

## **Using GIS for selection of Potential Waste Disposal Sites in Meknes city**

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**Abstract:-** In Morocco, as in most developing countries, landfill is still the only solution for the final disposal of municipal solid waste. The choice of suitable site for waste disposal is one of the main problems in waste management. This requires that many environmental and economic considerations be respected. This paper describes a decisional step for locating a suitable site to dispose the municipal solid wastes of using Geographic Information Systems (GIS). The methodology adopted is based on a multi-criteria analysis grid and was applied the case of the Meknes area in Morocco. The landfill sitting criteria were subdivided in two types: exclusion or constraint criteria and assessment criteria. These criteria are based on geographical data from several layers such, geology, hydrology, hydrogeology, demography, topography, etc. The prevailing wind direction, distance from city, proximity to water body, visual exposition, and proximity to road networks were also considered. After integration of all these constraints, suitable sites were shortlisted. Four sites were suggested as alternatives to the existing disposal site taking into consideration the environmental, social, and economical variables applied in the GIS analysis.

**Keywords:-** Site selection, Geographic Information System (GIS), Landfill, exclusion criteria, assessment criteria.

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### **I. INTRODUCTION**

The Rapid urbanization and the irregular increase of the human population caused the generation of important amounts and different kinds of urban waste [1]. Today, solid waste management is especially delicate; it's considered one of the most challenges and immediate environmental problems facing municipal authorities in developing countries such as Morocco, where lack of adequate resource, faulty planning and increased urbanization contribute to the misappropriate solid waste management. There are various techniques used for the management of waste as collection, transport, processing, recycling and disposing of waste etc. Landfilling is generally the ultimate disposal for municipal solid waste (MSW). However, the safe selection site for solid waste disposal is a very complex process and it depends on several criteria and regulations, which is still in use around the world [2]. The collection, processing transport and disposal of solid waste are important aspects of waste management for public health, aesthetic, and environmental reasons [3]. For this reason, it is essential to dispose the solid waste to a landfill without risking the public health [4]. One of the most delicate steps in waste management is the selection of the most suitable landfill site. However, landfill sitting is a complicated process because it requires data from diverse environmental and social aspects. These data often involve processing of a significant amount of spatial information which can be facilitated by the use of Geographical Information System (GIS) as a tool for land suitability analysis.

The primary objective of a site selection process is to assure that candidate sites selected are suitable with regard to protection of public health and the environment. Morocco produces about 6.77 million ton of solid waste per year. Nearly 78% of these wastes are concentrated in urban areas [5]. Solid waste represents a huge issue in Meknes city. In this context, GIS was used as a tool to develop an approach for decision support in the field of management of environmental issues, including tools that aid for the selection of proper sites for the disposal of domestic waste. This will thus contribute to environmental protection, public health and reduce obligations to future generations by limiting the proliferation of illegal dumps.

### **II. STUDY AREA**

The study area concerns the city of Meknes, Morocco (Fig.1), known as of Meknes-Tafilalet region. It is located in north-central part of Morocco at approximately 05°32'W and 33°53'N and approximately 140km

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east of the capital Rabat. The study area covers about 117 km<sup>2</sup>. The climate in the study area is Mediterranean climate and its population is approximately 530000 [6]. It is located on the plateau overlooking the Boufekrane and R'Doum rivers at an altitude of about 550 m. It occupies an area of contact between two mountain ranges, the Prerif and Atlas Mountain. During the past decade, the city has experienced rapid growth in population that consequently generates important amounts of solid waste. This has put a burden on the existing landfill which is rapidly filling up. Moreover, the current landfill in Meknes city does not meet the appropriate landfill siting criteria. The existing landfill is located near the residential area of Raddaya and to the Boufekrane stream. This might cause serious health and environmental hazards. Accordingly, appropriate selection of landfill is a major need toward sustainable development.

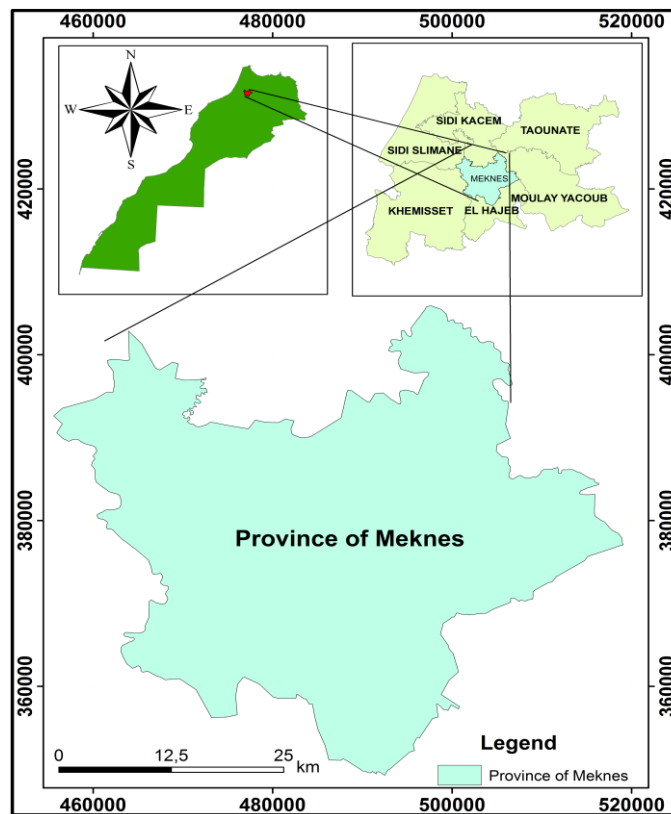


Fig. 1: Map of the study area.

### III. MATERIALS AND METHODS

#### A. The approach

In this paper, GIS plays a major role in determining the "appropriate location" for a landfill site. The flowchart of the methodology and used hierarchical model are shown in Fig.2.

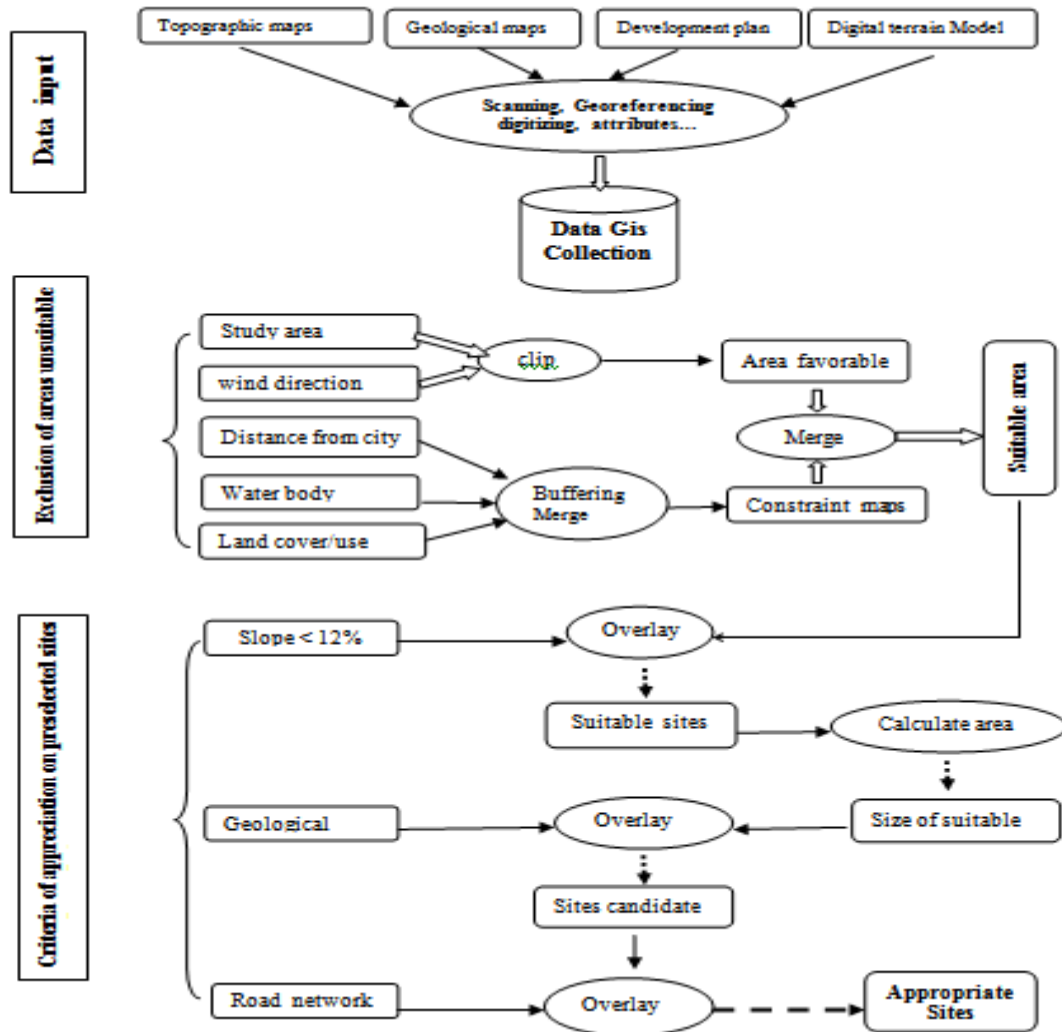


Fig. 2: Flowchart of the methodology followed in the study.

The first step that was taken in this methodology was to collect all of the data that would be needed to meet all of the criteria. In this study seven criteria or parameters have been identified for selecting a suitable location for a new landfill. All these parameters have been identified on the basis of guideline for selecting the favorable site of solid waste produced by the German Technical Cooperation (GTZ) for the regions of Larache and Chefchouane [7] and on the basis of information related to the selection of landfill sites, considered by international practice as Environmental Protection Agency (EPA) of the United States [8]. Thereafter, a list of decision criteria (exclusive criteria and assessment criteria) was selected [9]. Exclusive criteria "hard" were applied to exclude unsuitable areas. These criteria include: wind direction, Distance from city, Water body, Land cover/use, slope, Geology and transport Network.

### B. Data collection

Available information related to geology, hydrogeology, hydrology, soil, climatology and eco-sociology were collected and produced in a digital format. So Several source maps were used in preparation of the geographic database. These maps were at various scales and containing various types and amounts of information.

**Table 1: Data Source and Characteristics**

Data Type	Date	Resolution / scale	Source
Topographical map of south Meknes	2007	1 :25000	National Agency of Land Conservation, Land Registry and Mapping
Topographical map of north Meknes	2007	1:25000	
Topographical map of Ouislane	2007	1:25000	
Topographical map Moulay Mriss Zerhoune	2007	1:25000	
Topographical map of north Guerouane	2007	1:25000	
Development plan of Meknes city	2004	1:5000	urban agency of Meknes
Rouad map of Meknes	2012	1 :25000	Centre National des Etudes et des Recherches Routières
Geological maps of meknes	1951	1 :100000	Chérifienne Oil Company
Shuttle Radar Topography Mission (SRTM)	2010	30x30m	National Geospatial–Intelligence Agency (NGA) [10].

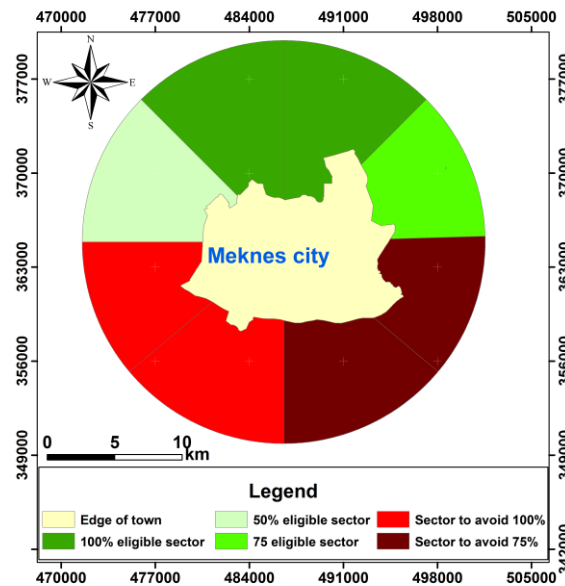
#### IV. RESULTS AND DISCUSSION

##### A. Exclusion of unsuitable areas for landfill

Constraints are criteria which cause the limitation of decision alternatives and omit some location from more investigations [9]. The law on waste management and disposal has no a requirement for the choice optimum location. All these parameters have been identified based on the on a review of literature on landfill site selection. In this step the data are in vector format and geo-processing techniques such as buffer, overlay, merge and erase, are used to create the exclusion areas.

##### A.1. Prevailing wind direction

The wind direction of the basin was also considered. Settlements must not be affected from the odor that originates from the landfill. The wind has the main factor in the spread of noxious odors to the inhabitants of the town (Fig. 3). Then we removed the sectors to avoid this operation allows us to reduce our search box (it has the right to search only in the green area) to almost the first halves of our study area (Fig. 4).



**Fig. 3: Map of prevailing wind direction**

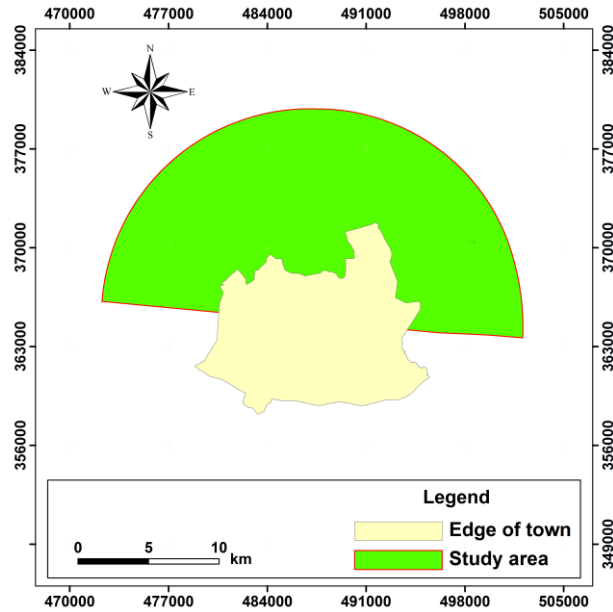


Fig. 4: Map of favorable area

#### A.2. Distance from city

After determining the appropriate sectors to dump the direction of the prevailing wind, we go to the distance from the city. In order to protect the settlements against excessive pollution resulting from the operation of the landfill (odors, noise machines and discharge from the carriers refuse trucks, waste spread by wind, dust) a buffer zone of 2 km around the residential areas[14]was chosen as restriction area not suitable for waste disposal (Fig. 5).

In this way, we specify exactly one of the area which has (ring area with a width of 6km) favorable areas for a dump, on which the various previous criteria are applied.

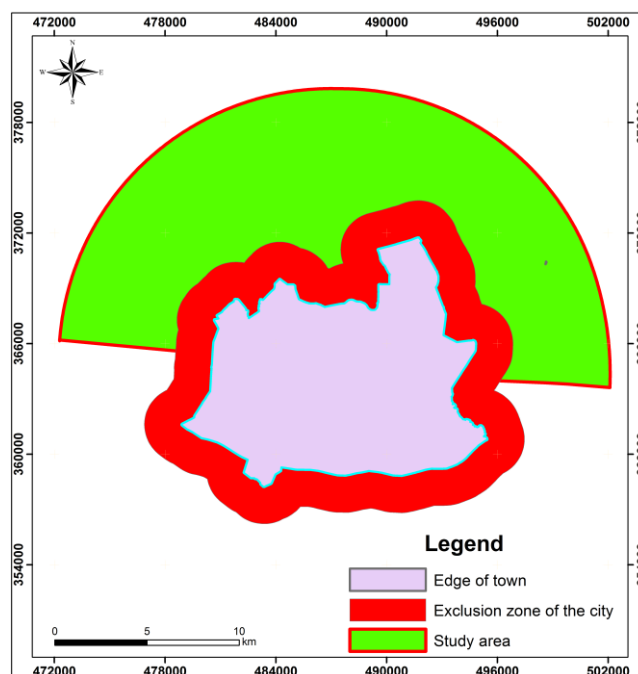


Fig. 5: Map of city buffered at 2 km.

#### A.3. Proximity to water body

This is an important criterion from the standpoint of both environmental and economic [15]. The landfill generates the leachate and noxious gases which render unsuitable to be in proximity to surface water [16]. Therefore, a landfill must not be situated near any surface stream, rivers, drilling, spring, or Water tower.

For this reason, a range of security (buffer) around all surface water would be placed using the function in Gis software (Table 1).

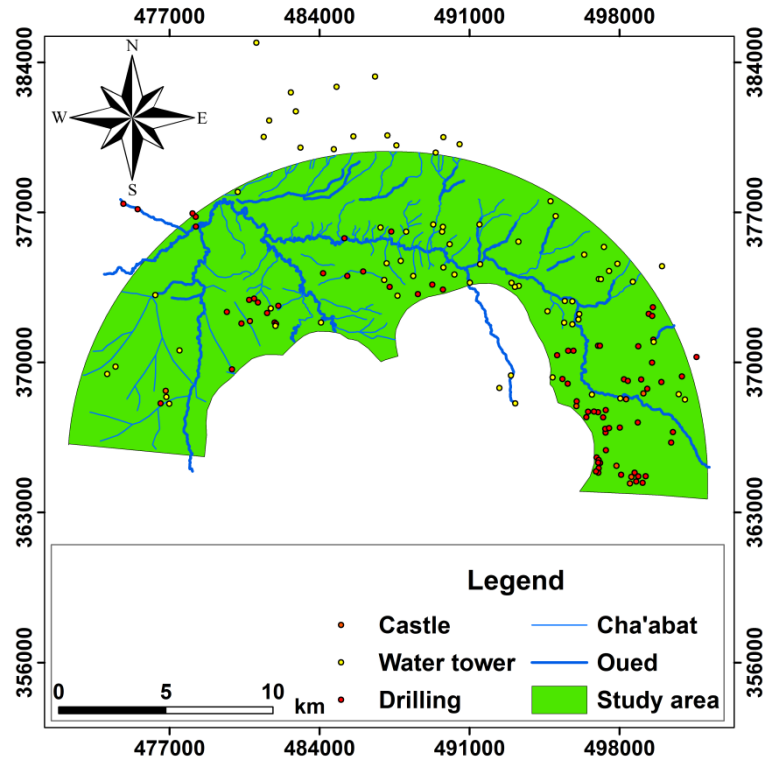


Fig. 6: Map of water body.

Table 1: Distance used to generate the buffer around water Body.

Criteria	Buffer zone (m)
Stream	500
Chaabat	100
Will, Spiring	300
Drilling, Water tower	500

#### A.4. Visual Exposition

For aesthetic considerations, the landfill site should be provided it is integrated into the landscape. The surface should not be exposed to view. For this reason, we chose a buffer zone around railways, road network, settlements, religious institutions, plant, etc. (Fig. 7). The following table summarizes the layers buffer zones used.

Table 2: Distance used to generate the buffer around land use.

Criteria	Buffer zone (m)
National road, highway	500
Provincial road	300
Regional road, railways, plant	200
Cemetery, mosque, sacred site, school	500

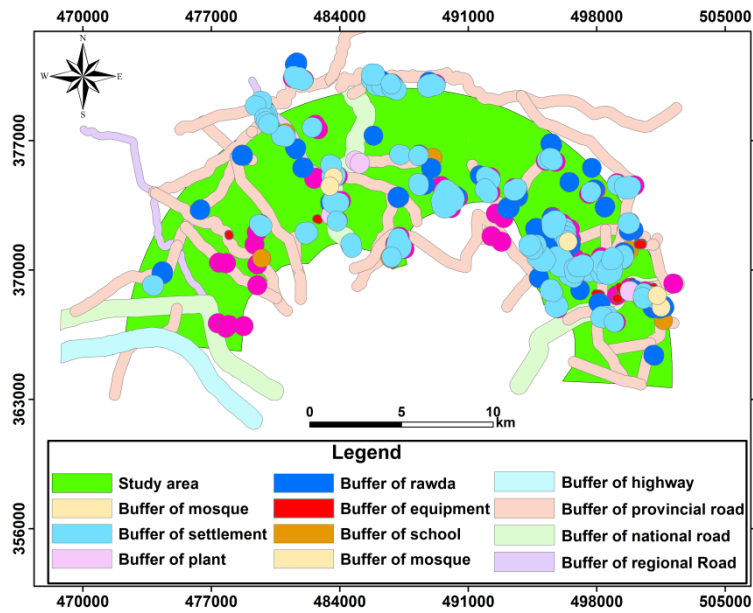


Fig. 7: Map of visibility criterion.

After overlay of all the buffer area, the latter of the study area is excluded, we obtained the first map area suitable for landfill siting (Fig. 8).

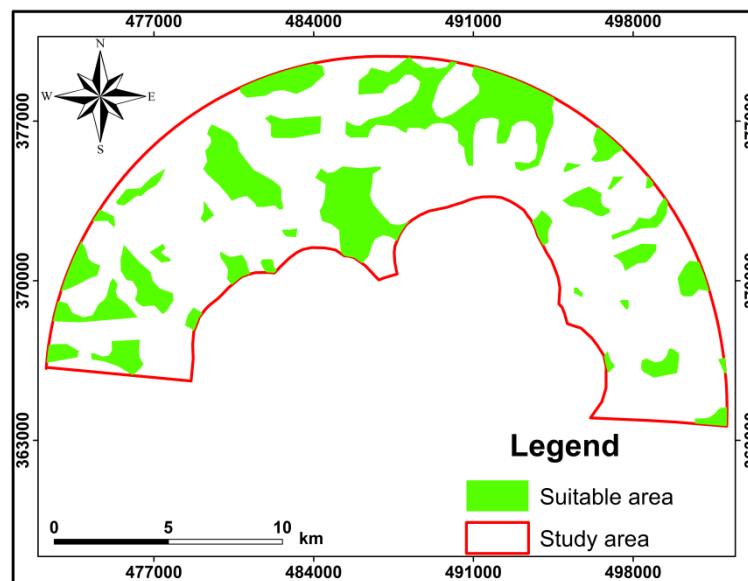


Fig. 8: Map of the potential areas for waste disposal.

## B. Criteria of appreciation on preselected sites

The assessment criteria are intended to enhance or reduce the relevance of the sites selected in the previous step. Our choice was focused on three types of factors (slope, geology, road network).

### B.1. Slope

The slope is a fundamental factor in landfill establishment. Steep slopes are unsuitable for landfill siting where the construction costs of excavation increases in higher slopes [17]. The suitable slope of land surface is important in preventing the leachate flowing [18]. Therefore, the landfill site should be in areas with ground slopes nominally less than 12 percent [19]. After superposition the map of the potential areas for waste disposal and map of slop, was obtained 26 potential sites (Fig. 9). The sites 0, 4, 12, 14, 19, 20, 24 and 25 were eliminated, as they are a small area for landfill.

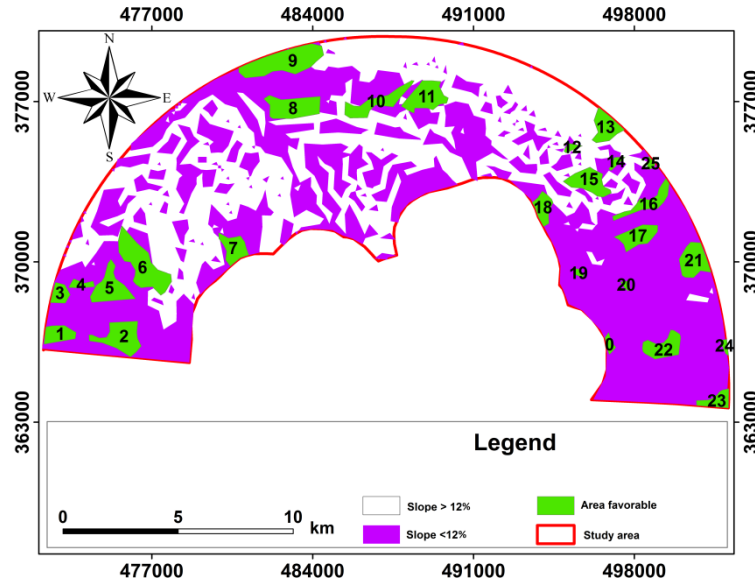


Fig. 9: Map of candidate sites for landfill.

**B.2. Geological areas**

The geological areas of a site are an important consideration. Sadek et al. (2001) noted that in selecting a site for the landfill particular attention should be given to the underlying bedrock and foundation soil [20]. A landfill must be located and designed so as to meet the necessary condition for preventing potential pollution of the groundwater. For this reason, the geological areas of new landfill should be impermeable and sufficiently thick. The sites 9, 13, 15, 16, 17, 18, 21, 22 and 23 were eliminated, as they do not have information relating to the geology. Sites 1, 2, 3, 5, 6, and 7 were also eliminated, as they are located in permeable geological layers. 3 sites were selected (Table 3).

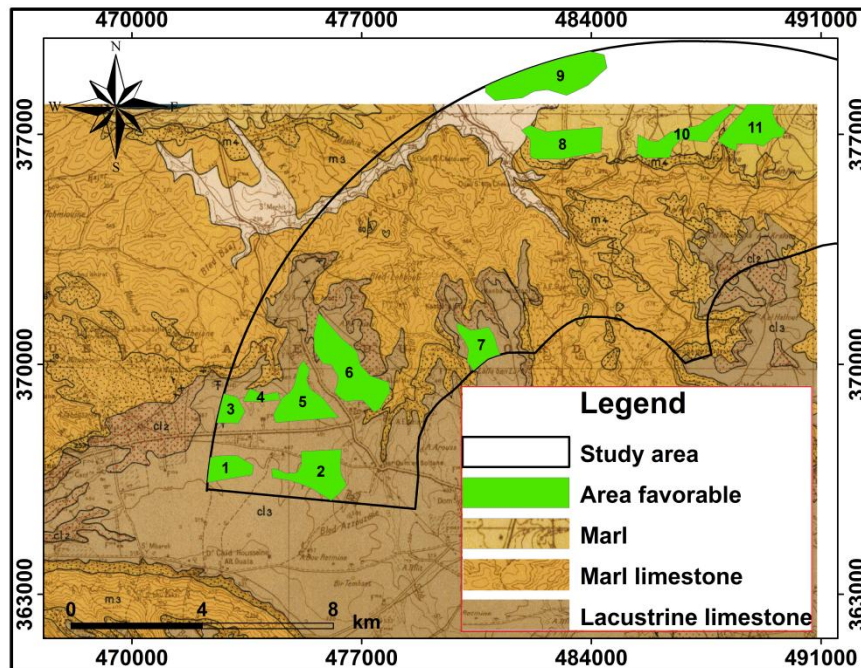


Fig. 10: Geological map of candidate sites for landfill.

**Table 3: Location and area of sites selected**

site	X(m)	Y(m)	Area (ha)
11	489073	377031	84
10	487315	377014	105
8	483065	376705	177.6



### B.3. Proximity to road networks

The proximity to road networks is a factor of great importance: If landfill is placed too far away from the existing road networks, costs for solid waste transportation will increase. That is why we superimposed the location map of the sites chosen that road network.

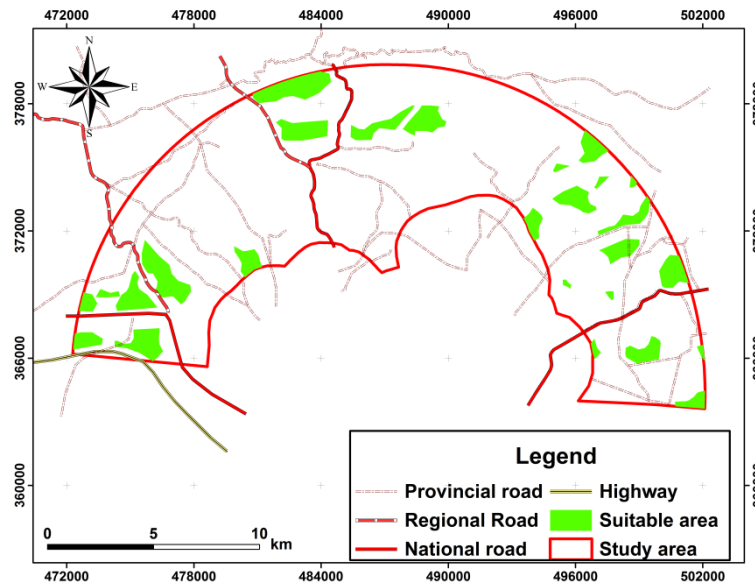


Fig. 11: Road accessibility map of candidate sites for landfill.

## V. CONCLUSION

This paper examines an approach for selection of Potential Waste Disposal Sites in Meknes city, it's provides an overview of the applicability of GIS to speed up the process of finding suitable sites for municipal solid wastes. The study was based on a set of key criteria, which were selected based on existing knowledge from the research literature. The GIS provided an effectiveness and efficiency in setting appropriate site for landfilling, he is as decision support tools to select suitable locations for landfill sites using constraint mapping where a large area is eliminated, A set of 26 potential sites were identified in the first level of application of exclusion criteria while subsequent screening and refinement on the basis of. Criteria of appreciation led to preselect of the 3 most suitable sites for the siting of a solid waste landfill.

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