ERDAS Imagine© and ArcGIS© software.

2.3. Urban growth

Rapid urban growth in developing countries contributes greatly to increasing problems related to unemployment, poverty, inadequate healthcare, low quality of life, damage to nature, poor water quality, and deterioration of living environments, especially in rural areas. [11, 12]. Unplanned population growth, together with the inadequacy of basic services; brings along problems especially for rural areas [12]. Recently, urban growth management has become a challenge for urban planners and developers, putting pressure on allocating land suitable for development [13, 14].

Unforeseen environmental threats have started to emerge as a result of socio-economic pressures such as industrialization, urbanization, migration, and population growth, especially in metropolitan settlements. To prevent these problems, central and local government actors must act together with urban growth management units / sub-units and produce results (Fig 3).

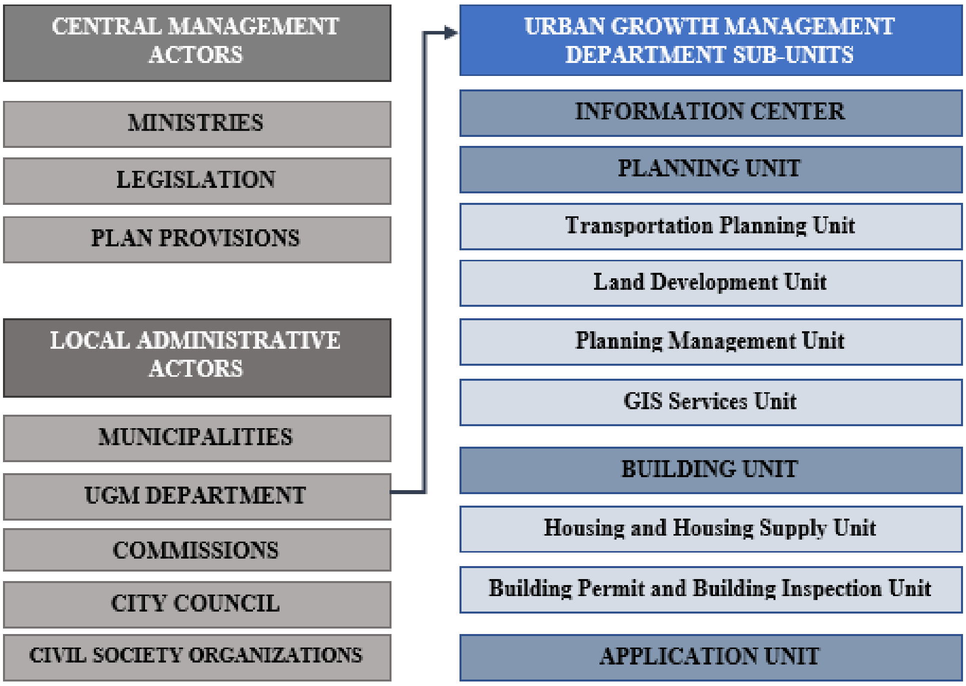

Fig 3. Urban growth management actors and administrative structuring [15]

Unless urban growth is realized in a planned and controlled manner, it leads to various adversities such as environmental pollution, distorted and irregular construction, agricultural land remaining in the city, and losing their qualifications [16]. Analysis of urban growth using past and present spatial and quality data is considered as one of the basic requirements of urban geographic studies, future planning, and political policies for urban development.

Mapping, modeling, and measurements of urban growth can be analyzed using GIS and remote sensing-based statistical models. Thanks to these technological developments, the change in the temporal and spatial scale of complex urban systems and the direction of this change have become analyzable [17].

2.4. *Solid waste generation*

According to statistical data, people generate 2-5% more solid waste each year compared to the previous year [18]. When the solid waste indicators for 2016 published by TURKSTAT are examined, it has been determined that 1390 of them provide waste service among 1397 municipalities. It is stated in the survey results that a total of 31.6 million tons of solid waste is collected from these municipal services. However, the daily average amount of waste collected by municipalities was determined as 1.17 kg for 2016. This amount was stated as 1.14 kg for Ankara, one of the big cities, 1.30 kg for Istanbul, and 1.32 kg for İzmir [19].

When the 2018 solid waste indicators published by TURKSTAT are examined, it has been determined that 1395 of 1399 municipalities provide waste services. It has been determined that municipalities providing waste services collect 32 million 209 thousand tons of waste. According to the results of the survey, the daily average amount of waste per capita collected by the municipalities was determined as 1.16 kg for 2018. In three major cities, the daily average amount of waste collected per capita was determined as 1.28 kg for Istanbul, 1.18 kg for Ankara, and 1.36 kg for Izmir [19]. 67.2% of 32 million 209 thousand tons of waste collected in municipalities where waste service is provided is sent to regular storage facilities, 20.2% to municipal dumpsites, and 12.3% to recovery facilities. It was stated that 0.2% of it was disposed of by burning in the open, burying, pouring into the stream or land (Table 1).

2.5. *Classification of solid waste landfills*

Storage areas are divided into two groups as irregular storage areas and landfills [20]. In irregular storage areas, which are used in developing and underdeveloped countries, solid wastes in waste storage areas are discharged irregularly into open land without taking any precautions and removed from the human environment. Since the wastes are not covered, the formation of dust clouds due to the wind effect in irregular storage areas, the resulting gases cause air pollution, and the environmental and visual pollution of solid wastes spread over a wide area cause infectious diseases for animals living in these areas [20, 21].

Table 1. Municipal waste indicators

Municipal Waste Indicators	2016	2018
Total number of municipalities	1397	1399
Number of municipalities providing waste services	1390	1395
The ratio of the municipal population receiving waste services to the total municipal population (%)	98.6	98.8
Total amount of waste (thousand tons)	31584	32209
Average amount of waste per person (kg $person^{-1}$ day^{-1})	1.17	1.16
The ratio of total waste according to disposal and recovery methods (%)		
Sent to landfill facilities	61.2	67.2
Sent to municipal waste	28.8	20.2
Sent to recycling facilities	9.8	12.3
Other disposal methods	0.2	0.2

Landfill facilities (DDT) can be defined as places where wastes are accepted as controlled, wastes are disposed of above ground and underground according to some technical conditions, and the wastes generated as a result of the mechanism formed in the waste after storage are controlled. Although the landfill is at the bottom of the waste management order, it is a widely used disposal method in many countries around the world [20]. In landfilling, solid materials and sewage sludge, which are intended to be disposed of by the producer but need to be removed regularly in terms of environmental protection, should be collected in a certain order by considering the physical, chemical, and biological effects they cause in the environment and stored accordingly [21, 22].

The following principles should be taken into consideration when performing landfill [20]: Regularly covering solid wastes with ground cover; compaction, slope, and subsequent use of vegetation, drainage of water flowing from the surface, control mechanisms to protect ground and surface waters; factors affecting the selection of landfill site location.

In the determination of alternative storage areas, the restrictions set in the Waste Management Regulation used in our country are taken into consideration [23]. The limitations to be used in the location of storage facilities in the Regulation on the Landfill of Wastes are as follows: distance to airports; distance to the forest, afforestation, and protected areas; distance to underground and surface water resources; topographic and geological situation; flood, landslide, avalanche, erosion and high risk of earthquakes; prevailing wind direction and precipitation, natural or cultural heritage situation; absence of pipelines.

Ciritci and Türk emphasized that since determining the location of the storage facility is a difficult and critical stage, solid waste management is not only an environmental issue and should not be ignored in various socio-cultural and economic issues (Table 2) [24, 25].

2.6. Identification of the criteria

Site selection is a complex spatial decision problem that offers many alternatives for decision-makers and carries different preferences. That is, this choice is not easy and unilaterally definable [26]. It is a difficult and long-lasting process to evaluate the existing information regarding the selection of the study area with classical methods [18].

Although current methods consider various objectives and relevant criteria, there is no integrated method to account for the best landfill in all policies [27]. Given these conditions, a model is needed that considers the importance of all three environmental, economic and socio-cultural criteria at the same time (Fig 4).

Table 2. Site selection criteria for sanitary landfills [25]

Dimensions	Criteria	Ideal options	Acceptable range
Economic (D_1)	Land price (C_{11})	1. The suitable site for waste disposal must be inexpensive as much as possible. 2. Land price is determined based on its distance from proximate roads (the closer, the more expensive)	For a distance less than 100 m from the road, the price was IRR 150000 per m^2. - For a distance within 100–400 m from the road, the price was IRR 100000 per m^2. - For a distance more than 400 m from the road, the price was IRR 50000 per m^2.
	Distance from roads (C_{12})	Due to economic constraints in terms of transportation costs, the waste disposal site should not be very far from main roads.	- Reasonable distance: less than 100 m from the road. - Relatively reasonable distance: within 100–1000 m from the road. - Unreasonable distance: more than 1000 m from the road.
Environmental (D_2)	Distance from rivers (C_{21})	The disposal site must be located somewhere far from rivers and flowing surface waters to avoid pollution.	- Unreasonable distance from rivers: less than 500 m - Relatively reasonable distance from rivers: 500–2000 m
	Distance from lakes (C_{22})	The disposal site must be located somewhere far from lakes to avoid pollution.	- Unreasonable distance from lakes: less than 500 m - Relatively reasonable distance from lakes: 500–2000 m
	Distance from grasslands (C_{23})	The disposal site must be located somewhere far from pastures and grasslands to minimize environmental pollution.	- Unreasonable distance from pastures: less than 1000 m - Relatively reasonable distance from pastures: 1000–2000 m - Reasonable distance from pastures: more than 2000 m
	Distance from forest regions (C_{24})	The waste disposed of must be considerably far from forest regions to minimize environmental pollution.	- Unreasonable distance from forests: less than 1000 m - Relatively reasonable distance from forests: 1000–2000 m - Reasonable distance from forests: more than 2000 m
	Distance from agricultural lands (C_{25})	The disposal site must be located somewhere considerably far from farmlands and agricultural areas to minimize environmental and social pollution.	- Unreasonable distance from agricultural lands: less than 1200 m - Relatively reasonable distance from agricultural lands: 1200–2000 m - Reasonable distance from agricultural lands: more than 2000 m
Climatic (D_3)	Climate conditions (C_{31})	The disposal site should be located in arid areas.	- Unappropriated areas: cold and humid - Relatively appropriated areas: cold and dry
	Distance from floodprone areas (C_{32})	The disposal site should not be located near water pathways, flood pathways, and flood-prone areas.	- Unreasonable distance from flood pathways: less than 1000 m - Relatively reasonable distance from flood pathways: 1000–2000 m - Reasonable distance from flood pathways: more than 2000 m
Geological (D_4)	Slope of land (C_{41})	The disposal site should be located, as much as possible, in level and straight areas.	- Reasonable slope: less than 10° - Relatively reasonable slope: 10–40° - Unreasonable slope: more than 40°
	Terrain (C_{42})	This factor has a function similar to that of slope and is calculated through the slope layer in GIS.	Reasonable areas: level lands - Relatively reasonable areas: hill sites - Unreasonable areas: uneven and mountainous regions
	AMSL (C_{43})	The disposal site must be located in places with a low AMSL to keep climatic states and terrains stable.	- Reasonable height: less than 1000 - Relatively reasonable height: 1000-2100 - Unreasonable height: more than 2100
Social (D_5)	Distance from residential areas (C_{51})	Due to social constraints, the disposal site must be located somewhere far from cities, rural regions, and residential areas.	- Unreasonable distance from residential areas: less than 700 m - Relatively reasonable distance from residential areas: 700–3000 m - Reasonable distance from residential areas: more than 3000 m

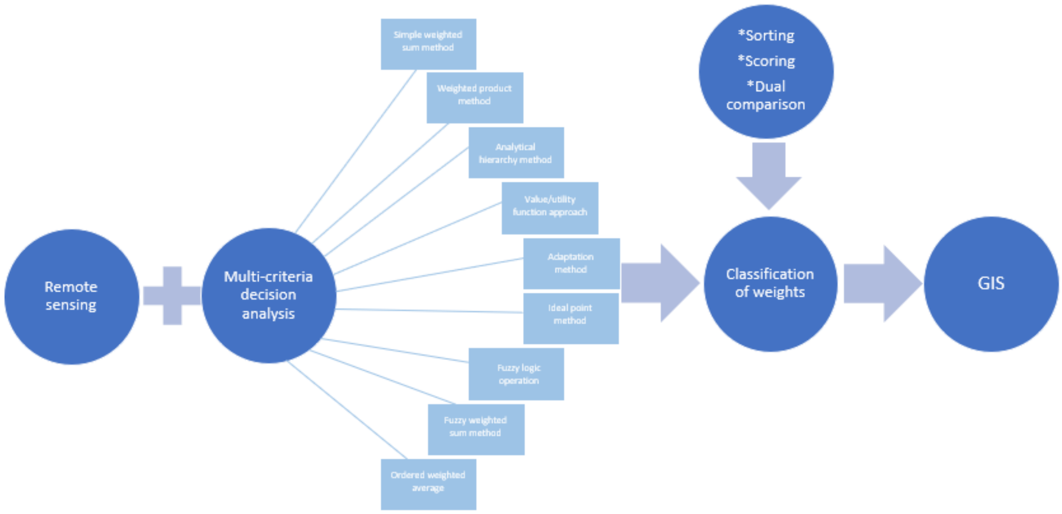

Fig 4. Use of (GIS-MCDV-Remote Sensing) technologies for choosing the appropriate place for waste storage

2.7. Urban growth estimation

Environmental pressures caused by the incorrect use of space on natural resources, both developed and developing countries as one of the important issues on the agenda in Turkey. The most important reason for the emergence of these problems is that the protection-use balance and environmental values are not considered sufficiently [10]. The cities develop, and settlement areas move in different directions with each passing day [28]. Many ecological problems arise when the demographic structure and spatial development of the province are not well followed and balanced with a plan [29].

3. RESULTS & DISCUSSION

Classification results for 1989 and 2019 are shown in Fig 5. Classification results of satellite images differ visually. In these images, mainly green areas are gathered especially in the south of the city. Sanliurfa, which was a small city in 1989, turned into a megacity by 2019. The urban land rate has increased. Urban population growth between these years was faster than urban land growth in the same period.

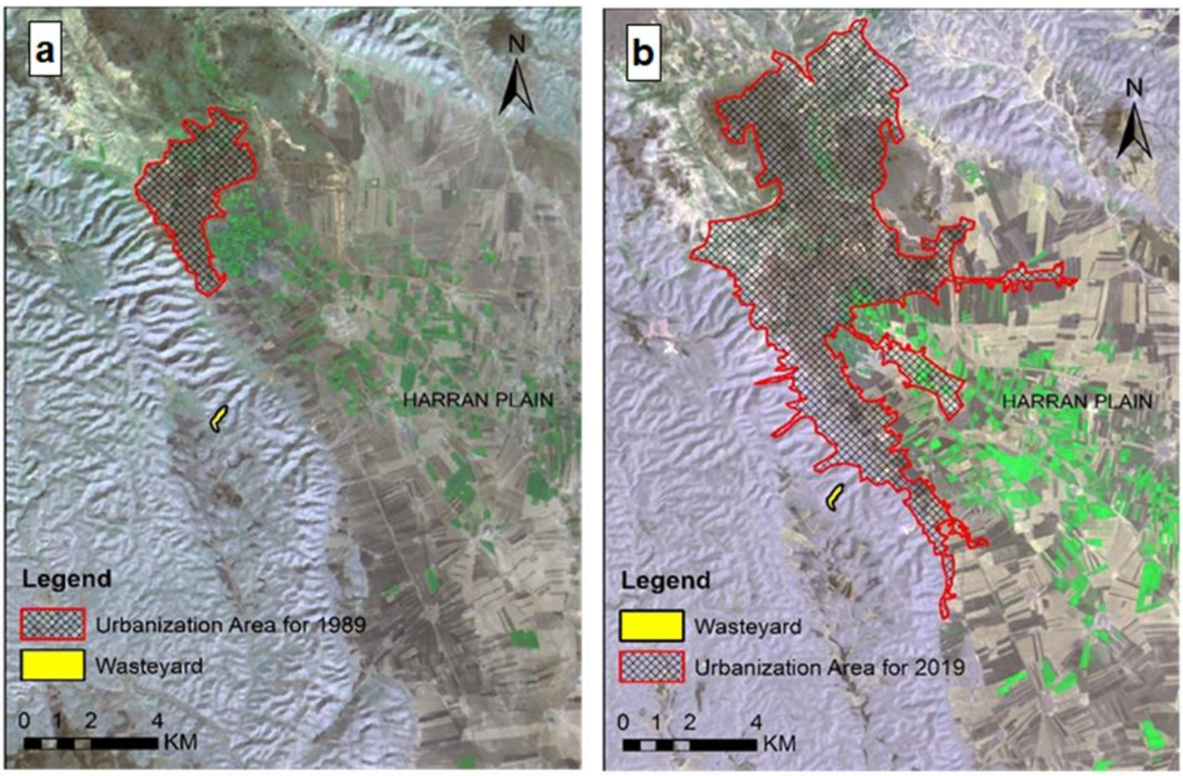

Fig 5. Classification results for (a) 1989 and (b) 2019

When Fig 5 is examined, it is understood that the construction works in the north, east, and southeast axes of the city have increased over 30 years. Especially in this process, it is seen that industry and construction areas interact. It is observed that the settlements also differed in these 30 years. In general, the population increases twice every 32 years, and the direction of the development area was determined by considering the land resources of the plain, the development direction of the city, and the areas suitable for the urban structure. Since its development towards the lands of the Harran plain is prevented by law no 5403 on soil protection and land use, the development is mostly towards Karaköprü, organized industry, and Fatik mountains (Fig 6).

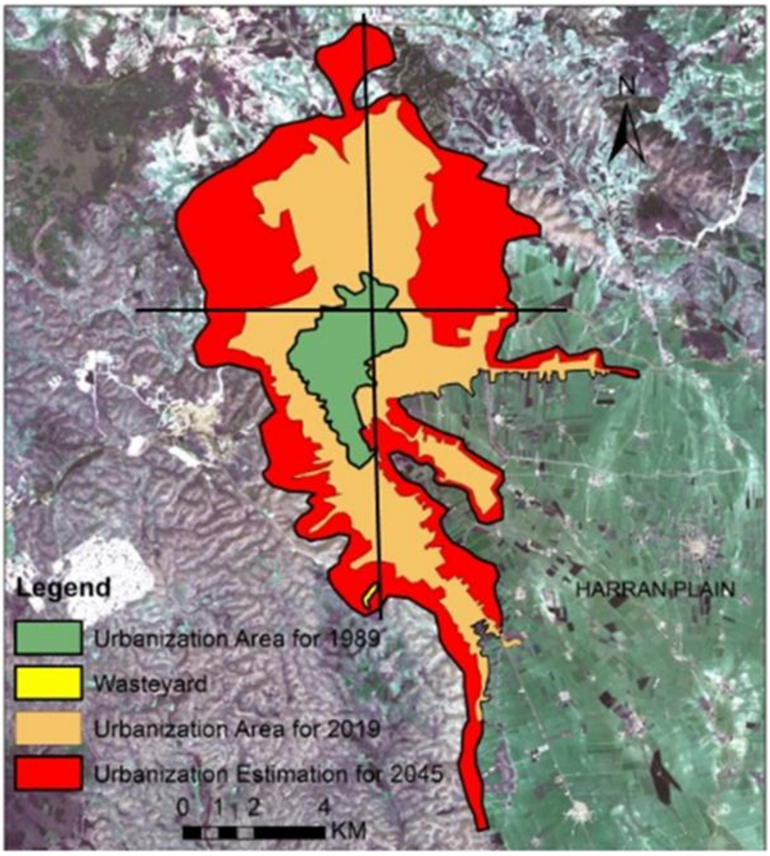

Fig 6. The development direction of the Sanliurfa city and areas suitable for the urban structure

The dynamics of established land-use models analyzed with remote sensing (RS) and GIS data revealed that it is useful to identify the type and development of urban growth, as well as the recent and future urban growth that helps local planning authorities manage growth and growth. Thanks to this study, the effects of urbanization on environmental and sustainable urban growth are seen and contribution is made to future planning to reduce its possible damages [30, 31].

Evaluation of a new sanitary landfill site is a difficult and complex process and requires consideration of many criteria such as distance from the settlement area, distance from main roads, investment costs, climate, availability [32]. Unregulated disposal has negative effects on all components of the environment and human health. Therefore, for the settlement of sanitary landfills, many effective criteria such as distance from residential areas, distance from main roads, investment costs, presence of solid wastes, geology, surface water, aquifer, land use, elevation, and land slope should be considered. There are various techniques for landfill selection, including GIS, mathematical models, heuristic algorithms and different multi-criteria decision-making methods, fuzzy analytical hierarchy process, and technique [33].

Methods based on traditional statistical data and old maps are mostly not possible in determining spatial growth areas and creating future predictions [17]. Another limitation of urban expansion modeling is that land change processes are not static. The instability of land change processes includes not only the rate of change but also the nature and spatial distribution of the changes [34]. Land cover and land use changes vary according to the physical, sociological, and administrative structure of the region. Since the end of the 20th century, both the development of remote sensing techniques and the efficiency of the GIS platforms enable us to make more efficient, faster, and more sensitive decisions at many points [35, 36].

4. CONCLUSIONS

Consequently, when the distance of the sanitary landfill site to the city periphery -at the site selection investigation stage- is 4 km in 1989 (this buffer distance complies with the Waste Management

Regulation); As of 2019, as a result of the increasing population and the related urbanization, the city and the landfill area are almost intertwined, and the distance has decreased to 800 meters. In the past 20 years, the failure to stop/limit or control this growth should lead to the self-criticism of central and local government actors' powers and responsibilities. Likewise, this situation has started to pose a serious problem in terms of environment and public health and has been recently caused the need for a new site selection for the sanitary landfill in Sanliurfa. This fact is not specific to the province of Sanliurfa. Unforeseen environmental threats have started to emerge as a result of socio-economic pressures such as industrialization, urbanization, migration, and population growth, especially in metropolitan settlements.

REFERENCES

[1]. L. Cao, Y. Cheng, J, Zhang, X. Zhou and C. Lian, "Application of Grey Situation Decision-Making Theory in Site Selection of a Waste Sanitary Landfill," *Journal of China University of Mining and Technology (English Edition)*, Vol. 16 (4), pp. 393-398, 2006.

[2]. G. Wang, L. Qin, G. Li and L Chen, "Landfill site selection using spatial information technologies and AHP: a case study in Beijing, China," *Journal of Environmental Management*, Vol. 90, pp. 2414-2421, 2009.

[3]. A. Soltani, K. Hewage, B. Reza and R. Sadiq, "Multiple stakeholders in multicriteria decision-making in the context of municipal solid waste management: a review," *Waste Management*, Vol. 35, pp. 318–328, 2015.

[4]. M. E. Hereher, T. Al-Awadhi and S. A. Mansour, "Assessment of the optimized sanitary landfill sites in Muscat, Oman," *The Egyptian Journal of Remote Sensing and Space Sciences*, Vol. 23 (3), pp. 355-362, 2019.

[5]. A. Allen, G. Brito, P. Caetano, C. Costa, V. Cummins, J. Donelly, C. Fernades, S. Koukoulas, V. O'Donell, C. Robalo and D. Vendas, "Procedure for the location of landfill sites using a GIS model," In: *9th Congress of the International Association of Engineering Geology and the Environment*, Durban, South Africa, pp. 100, 2002.

[6]. D. Pokhrel and T. Viraraghavan, "Municipal solid waste management in Nepal: practices and challenges," *Waste Management*, Vol. 25, pp. 555-562, 2005.

[7]. B. Sener, M. L. Suzen and V. Doyuran, "Landfill site selection by using geographic information systems," *Environmental Geology*, Vol. 49, pp. 376-388, 2006.

[8]. T. D. Kontos, D. P. Komilis and C. P. Halvadakis, "Siting MSW landfills on Lesvos island with a GIS-based methodology," *Waste Management & Research*, Vol. 21, pp. 262-278, 2003.

[9]. M. I. Yesilnacar and H. Cetin, "Site selection for hazardous wastes: a case study from the GAP area, Turkey," *Engineering Geology*, Vol. 81, pp. 371-388, 2005.

[10]. M. Tunay, B. Yılmaz and A. Ateşoğlu, "Determination of the Impacts of Bartin-Amasra Highway Location on the Natural Landscape Characteristics," *Ecology*, Vol. 17 (66), pp. 23-30, 2008.

[11]. UN-Habitat, "The state of the world's cities 2004/2005: Globalization and urban culture," United Nations human settlements programme, Nairobi/London, 2004.

[12]. J. AbuSada and S. Thawaba, "Multi criteria analysis for locating sustainable suburban centers: A case study from Ramallah Governorate, Palestine," *Cities*, Vol. 28 (5), pp. 381-393, 2011.

[13]. B. Cohen, "Growth in developing countries: A review of current trends and a caution regarding existing forecasts," *World Development*, Vol. 32(1), pp. 23-51, 2004.

[14]. A. A. Gharaibeh, A. H. Shaamala and M. H. Ali, "Multi-Criteria Evaluation for Sustainable Urban Growth in An-Nuayyimah, Jordan; Post War Study," *Procedia Manufacturing*, Vol. 44, pp. 156-163, 2020.

[15]. A. Seydanlioğlu and S. Turgut, "Urban growth management system for sample cities of Turkey and İstanbul," *Megaron*, Vol. 12 (3), pp. 429-442, 2017.

[16]. A. Alkan, "Impact of Spatial Growth on Land Use in Batman City," *Turkish Journal of Agricultural Research*, Vol. 5 (3), pp. 260-273, 2018.

[17]. O. Aydin, "Complex urban system, understanding urban growth concepts, and urban modeling techniques," *Turkish Geographical Review*, Vol. 64, pp. 51-60, 2015.

[18]. B. Guler, A. Jentsch, I. Apostolova, S. Bartha, J. M. G. Bloor, G. Campetella, R. Canullo, J. Házi, J. Kreyling, J. Pottier, G. Szabó, T. Terziyska, E. Uğurlu, C. Wellstein, Z. Zimmermann and J. Dengler, "How plot shape and spatial arrangement affect plant species richness counts: implications for sampling design and rarefaction analyses," *Journal of Vegetation Science*, Vol. 27 (4), pp. 692-703, 2016.

[19]. The TURKSTAT website, 2020, Available: http://www.turkstat.gov.tr/, (accessed 6 August 2020).

[20]. H. Güven, "Investigation of Different Waste Management Scenarios on Effects of Greenhouse Gas Emissions," İstanbul Technical University, Institute of Science, Master Thesis, İstanbul. pp. 167, 2012.

[21]. A. Yilmaz and Y. Bozkurt, "Urban solid waste management applications in Turkey and KUKAB case," *Suleyman Demirel University the Journal of Faculty of Economics and Administrative Sciences*, Vol. 15 (1), pp. 11-28, 2010.

[22]. S. S. Uluatam, M. Y. Özkan and Y. Wasti, " A Review of Landfill Landfills and Arrangement of Old Areas," *Dizayn construction*, Vol. 276, pp. 611-624, 2008.

[23]. Official Newspaper website, 2020, Available: https://www.resmigazete.gov.tr/eskiler/2015/04/20150402-2.htm, (accessed 6 August 2020)

[24]. D. Ciritci and T. Türk. "Automatic determination of alternative landfill sites with analytical hierarchy process and geographical information systems: a case study in Sivas city," *Journal of Geodesy and Geoinformation*, Vol. 6 (1), pp. 61-74, 2019.

[25]. M. Eghtesadifard, P. Afkhami and A. Bazyar, "An Integrated Approach to the Selection of Municipal Solid Waste Landfills Through GIS, K-Means and Multi-Criteria Decision Analysis," *Environmental Research*, Vol. 185, pp. 109348, 2020.

[26]. M. Uyan and Ş. Yalpir, "Site selection for medical waste sterilization plants by integration of multi criteria decision making model with GIS," *Afyon Kocatepe University Journal of Science and Engineering*, Vol. 16 (3), pp. 642-654, 2016.

[27]. M. Eskandari, M. Homaee and S. Mahmodi, "An integrated multi criteria approach for landfill siting in a conflicting environmental, economical and socio-cultural area," *Waste Management*, Vol. 32 (8), pp. 1528-1538, 2012.

[28]. S. Yilmaz, A. M. Marangoz, A. Şekertekin, M. Oruç and Ş. H. Kutoğlu, "Monitoring the urban development of Zonguldak province with remote sensing techniques and determining alternative residential areas," *TUFUAB VIII. Technical Symposium*, pp. 21-23, 2015.

[29]. A. E. Gülersoy, M. A. Çelik and M. E. Sönmez, "Ecological overview to spatial development (1985- 2011) of Tarsus City," *Electronic Turkish Studies*, Vol. 9 (2), pp. 741-759, 2014.

[30]. B. Roy and N. Kasemi, "Monitoring urban growth dynamics using remote sensing and GIS techniques of Raiganj Urban Agglomeration, India," *The Egyptian Journal of Remote Sensing and Space Science*, Vol. 24 (2), pp. 221-230, 2021.

[31]. L. N. Kantakumar, S. Kumar and K. Schneider, "What drives urban growth in Pune? A logistic regression and relative importance analysis perspective," *Sustainable Cities and Society*, Vol. 60, 102269, 2020.

[32]. H. C. Liu, J. X. You, X. J. Fan and Y. Z. Chen, "Site Selection in Waste Management by The VIKOR Method Using Linguistic Assessment," *Applied Soft Computing*, Vol. 21, pp. 453-461, 2014.

[33]. M. Torabi-Kaveh, R. Babazadeh, S. D. Mohammadi and M. Zaresefat, "Landfill Site Selection Using Combination of GIS and Fuzzy AHP, A Case Study: Iranshahr, Iran," *Waste Management & Research*, Vol. 34 (5), pp. 438-676, 2016.

[34]. M. K. Firozjaei, A. Sedighi, M. Argany, M. Jelokhani-Niaraki and J. J. Arsanjani, "A geographical direction-based approach for capturing the local variation of urban expansion in the application of CA-Markov model," *Cities*, Vol. 93, pp. 120-135, 2019.

[35]. M. A. Dereli, "Determination of Short-term Land Cover Change by Sentinel-2A Satellite Imagery for Giresun City Center," *Afyon Kocatepe University Journal of Science and Engineering*, Vol. 19 (2), pp. 361-368, 2019.

[36]. M. E. Çakır, A. Demir-Yetiş, M. İ. Yeşilnacar and M. Ulukavak, "Determination of the Optimum Routes and Performing of the Spatial Distribution Maps for Solid Waste Using GIS: A case of study from Suruç (Şanlıurfa)," *Bitlis Eren Üniversity Journal of Science*, Vol.8 (2), pp. 595-603, 2019.