Waste Assessment and Management Utilizing Remote Sensing and Geographic Information Systems Case Study Governorate Eldakahlia

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Key words: Remote Sensing, GIS, Waste, Multi-spectral and Images

SUMMARY

Remote sensing (RS) images are extremely helpful data for hazardous waste management and evaluation. The selection of the best site of waste disposal is a powerful tool for assessing environmental consequences. Archival aerial images provide the evidence necessary for analyzing the borders, points of access, and neighboring land usage of uncontrolled waste disposal sites. Comparative temporal analyses of a waste disposal site utilizing historical aerial images aid in determining how an area has evolved over time and, as a result, provide a better understanding of present site conditions. The evaluation of a site over time enables the analysis of land cover succession or replacement to establish the state of an abandoned site and to detect a hazardous site that is now covered owing to new construction. The main goal of the research is to help decision-makers in Eldakahlia Governorate, Egypt in choosing the best location suitable for waste landfill that does not interfere with human activities by using geographic information systems based on satellite images. aiming to reduce waste transport costs and reduce problems caused by bad site selection. Some proposed locations based on planning and environmental factors will be discussed. The study was conducted using multi-spectral satellite images for land use, regional risk, and spectral features. As a result of the research hypotheses, it was found that the Eldakahlia governorate has only 0.57 % of its lands, which is located in the desert back of the governorate, which is an acceptable result, as the governorate is one of the Delta governorates in Egypt.

SUMMARY

صور الاستشعار عن بعد هي بيانات مفيدة للغاية لإدارة وتقييم النفايات الخطرة وتعد مراقبة المواقع بمرور الوقت أداة قوية لتقييم العواقب البيئية. توفر صور الاقمار الصناعية الأرشيفية الأدلة اللازمة لتحليل الحدود ونقاط الوصول واستخدام الأراضي المجاورة لمواقع التخلص من النفايات. تساعد التحليلات الزمنية المقارنة لموقع التخلص من النفايات باستخدام الصور الجوية التاريخية في تحديد كيفية تطور المنطقة بمرور الوقت ، ونتيجة لذلك ، توفر فهمًا أفضل لظروف الموقع الحالية. يتيح تقييم الموقع بمرور الوقت تحليل تعاقب الغطاء الأرضي أو استبداله لتحديد حالة الموقع واكتشاف مواقع تمت تغطيته الآن بسبب البناء الجديد. الهدف الرئيسي من البحث هو مساعدة متخذي القرار في محافظة الدقهلية بمصر في اختيار أفضل موقع مناسب لمكب النفايات الذي لا يتعارض مع الأنشطة البشرية باستخدام نظم المعلومات الجغرافية المعتمدة على صور الأقمار الصناعية. بهدف تقليل تكاليف نقل النفايات وتقليل المشاكل الناتجة عن سوء اختيار الموقع. أجريت الدراسة باستخدام صور الأقمار الصناعية متعددة الأطياف لاستخدام الأراضي والمخاطر الإقليمية والسمات الطيفية. وكنتيجة لفرضيات البحث تبين أن محافظة الدقهلية تمتلك 0.57٪ فقط من أراضيها تصلح لمدفن صحى والتي تقع في الجهة الخلفية الصحراوية للمحافظة وهي نتيجة مقبولة حيث أن المحافظة هي إحدى محافظات الدلتا بمصر.

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1. INTRODUCTION

Solid waste is defined as any byproduct of human activity that is neither liquid or gaseous that are deemed unproductive (Ipieca et al., 2015). Municipal solid waste (MSW) is a word that refers to a diverse a variety of solid waste generated in metropolitan regions. Inadequate waste disposal and management infrastructure is a major problem around the world (David et al., 2020). The development of massive of solid waste and its treatment has been critical in terms of the environment and human health. Toxic gases, leachate, heavy metals, and nitrate pollution are present in high amounts in solid waste disposal sites(Abd El-Salam & Abu-Zuid, 2015). Current information and evaluations concerning these landfills are crucial. Open sanitary landfills include significant hazardous wastes and pollutants that endanger the ecosystem (Vaverková, 2019). Remote sensing and Geographic Information Systems (GIS) help identify prospective dump sites and assess pollutant emissions(Adeofun et al., 2012). Groundwater contamination has been assessed using a GIS-based methodology. GIS and Remote Sensing have been helpful in identifying prospective landfill site choices. Because of the topographic coverage, geographical and temporal database, and capacity to merge numerous thematic diagrams on a shared platform(Areas & Dai, 2021). Identifying and monitoring of landfill sites using RS and GIS has been instrumental in the development and evaluation of a suitability index(Issa & Al Shehhi, 2012).
An Analytical Hierarchy approach was utilized to identify an MSW landfill site using several base layer maps of groundwater characteristic and water quality. In the Pondicherry region of India, a GIS study employing overlay technique for landfill site detection was completed(Mallick, 2021). A pioneer research was undertaken utilizing IKONOS satellite (July 2001) data to detect probable unlawful dump sites in Venice, NE Italy(Dutta et al., 2021). A study for the suitability map classifies locations for dumping solid waste in Dharmanagar, Tripura, India (Deswal & Laura, 2014). Locations are classified based on geomorphological and land usage criteria, as well as due weightage. An extended technique utilizing Landsat thermal bands on a time scale was employed for landfill identification at Glina dump, Romania (Iacoboaea & Petrescu, 2013).
Identifying existing polluted areas and using multi-factor evaluation (MFE) to determine the likelihood of unlawful activity (Biotto et al., 2009). landfills using GIS with multi criteria evaluation is cited as a pioneer work in which site identification and an analysis numerous characteristics that lead to illegal activity were investigated(Alkaradaghi et al., 2020). A multi criterion decision analysis technique was performed on a 277 km^2 area coverage in Mohammedia, Morocco (El Maguiri et al., 2016). Six indicators, namely waste management, water resources, land use, gradient of ground, roads and geology were produced using a GIS

database. This led to the tentative selection of several viable locations and the later confirmation regarding the ground tenure (Darwish Talal, CChemini Faycel, 2012).
Another study used an analytical Hierarchy Process on multiple thematic maps to create an indexed map for the acceptability of solid waste dumping in Logia, Afar region, Ethiopia. Urban growth and the spread of unplanned informal settlements have contributed to this (Ahmed Mussa, 2018). Nyahururu employs an open dumping site approach, which has exacerbated the need for landfill placement (Kimwatu & Ndiritu, 2016). The siting procedure was driven by the principles of environmental friendliness and social acceptability. Kenya is rapidly urbanizing, and as a result, solid waste management issues are rising (Haregu et al., 2017).
The area had been defined by dynamic urban development, which has resulted in a rise in solid waste creation and disposal techniques. Dumping of solid waste is become a regular sight, particularly along highways, corners, and open spaces (Solomon, 2011). The use of GIS and remote sensing given a powerful platform for integrating diverse aspects which had a real influence on location strategic planning in a relatively short timeframe. Hence prompted the requirements for a thorough examination of the existing situation and the development of long-term and short-term solutions (Thakur et al., 2017). The disposal of solid waste is dependent on the selection of an appropriate site as well as sustainability and social acceptability (Ak & Braida, 2015). The study makes use of LANDSAT satellite images and an open source DEM image from the USGS https://earthexplorer.usgs.gov/.

2. STUDY AREA

Eldakahlia is a governorate in Egypt located northeast of Cairo. It covers around 3,500 km^2. Mansoura is its capital. The town was founded around 1219. The city, formerly known as Flowers Island, has an average elevation of 15 meters and is located between 31^0 03'00" N and 31^0 23'00" E (Hussain El-Dardiry & El-Ghonaimy, 2009). The study area is located in northern Egypt and had a population of 6,516,489 in July 2017. According to population estimates, the governorate's majority of citizens resided in rural regions in 2015, with an urbanization rate of 28.2 percent. The governorate has an estimated population of 5,949,001 people, with 4,271,428 living in rural regions and 1,677,573 living in urban areas. By 2018, the population was predicted to be 6,577,000 (IBÁ, 2019). Figure 1 depicts the study area.

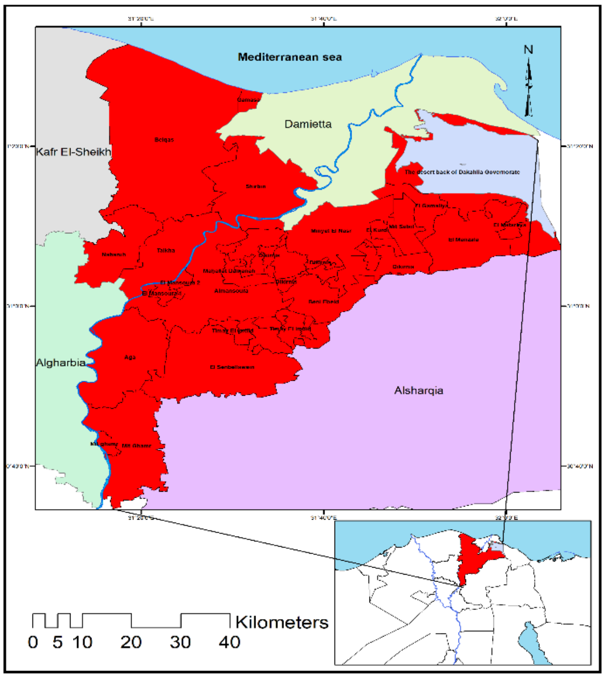


Figure 1 Study area

3. METHODOLOGY

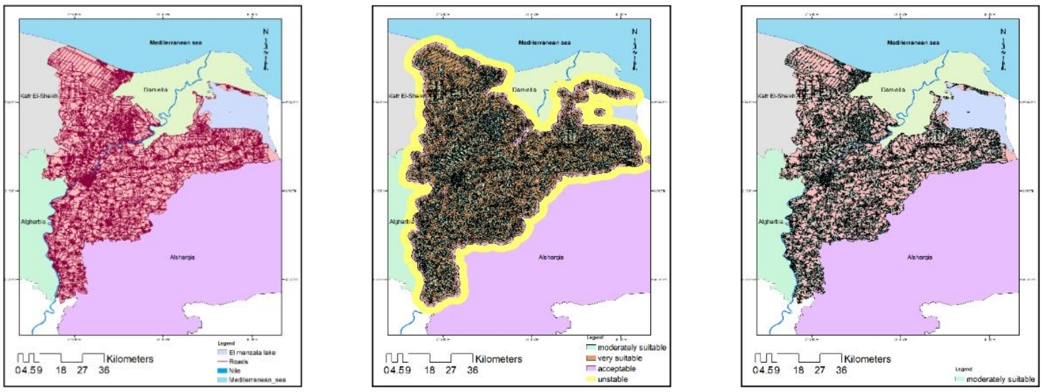
The study area is Eldakahlia Governorate which is located on the Mediterranean Sea and through which one of the two branches of the Nile flows. it categorized as an overcrowded governorate with population over 6.50 million. It has one of Egypt's largest lakes, Lake Manzala, as well as a large extended road and irrigation canals networks. The images were captured on February 13th, 2015. They were used to produce the study area's current land use/land cover classifications. This was done on the ERDAS IMAGINE WORLD. The Digital Elevation Model (DEM) was created using The Shuttle Radar Topography Mission (SRTM) (30m x 30m) resolution. The composition of the soils in Eldakahlia municipality was then extracted. The relevant information, including the road and water resource networks, were obtained from Google Earth. Detailed descriptions of land use / cover were produced using a supervised classification study of satellite images. Bare land, agricultural land and urban areas were classified as land cover classifications(Birdi & Ajith, 2021). The approach used GIS to analyze the content according to specific performance indicators regarding waste dump suitability study. The selection of a suitable dump site is a difficult, time-consuming, and expensive procedure(Kharat et al., 2016). The criteria were divided into four categories: Very high, High, Moderately suited, and Poorly suitable. Certain conventional and national criteria obtained from various literatures were used to reclassify and weight the classes (Djokanović et al., 2016).

The study methodology is based on the following steps: determining the water sources in the governorate and to classify the areas according to the distance of the landfill from the water sources; determining the main and secondary roads and to classify the areas according to the distance of the landfill from the roads; determining the green places and to classify the areas according to the distance of the landfill from the green areas; determining building locations and to classify the areas according to the distance of the landfill site from the buildings; determining the topography of the land and determining the appropriate tendencies of the land for the work of a landfill; determine the buffer from the borders of the neighboring governorate; the best location of the landfill is the area which meets the previous requirements

4. RESULTS AND ANALYSIS

4.1. Proximity to major high ways

Dumpsites should really be located at least 100 meters away from main roadways, other modes of transit. To enable transportation and, as a result, to lower relative costs, solid waste dumping sites should be placed at a reasonable distance between the road. In the current study, the adequacy of the road network was defined as 0-100m (moderately suitable), 100-700m (very suitable), 700-1500m (acceptable), and 1500-4500m (unsuitable). This was owing to higher transportation costs and the area's inaccessibility (Kebede et al., 2021).



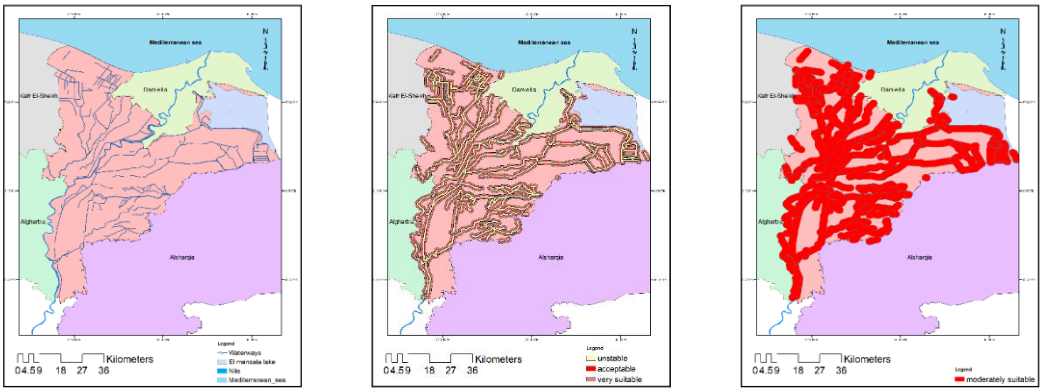
a) roads b) roads buffers c) roads the best buffer

Figure 2 The distance from roads

4.2. Proximity to water sources (rivers, drainage systems)

In this study, a buffer distance of 300 meters was selected as the lowest distance from which a landfill may be sited, while a distance of 3000 meters got specified to the maximum horizontal distance. Numerous circle buffer using ArcMap's analytical capabilities was used to create various polygons around the water resources networks between the respective ranges (Engineering, 2005): Various researchers have determined that the greater distance from water resources and drainages, the better region for a dumping ground. As a result, this research employs notion appropriately. Figure 3 depicts fit categories and a standard map of water resources. It was focused on characterizing the range to the water resources network so that ≤ 300m was deemed inappropriate, 300m to 500m was deemed moderately acceptable, 500m to

1000m was deemed ideal, and more than 1000m was deemed extremely ideal (Şener et al., 2010).

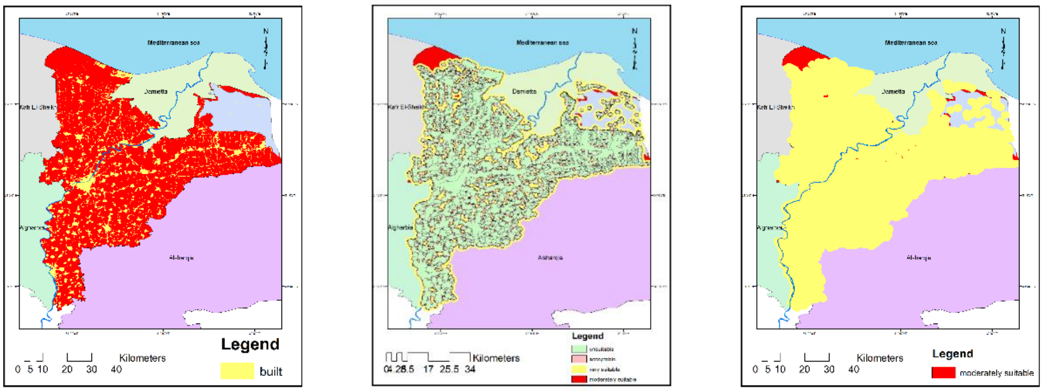


a) water sources b) water sources buffers c) water sources the best buffer

Figure 3 The distance from water sources

4.3.Settlement-based proximity

The closeness to settlements was categorized, and a multi buffer analysis was performed, yielding the following classifications: The class 900-1500m provided the most appropriate regions. Because of its near proximity to communities, the distance of 400-900m was inappropriate. The reclassify tool was used, and zones with distances ranging from 0 to 400m, 400 to 900m, 900 to 1500m, and more than 1500m were acquired and connected with the grade of appropriateness i.e. inappropriate, moderately ideal, extremely ideal, and ideal. It discovered that the majority of favorable places for landfill placement are located distant from the governorate center, on the outskirts of the municipality (Kharat et al., 2016).

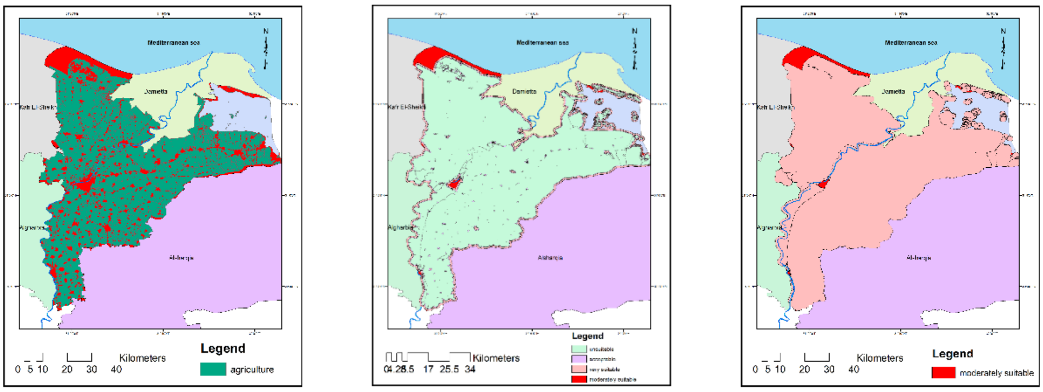


a) buildings b) buildings buffers c) buildings the best buffer

Figure 4 The distance from buildings

4.4. Based on proximity to a green region

The proximity analysis required a minimum distance of 400m. A multi buffer analysis was performed utilizing the analysis tool's Multi ring buffer, yielding four categories: below than 400m, from 400 to 800m, from 800m to 1200m, and from 1200 to 2000m. Due to the environmental consequences of putting a landfill near an existing sensitive region, it should be positioned as far away from it as possible. As a result, the acceptable region was judged to be distances greater than 2000m from wooded areas. Figure 5 was then divided into four categories depending on its closeness to an environmentally vulnerable location, namely below than 300m, from 300 to 500m, from 500 to 1000m, and greater than 1000m. Categories were delegated a degree of appropriateness, i.e. inappropriate, somewhat ideal, ideal, and extremely ideal. It was discovered that a considerable section of the research area was appropriate for landfill placement (Mallick, 2021).



a) green areas　　b) green areas buffers　　c) green areas the best buffer

Figure 5 The distance from green areas

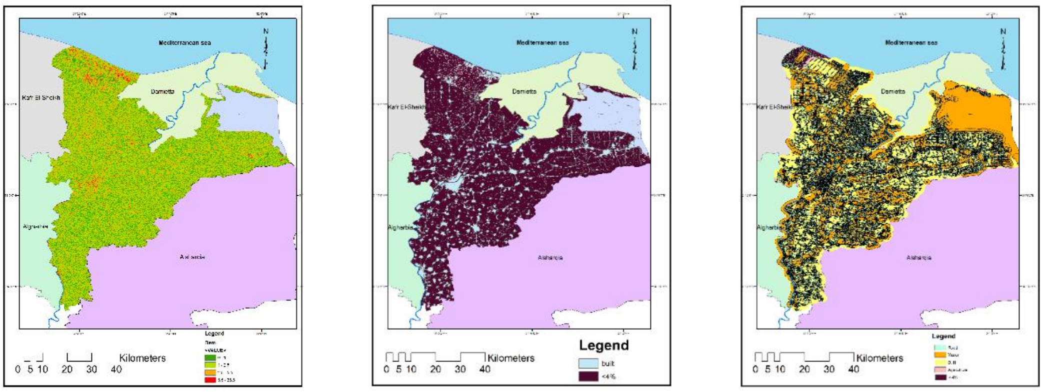
4.5. Geological conditions determine suitability

Mineral makeup of the fundamental igneous stones was phonolites, mostly feldspar. Due to the degree of weathering and fracture, such stones decay naturally to clay and have an extremely poor porosity. The geological composition's suitability characteristics were taken into account. Basalt lava with low permeability was deemed very appropriate, but fluvial deposits with high permeability were deemed unsuitable for landfill locations. Because basic igneous has a very low permeability, it is best suited for waste sites. The vast bulk of the region was found to be appropriate for dump segment site. All these are areas characterized by basic igneous stones.

Fluvial stones were found to be very permeable and so inappropriate for selection in these regions(Agriculture United States Department of Agriculture, 2012).

4.6. Slope of the ground

The slope of the research region was derived using a DEM, (SRTM) 30m x 30m resolution) and utilized as a thematic map in a GIS environment. The grades computed. The grade values were categorized into sectors varying from 0 to 4 percent, 4 to 8 percent, 8 to 15 percent, 15 to 24 percent, and 24 to 37 percent. The slope grades of 0 – 4% and 4 – 8% represent the most favorable and acceptable region for dump site selection. The area was flat land, as indicated by the 0-4 percent slope class. The grades values of 15 – 24% and 24 – 37% locations were often unsuitable due to excessive precipitation runoff rates. This exposed the environment, particularly surface waterways, to the hazardous compounds found in landfill leachate. These locations were also unsuitable owing to the difficulties of building or levelling, which incurs additional costs during the landfill's development phase (Elmoulat & Brahim, 2018).



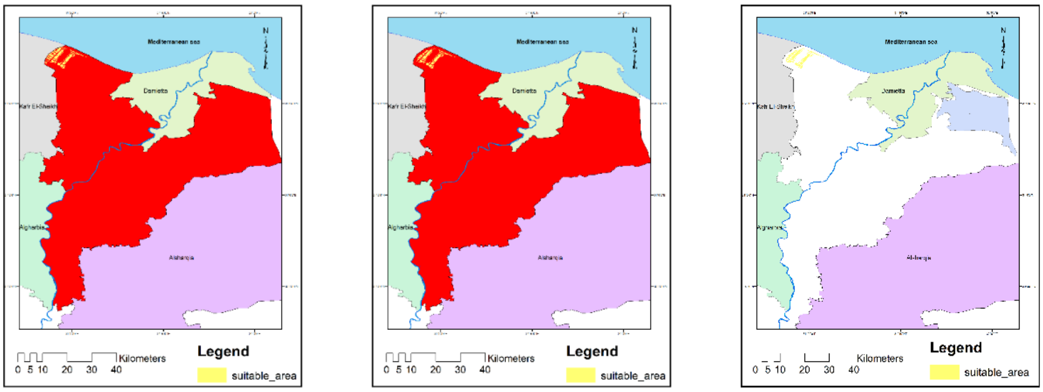
a) DEM b) slope ≤ 4% c) the best buffers layers

Figure 6 DEM image and the best buffers of all layers

4.7. Land cover and land usage

Satellite images were used to determine the land use/cover of the research region. The research proved extremely useful in determining the area's existing land use/cover trends. A subset approach was used to construct an image with the requisite research area extent, resulting in the required Eldakahlia municipality boundaries. As a result, five land use/land cover types were identified, as illustrated in figure 4 (Albalawi et al., 2018).

Table 1 shows the weightages allocated to various subjects. Buffer zones were established in order to obtain a suitable location. Solid waste site appropriateness criteria are primarily centered on two categories: physical and social(Mallick, 2021). Different input map layers, such as drainage, watershed, roads, towns, woods, crops, barren land, and weightage, are assigned to these categories depending on the various factors. The criterion scores are offered on several scales. The solid waste management process employs solid waste reduction, waste reuse, and recycling procedures as needed at a specific location. As stated in the table below, weights have been allocated to each category(Sivasankar & Rathinam, 2017).



a) the suitable area

b) the suitable area after buffering boundary

c) the best site

Figure 6 final results

Table 1 Requirements weights

Requirements	Concept	Weights
Physical	Slope	6
	Water resource	7
	Settlement	8
Social	Road	6
	Green area	5

Table 2 The effect of distances

type	moderately suitable	very suitable	acceptable	unsuitable
Distance from roads	≤ 100m	From 100-700m	From 700-1500m	From 1500-4500m
Distance from water source	above 1000m	500m-1000m	300m-500m	0-300m
Distance from settlement	above 1500m	900-1500m	400m- 900m	0 to 400m
Distance from green area	above 1000m	500m-1000m	300m-500m	0-300m
Slope	0-4%	4-8%	8-15%	≥15%

The acquired data was put into the ArcGIS 10 system. The vector map of Eldakahlia was exported. The necessary data was cut (i.e. roads layer, settlement layer, green land layer, water source layer and slope layer). The geographic analysis was initiated by using the buffer option from the Geo-processing tools of the ArcGIS 10 system, and excluded regions were extracted for each data layer as follows: 1000m from a water source; 1000m distant from green space; 1500 meters distant from settlements; 100m from the road; 0-4 % slope layer and 1000m from

the nearest governorate. composed of all buffered layers merged into one layer to compose unsuitable areas for proposed land fill site. The landfill-site-suitable regions were identified.
The weighted overlaying of the various component maps resulted in the final composite map displayed in figure 5. The somewhat appropriate area locations were critical because they served as a backup plan for the selection process. The candidate site described possible locations for a site. These locations may be required to meet future solid waste management standards. The following criteria were satisfied by the locations identified: Areas larger than 10 km^2 located near road networks and Eldakahlia (Issa & Al Shehhi, 2012).
The goal of reviewing dump site locations was to find the most acceptable sites based on particular criteria. The fundamental criterion for analyzing the possible locations were determining the size of the land and its accessibility to metropolitan centers. For economic and sustainability reasons, the site must be large enough to last at least 10-15 years. Such restrictions are required in order to reduce the cost of design, maintenance, and closure. Figure 6 demonstrated that the possible landfill sites were represented. Figure 6 depicts a candidate dump site with the most appropriate area chosen by a basic set of criteria that included determining the area size of the current acceptable site location as well as its closeness to settlements and the metropolitan region.

5. CONCLUSIONS

Consistent selection of dump sites using standard field methods is time-consuming and can be simplified by combining laboratory and ground measurements with satellite-based approaches. Recent improvements in GIS have made it possible to effectively identify and examine potential waste sites on a regular basis. An integrated strategy can provide a broader scope for selection. Remote sensing and geographic information systems (GIS) were used to determine acceptable landfill locations.
The generated maps were classified into four categories, ranging from unacceptable to extremely suitable. For the study of these factor maps, both GIS were employed. The study found that 0.568 percent of the municipality's research area was most suitable for such a dump. This would try to extend their life while lowering the cost of dump. The council should also consider strategic positioning of solid waste. The research was achieved the main objective, which is to reach the most suitable place to establish landfill in Eldakahlia Governorate, as the resulting place of the study is located in the desert back of Eldakahlia Governorate and away from the various activities at distances that do not affect those activities.

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