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LAND SUITABILITY SCENARIOS FOR ARID COASTAL PLAINS USING GIS MODELING: SOUTHWESTERN SINAI COASTAL PLAIN, EGYPT

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Abstract: Site selection analysis was carried out to find the best suitable lands for development activities in an example of promising coastal plains, southwestern Sinai, Egypt. Two GIS models were developed to represent two scenarios of land use suitability in the study area using GIS Multi Criteria Analysis Modeling. The factors contributed in the analysis are the Topography, Land cover, Existing Land use, Flash flood index, Drainage lines and Water points. The first scenario was to classify the area according to various gradual ranges of suitability. According to this scenario, the area is classified into five classes of suitability. The percentage of suitability values are 51.16, 6.13, 22.32, 18.49 and 1.89% for unsuitable, least suitable, low suitable, suitable and high suitable, respectively. The second scenario is developed for a particular kind of land use planning; tourism and recreation projects. The suitability map of this scenario was classified into five values. Unsuitable areas represent 51.18% of the study area, least suitable 16.67%, low suitable 22.85%, suitable 8.61%, and high suitable 0.68%. The best area for locating development projects is the area surrounding El-Tor City and close to the coast. This area could be an urban extension of El-Tor City with more economical and environmental management.

Keywords: GIS; remote sensing; environment; Egypt

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INTRODUCTION

Land use suitability is a kind of analysis that is used to determine the most suitable tract of land for establishing new land uses, usually among multiple, competing uses (Steiner *et al.,* 2000; Collins *et al.,* 2001; Marull *et al.,* 2007). This analysis depends on multi-criteria evaluation of the concerned land for land development and/or environmental planning purposes. Riveira & Maseda (2006) described two phases of land use planning modeling; land evaluation and Land use allocation. Land evaluation is the suitability of the land for the uses considered, whereas land use allocation is decided according to the results of the land evaluation phase. Land evaluation and Land use allocation overlap and integrate for the site selection phase of the land use planning model. The analysis then groups specific areas of lands in the terms of their suitability for a defined use.

Land use suitability analysis has passed through different stages in the history of the development of methodology and theory. Collins *et al.* (2001) distinguished five stages of land use analysis development. Stage 1: early hand-drawn, sieve mapping; Stage 2: advancement in the literature; Stage 3: computer-assisted overlay mapping; Stage 4: redefinition of spatial data and multi-criteria evaluation; and Stage 5: replicating expert knowledge in the process (current state). With the rapid development of Geographic Information Systems (GIS) techniques, GIS is now playing a major role in spatial decision making for Land use suitability analysis. One of the most useful applications of GIS for planning and management is the Land use suitability mapping and analysis (McHarg, 1969; Hopkins, 1977; Brail & Klosterman, 2001; Collins *et al.,* 2001, Malczewski, 2004). Remote Sensing (RS) also plays an important role in providing the various spatial information required for the suitability analysis. The integration of GIS and RS is a powerful tool in saving time, yielding good data quality and efficient presentation of results. When land use planning analysis becomes more complex due to the multipurpose of the planning and seeking a balance between development needs and environmental restrictions, the Multi Criteria Decision Analysis (MCDA) is very helpful. Progress in computing sciences, including GIS and MCDA can help planners handle this complexity (Joerin *et al.,* 2001). The mission of MCDA with GIS is to analyze consider a time trading off the conflict between the many various multi criteria used for land use planning analysis.

Land use suitability analysis is needed for various purposes in the context of present sustainable development activities. The land use planning function must be viewed as an integral part of the national development process that cannot be viewed in isolation from the other critical elements of that process, namely social and economic planning (Thomas, 2001). Land use suitability analysis helps the development planners to accommodate the economic and environmental needs of people in technical and spatial networks. Furthermore the need for intensive and accurate Land use planning for developing countries is more urgent for the optimum use of their natural resources. Land use planning and necessary supporting data are crucial to developing countries that are usually under severe environmental and demographic strains (Bocco *et al.,* 2001). In Egypt, the government works for releasing the pressure of high population of the Nile Valley. It is reported (e.g., Sultan *et al.,* 1999) that the bulk of the Egyptian, rapidly growing, population is living on less than 5% of the total area of Egypt (over 1 million km^2). The rapid growth of the population leads to the urbanization of the highly fertilized agricultural areas, which is harmful economically and environmentally. Unfortunately, urban encroachment on agricultural lands is taking place at a rate higher than that of reclamation (Lawrence, 2002). Therefore, it is a priority to perform land use planning on the promising areas, like the studied plain, to evaluate the availability of establishing development projects that attract population to new land away from the Nile Valley.

Southwestern Sinai coastal plain (locally called Qaa Plain) extends along southwest Sinai, Egypt and occupies an area of about 3500 km^2 (**Fig. 1**). Southwestern Sinai is a promising area for land use planning as it has a long coast (approximately 180 km) and the low, sandy, gravelly plain surface that sharply contrasts with the adjacent high, hard, rocky mountains of South Sinai. The high mountainous range in the eastern part of the study area plays an important role in the development of this coastal plain.

The plain is drained by a considerable number of valleys known as wadis which originate in these granitic mountainous massive and are a component of the Gulf of Suez drainage system. These wadis were buried in the Plain through different cycles of sedimentation during Quaternary time and were active during rainy periods (Gilboa, 1980; Hammad, 1980). These separate drainage systems are of significant importance to the study area. They deliver sediments from the source rocks of the granitic mountains to the coastal gravelly plain. They also represent the main recharging source for coastal water resources, which are fed by seasonal floods as surface runoff, or as ground water.

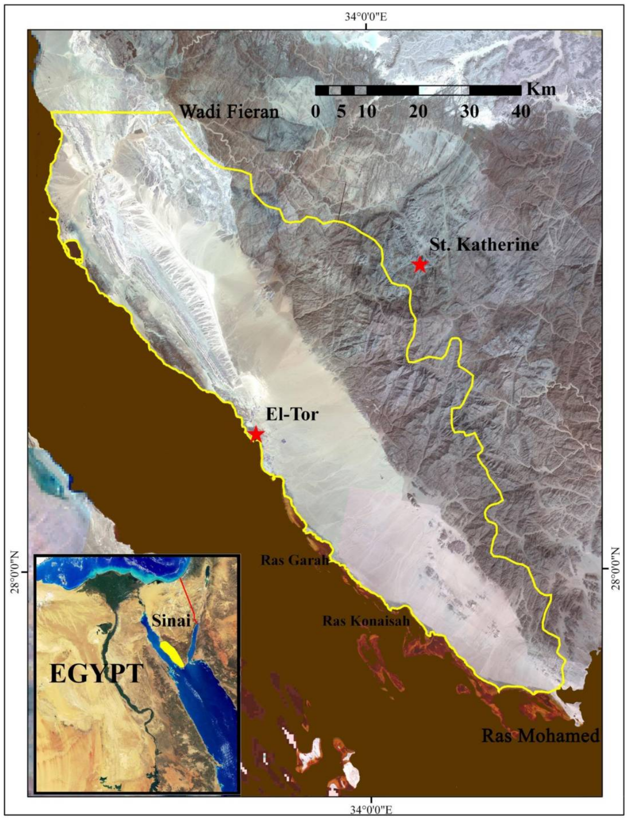

Fig. 1. Location of Southwestern Sinai Coastal Plain and meteorological stations depicted as red stars in a display of short wavelength infrared (SWIR) and near-infrared (VNIR) of an ASTER satellite mosaic at 15-m resolution.

METHODOLOGY

Spatial Analysis for Land use Suitability

In addition to storing, retrieving and displaying spatial data, a GIS enables the user to create buffers, overlays, intersections, proximity analysis, spatial joins, map algebra, and other analytical operations. Spatial analysis in GIS helps to define the criteria data, and operation of analysis, run the analysis model and analyze the results.

The greatest advantage of spatial analysis is that it is easy to refine the created model rather than create new one. The data used for the analysis model can be vector or raster. In a vector data model, multiple attributes are associated with each feature. Vector data enable analysis on only two layers at a time in an operation. The raster model represents features in grids of pixels, where each attribute is represented in one grid; however, it is possible to combine different layers in one raster layer where pixels will have different values for different features.

For spatial analysis using raster data, defining the suitable resolution is very important, as the very large pixel size can cause missing information and too small pixels size will produce very large size file. Raster data are used for land suitability modeling because analysis can be performed on several raster layers at once and the process is more efficient than in vector data.

Criteria for the analysis model

Site selection requires consideration of a comprehensive set of factors and balancing of multiple objectives in determining the suitability of a particular area for a defined land use (Al-Shalabi *et al.*, 2006). Different data resources were referred to various factors of land suitability analysis that were selected on the basis of their specific relationship with the assessment of land suitability for development. Some of the factors are considered positive that support existing development activities (including elevation, roads, soil or land type and water resources) and others are considered limiting or negative factors such as environmental factors of flood risk areas, oil and gas pipelines and environmentally sensitive areas like the wetlands. Specific factors can be chosen for specific kinds of development. The factors used for the model analysis are:

1 - Topography: is considered one of the most frequent required criteria for determining the Land use suitability. Topography is represented by both elevation and slope. For elevation; the lower the land the more the suitability, since low areas have more accessibility for basic facilities, such as transportation and water supply which is more difficult and expensive to be accessible for higher lands. Slope is more important because the higher slope makes accessibility more difficult in addition to the possibility of land sliding in some rock types.

2 - Land cover: some land covers are least or not suitable for Land use. For example, wetlands and granitic mountainous parts are least suitable, while gravelly and sandy plains are more suitable.

3 - Existing land use: site selection should take into consideration both site conditions and infrastructures (Dai *et al.*, 2001). The suggested land use should not interfere with the existing Land use. In other words, the existing urban areas must be excluded from the suggested area for development. Also some existing Land uses are important for the suitability of new Land uses. For example, areas close to water pipelines and paved roads are more suitable than areas far away.

4 - Flash flood index: lands subjected to high risk of flash flood are not suitable for Land use activities. Areas with medium risk of flood hazards can be suitable with some considerations and cautions.

5 - Drainage lines: development activities should not be located on the course of the main streamlines and a considerable buffer around these main drainage lines should be taken into consideration.

6 - Water points: underground water is an important natural resource for development activities in arid areas. According to World Health Organization (WHO, 1984) the groundwater contains less than 500 mg/L of TDS is suitable for drinking and domestic purposes, while water that contains more than 1500 mg/L of TDS is not suitable for these purposes. It must be taken into consideration the type of water of the dug water points in selecting lands for development activities.

PREPARING THE LAYERS FOR THE MODEL

Digital Elevation Model (DEM) extraction

Because of its off-nadir sensor pointing capability, ASTER can collect stereo pairs necessary to generate high resolution DEMs (using bands 3N and 3B). The DEM of the study area was created using ASTERDTM, a module that works as an extension of ENVI 4.2, ITT Visual Information Solutions. ASTERDTM uses the data of two sensors; the nadir-looking VNIR (band 3N) and the backward looking-VNIR (band 3B) to extract height information. The band 3B data is acquired approximately 30 seconds after the band 3N data, creating a stereo pair.

The extraction process matches the two scenes on a pixel by pixel basis, notes the parallax and then calculates the relative or absolute height. DEMs are extracted for each image separately and then mosaiced using ERDAS Imagine. The resulting DEM grid has 30-m post spacing resolution.

Check points were collected from topographic maps (1:50 000) for the vertical accuracy assessment. Using the check points, root-mean-square errors [RMSE] in the Z-coordinates were calculated. Assuming parallax difference correlation errors in the range of 0.5 to 1.0 pixels (7–15 m), elevation errors (RMSEz) are expected to be in the ±12 m to ±26 m range (Chrysoulakis *et al.*, 2004). By comparing the computed Z-coordinate values at check points with those collected from the topographic maps, DEMs of the study area yielded RMSEz of 3± to 15±. This result is considered reasonable and DEMs were not applied to correction.

Land use land cover map (LULC)

A combination of semi-automated classification techniques that include (1) supervised and unsupervised pixel-based classification contextual; (2) object-based feature extraction; and (3) manual delineation for defining the land use/land cover (LULC) of the study area. Procedures described in this paragraph were performed using ERDAS Imagine according to the ERDAS IMAGINE FIELD GUIDE, (7th edition ERDAS Imagine, 2003). VNIR and Short Wave Infrared Radiometer (SWIR) bands for each image were stacked and images were mosaiced to produce a comprehensive 15-m spatial resolution image data set of southwestern Sinai plain. Supervised classification was performed to derive the various LULC types. Field observations, prior unsupervised classification and previous work and reports were used for training site selection for the supervised classification of the image.

Linear features (Roads and pipelines) were extracted from topographic maps (1:50 000 scale) by Visual Learning Systems, Inc, in ArcGIS as an alternative to manual digitizing. The Feature Analyst uses contextual image classification and machine learning that is well-suited for linear feature extraction (Jordan & Manglass, 2005). Training samples for roads and pipelines were taken from the scanned, registered topographic maps and the complete linear features are then extracted. Small features such as farms and cultivated areas were digitized manually from the ASTER and topographic maps. The LULC data set created from image classification was updated with the classes extracted by feature analyst and manual digitizing. The LULC classes in the study area, named according to Anderson *et al.* (1976), level I and II.

LULC map were subjected to accuracy assessment. A total of 822 points were selected using a stratified random approach to ensure that each class is represented with an adequate number of points according to its area related to the total region area. Each accuracy assessment ground truth point was then examined to ensure that it did not fall within the associated class of interest's training regions; any point that did was removed from the reference dataset. The land use/land cover ground truth points were determined from field data, original ASTER image and Virtual Earth Images accessible through the Google Earth interface. The accuracy is evaluated using computed producer accuracy, user accuracy, overall accuracy and kappa index (**Table 1**). Almost all errors occurred in the boundary area between different land use/land covers. The overall accuracy is 82.4% and overall Kappa is 0.79.

The produced DEM and LULC data sets were re-projected to WGS 1984 UTM Zone 36N and were clipped to the study area using a digitized boundary layer.

The input data for the Land use suitability are prepared in GIS format using ArcGIS™ in order to be used for the analysis model. As mentioned before, raster data is to be used for the model and each layer must

Table 1. LULC Accuracy assessment results*

Class	User Accuracy	Producer Accuracy	Total Accuracy	Kappa
Gravelly plain	85.8%	86.2%	92.6%	0.8099
Igneous rocks	88.4%	95.8%	96.6%	0.8980
Sedimentary rocks	80.6%	89.9%	95.0%	0.8200
Sandy plains	75.5%	59.7%	95.1%	0.6408
Wetlands	79.4%	77.1%	98.2%	0.7731
Oil and water fields	93.6%	67.4%	98.1%	0.7739
Vegetation	72.7%	61.5%	97.2%	0.6515
Urban areas	75.0%	75.0%	98.1%	0.7399
Farms and cultivated lands	81.8%	99.2%	99.3%	0.8534
Paved roads	71.4%	57.7%	97.9%	0.6278
Non-paved roads	77.8%	73.7%	98.9%	0.7512
Oil and gas pipelines	70.6%	92.3%	99.2%	0.7963
Water pipelines	58.8%	71.4%	98.7%	0.6384

*Overall Acuracy = 82.36 % and Kappa= 0.79.

contain only one attribute. Some layers are kept as vector and converted to raster in model operations. All layers are clipped to the base map of the area of study and all raster data were created or resampled to a 30 meter cell size. The existing raster data are the DEM, slope and flash flood index.

Each Land use and land cover in LULC layer is separated in a separate layer. These layers are kept as vector; however the buffering results were in raster layers. A total of 12 layers were created to represent all the land use and land cover types within the plain. These layers are igneous heights, sedimentary heights, gravelly plains, sandy plains, vegetations, wetlands, paved roads, water pipelines, oil and gas pipelines, urban areas, farms and cultivated lands and oil and water field's areas.

The model starts by adding the prepared data layers (**Fig. 2**). Then the next analyses were used:

- Euclidean distance: this operation was subjected to the land use, land cover, water points and streamlines layers. Euclidean distance is an operation that calculates the straight-line distance to the closest source. This operation is used as a multi-buffer for these layers, where 0 distance is the feature itself and values over 0 are distances in meter from it.

- Reclassifying: the outputs rasters of the previous operation and the rest of the layers (DEM, slope and flash flood index grids) are reclassified. Reclassification means to change cell values into alternative values. For example, the distance from the paved roads can be reclassified (re-valued) as follow: 0–1 = 0; 1–1000 = 1; 1000–2000 = 3 and so on.

- Weighting overlay: weighted overlay is a technique for applying a common measurement scale of values to diverse and dissimilar inputs in order to create an integrated analysis (ArcGIS Desktop help, 2007). All the reclassified layers were overlaid. In this operation each layer is weighted in percentage according to its importance to the analysis. The sum of the weighting percentage should be 100%. Each value of the reclassified raster was scaled according to its association to suitability. For example, the very high slope values take the least scale value where the low slope will take the highest scale. Restricted scale value is used to identify the areas that are definitely will known unsuitable for land use. Cells represent the unsuitable values are assigned to restricted 0 scale values.

Scenarios for suitability

The advantage of the land use suitability model is the flexibility in modifying the input elements, ranking and weighting. The main purpose of this analysis is to find the best suitable lands for development activities; however the model can be modified for different purposes of planning. A land use scenario can be defined on the basis of one or more development targets (Trung *et al.*, 2006). So, distinctive scenario can be generated specifically for tourism, urbanization or agriculture activity by adding new criteria and/or changing the weight values of the layers.

For the present work two scenarios were suggested for land use planning of the study area. One of them is general for locating suitable lands for all development activities and the other is an example scenario for a specific kind of activities (**Fig. 3**).

Scenario #1: Multi-zoning suitability

The idea of this scenario is to classify the area of study for zones of suitability. In this scenario, the layers are reclassified into graded scale values according to the suitability for land-use (**Table 2**).

These zones range from unsuitable to high suitable zone. The result of this analysis is important for planners and decision makers to find the priority areas for locating the suggested development activities. This also can be helpful for defining the best location for a particular activity. For example, for establishing new urban areas the planner can select the best location that is in high suitability rank and close to infrastructures.

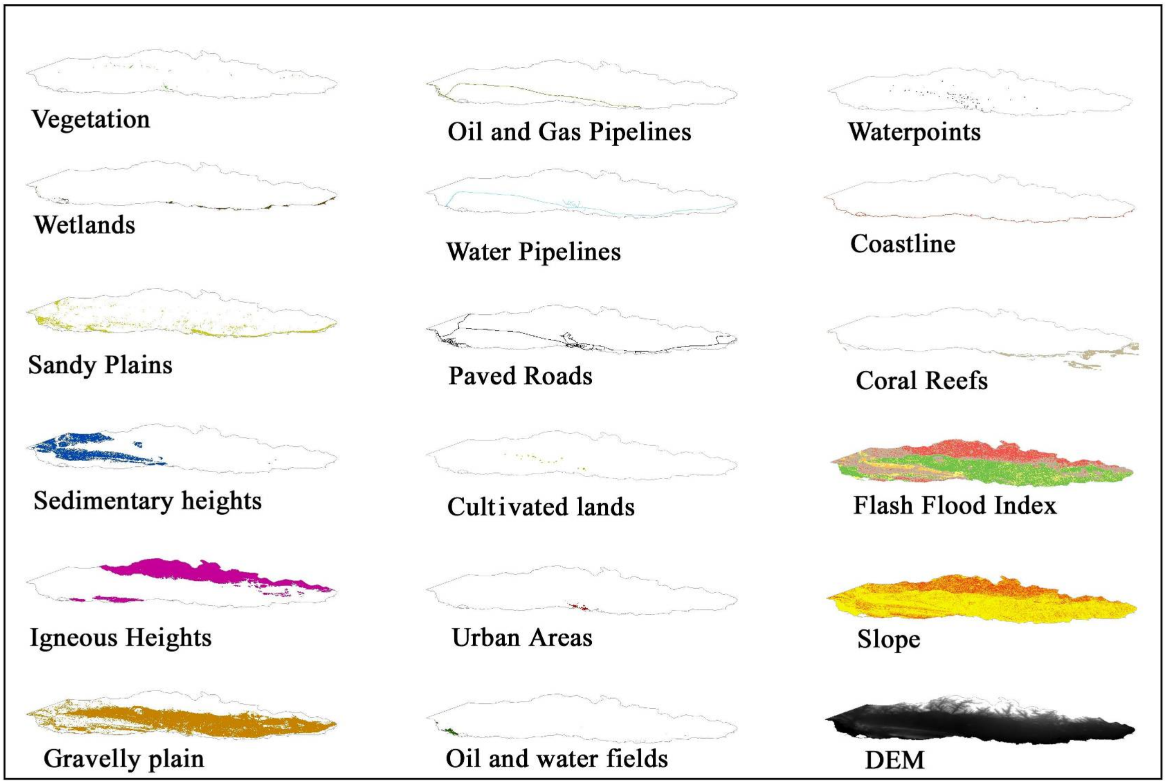

Fig. 2 Spatial data contribute in land use suitability analysis.

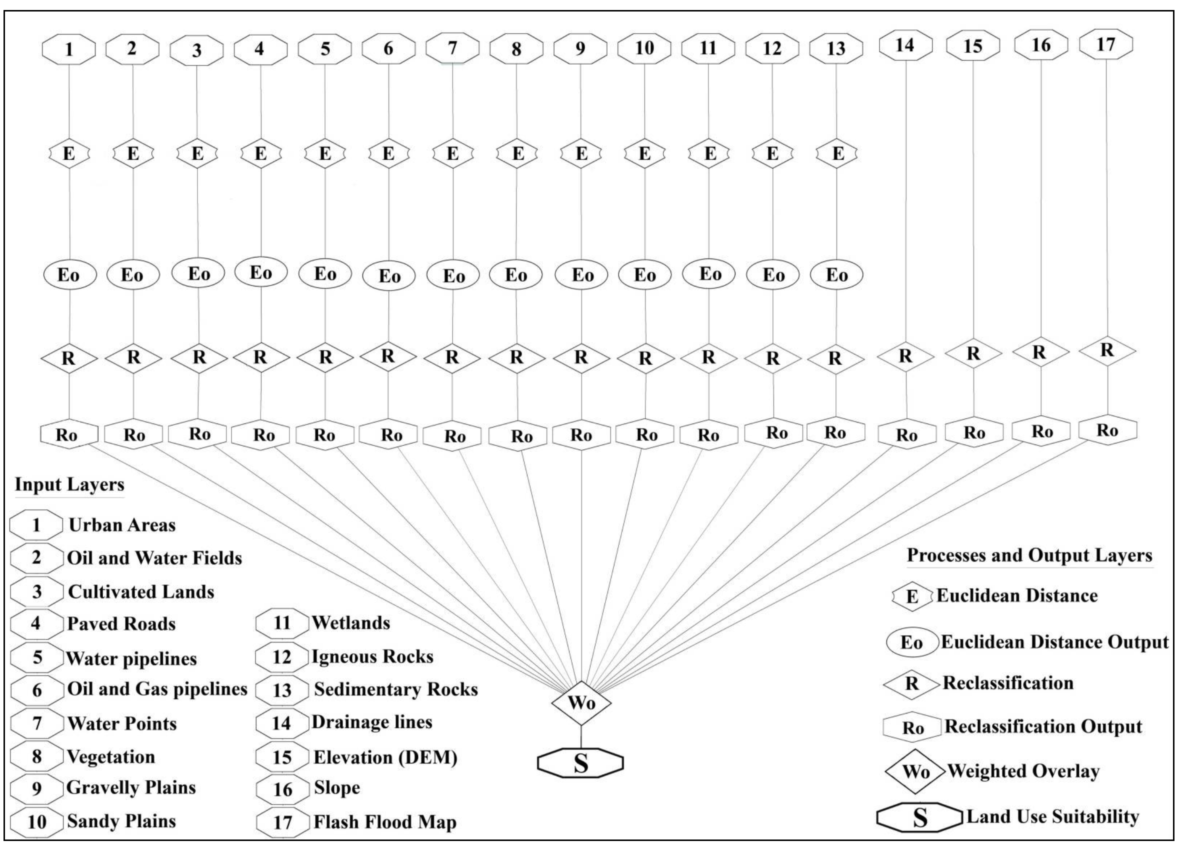

Fig. 3 Model developed for potential land use suitability in the study area.

Table 2. Weight ranks for the criteria used for the land-use suitability analysis – First Scenario

Layer	Distance Rank in relation to suitability	
	0	1
Igneous Rock	≤ 5000	> 5000
Sedimentary Rocks	≤ 5000	> 5000
Sandy Plain	≤ 1	< 1
Gravelly plain	≤ 1	< 1
Wetlands	≤ 1000	> 1000
Vegetation	≤ 1000	> 1000
Oil and water fields	≤ 2000	> 2000
Farms and cultivations	≤ 1000	> 1000
Urban Areas	≥ 10000	≤ 10000
Road	≤ 50	≥ 5000
Water pipelines	≤ 5000	≥ 5000
Oil and Gas Pipelines	≤ 1000	> 1000
Drainage Streams	≤ 50	> 50

Layer	Elevation values ranks for suitability	
	0	1
Elevation	100–2000	≤ 100

Layer	Slope values ranks for suitability	
	0	1
Slope	> 25	≤ 25

Layer	Flash flood index values ranks for suitability	
	0	1
Flash flood index	≥ 6–10	≤ 0–6

Layer	TDS amount in ground water	
	0	1
Water points	≤ 1500	≥ 1500

Scenario #2: Suitability of recreation and tourism

This scenario is selected among the other specific development activities, because the study area has the constituents of the recreation and tourism projects that are described by Shaalan (2005) as 3S (Sand, Sea, Sun) tourism package. It has a long coastline with sandy beaches. In this scenario in order to approach suitability related to recreation and tourism activities, three new factors are added to the previous model factors (**Table 3**):

(a) The coastline: the closer to the coast the more suitable;
(b) The coral reefs communities: the closer the beach that has coral reefs, the more suitable;
(c) The existing human resources that specifically related tourism activities such as airport, tourist locations, seaports, marina and diving sites. Buffers around these sites are taken into consideration to avoid conflict between the existing site and the desired ones.

RESULTS AND DISCUSSION

Development statement in the study area

Generally, the Gulf of Suez is one of the most interesting parts of Egypt; geologically and environmentally. However, development activities on the eastern side of the Gulf were mainly oil and gas exploration and exploitation. The development of the Sinai started seriously in the 1980s. Ali (1998) attributed the late time for the development of Sinai to several reasons, such as the remote location of Sinai from the central administration in Cairo that contributed to its isolation and the instability in the region since 1948 and three wars in 1956, 1967, and 1973 with Sinai as the battlefield that delayed the integration of South Sinai with the rest of Egypt.

The study area is part of the South Sinai governorate. The demographic data of this governorate (**Table 4**) shows that population changes from 54 806 to 149 355 from 1996 to 2006 with the rate of increase being 172%. This indicates that the population increases rapidly in this area of Egypt. The young people (under 15 years age) represent 19% of the total population, which is a good socioeconomic factor supporting the suggested development projects in the study area. The population census is concentrated mainly in three places in the study area; El-Tor City and the village of El-Gebeel and El-Wady (**Fig. 4**).

The development activities in southwestern Sinai usually were associated with the oil production activities and serving the local residents and workers in these oil projects. Recently, tourism and recreation projects took place due to the increased concern of the Egyptian government for developing Sinai and the urbanization growth in the study area. **Figure 4** shows the present economic, tourism and social activities in the studied plain. It is obvious that most of the few developing activities are concentrated around the residential areas where facilities and utilities are presented. Some are related to coast activities, such as marinas and seaports that serve the fishing and diving activities. These development sites represent less than 2% of the study area.

Development scenarios

More details about the ecological factors and the relationship with other physical factors are required for obtaining more useful results for sustainable development. There is still a great deal to be done in the

Table 4. Demographic data of the South Sinai Governorate in relation to Egyptian data (CAPMAS, 2008)

Statement	Egypt	South Sinai Governorate
Population 2006	72 580 653	149 335
Population Census 1996	59 276 672	54 806
Percent Change 2006	22%	172%
Population Under 6 Years Old 2006	14%	9%
Population Percent Under 15 Years Old 2006	32%	19%
Population Percent Over 45 Years Old 2006	20%	13%
No of Households 2006	17 265 994	22 377
No of Persons Per Family 2006	72 132 719	88 923
Family average 2006	4	4
University Graduates 2006	5 476 760	32 075
Illiterates 2006	16 807 003	15 391
Buildings Number 2006	11 531 516	25 050
Dwelling Units 2006	27 786 857	45 967
No of Governmental Units 2006	323 144	3542
No. of Public or Public Business Buildings 2006	55 893	226
No. of Private Buildings 2006	11 022 673	21 163
Raw Birth Rate Per 1000	26	29
Raw Death Rate Per 1000	6	8

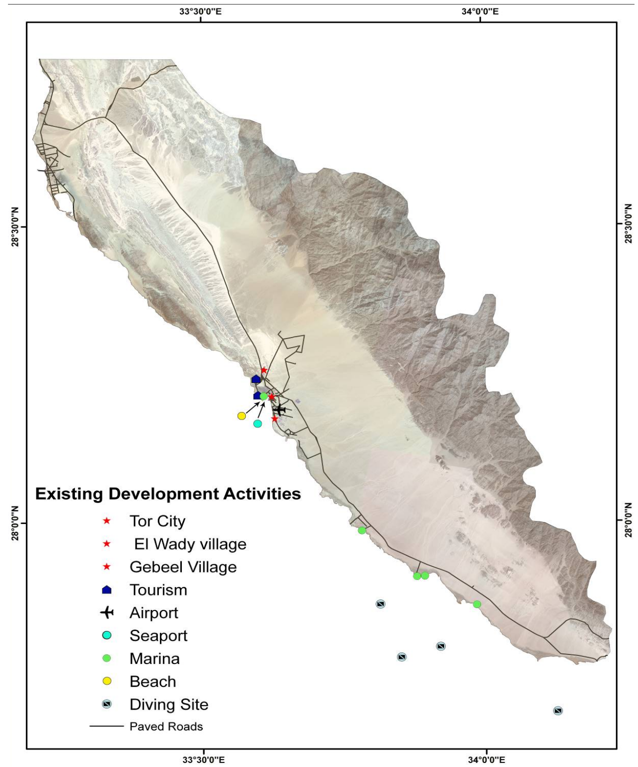

Fig. 4 Existing development activities in the study area.

process of integrating ecological and landscape considerations in most regional, urban, and sectorial planning to attaining an acceptable standard of sustainable development (Marull *et al.*, 2007). The developed scenarios will be discussed from the point of view of the results and the efficiency of the created model to give reasonable results about the suitability of the study area for development activities.

The first scenario shows that the igneous and sedimentary heights (mountains and hills) surrounding the study area are considered the most negative factors affecting the land suitability. It directly affects four factors. The land type; these mountains and hills are made of granitic and sedimentary hard rock that is not suitable for most land-uses.

It affects elevations as the heights can reach in elevations up to 2000 meters and decrease gradually towards the seaside. The slope on and around these heights are steeper than those close to the sea especially southwards. The drainage pattern running through these heights can cause flash flood hazard to the nearby areas. In the other hand, the south western part of the study area involves most of the positive factors including the socioeconomic factors represented by the residents of the urban areas, the transportation factor represented by the paved road running parallel to the coastline, water supply pipelines, in addition to the convenient topographic setting (slope and elevation) for establishing development projects.

The first scenario results range from zero which is unsuitable to 5 that is the most suitable. The least suitable areas are located around the eastern and northern heights and change gradually to more suitable to the sea direction and finally around and close to the urban areas. Some spots of high suitable values are distributed southward (**Fig. 5**). The percentage of suitability values are 51.16, 6.13, 22.32, 18.49 and 1.89% for unsuitable, least suitable, low suitable, suitable and high suitable, respectively (**Table 5**).

The second scenario is developed for a particular kind of land-use planning; tourism and recreation activities. The new factors added to the model change the values and locations of suitability. It is observed that the suitable areas are closer to the sea and other existing tourism and recreation places. The suitability grid of this scenario was reclassified to five values. Unsuitable areas represent (51.18%) of the study area, least suitable (16.67%), low suitable (22.85%), suitable (8.61%), and high suitable (0.68%) (**Table 5**).

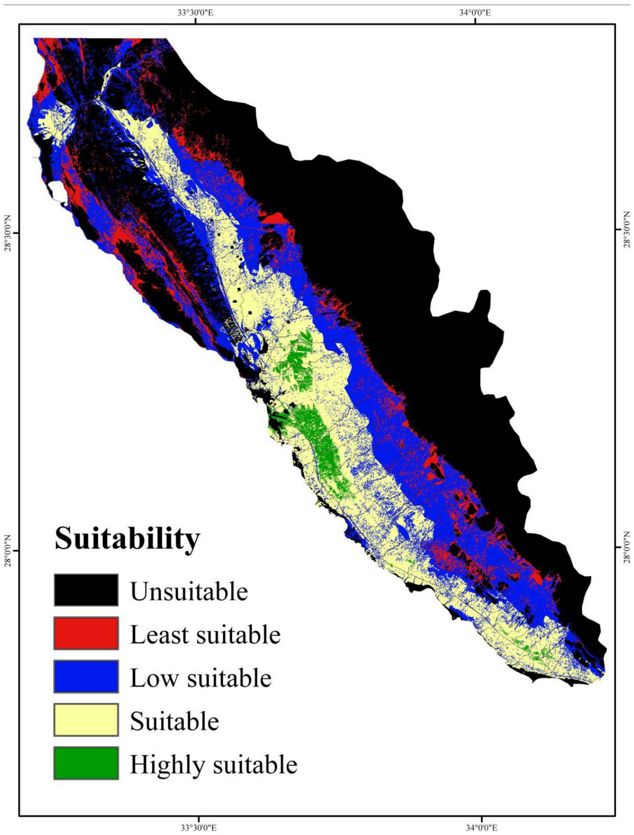

Fig. 5 Land use multi-zoning suitability map – scenario #1.

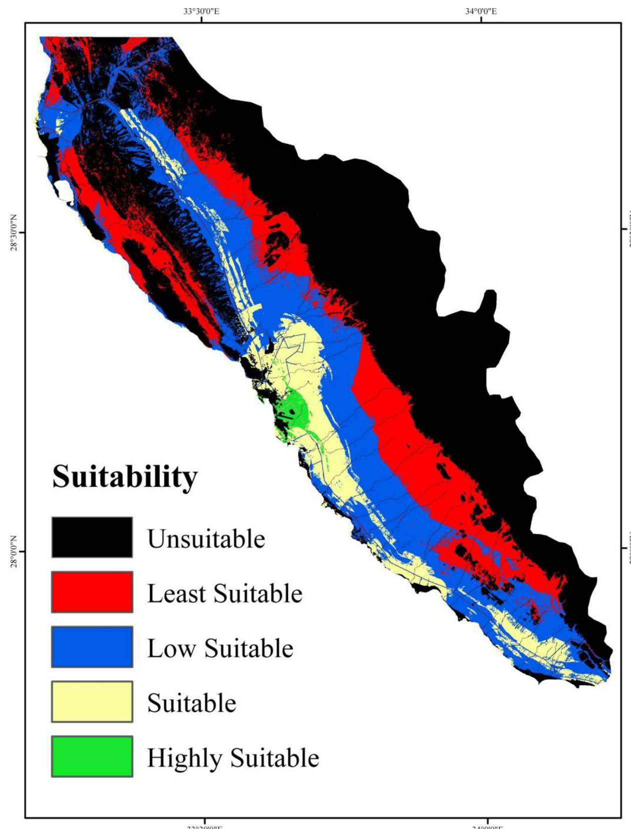

Fig. 6 Land use suitability map for tourism and recreation sites – scenario #2.

Table 5. The percentages of the different suitability levels for the developed scenarios

Scenario	Suitability Level	Area (km²)	Area %
First Scenario	Unsuitable	2 317.14	51.16
	Least suitable	277.67	6.13
	Low Suitable	1 010.93	22.32
	Suitable	837.52	18.49
	Highly Suitable	85.78	1.89
Second Scenario	Unsuitable	2 318.03	51.18
	Least Suitable	755.08	16.67
	Low Suitable	1 035.10	22.85
	Suitable	390.14	8.61
	Highly Suitable	30.67	0.68

Suitable values are also extending southward and slightly northward. This depends mainly on the meeting of the combination of the supporting factors to the suitability of this development activity, such as the proximity to transportation utilities, water supply and coral reefs coasts, along with the previous factors of the last scenario (**Fig. 6**).

It is noticed that the high suitability values in the two scenarios intersect in the middle part of the plain. This gives priority to this part that requires more evaluation concerning the analysis of physical suitability, economic viability, social consequences and environmental impact produced. This suitable area might be prepared to be an urban extension of El-Tor City with more economical and environmental management. It is also possible to establish a new community with various kinds of development activities that provides more job opportunities from El-Tor and other small communities in South Sinai governorates and/or from the crowded Nile valley communities.

The created model is kind of multi criteria analysis (MCA) that includes most of the data layers and processes required for land use evaluation and allocation. The model is flexible and can be modified by adding new layers or operations. It also is possible to modify the rank and weight of the input data criteria, and reclassify the result grids according to the needs and view of the analyst and decision maker.

CONCLUSIONS

The southwestern Sinai coastal plain is one of the promising areas that the Egyptian government is interested in developing them. This work is to evaluate the availability of establishing development activities that attract population to this area by conducting land use suitability analysis. Two models representing three scenarios of development using GIS Multi Criteria Analysis (MCA). The developed model for land use suitability that depends on the factors influencing the study area is a good product for project planners and decision makers when choosing the part of the study area for locating development project.

The created models are very flexible for modification and update according to the purpose of development. High suitability values in both scenarios intersect in the middle part of the plain. Priority is to be given to this part might be prepared and managed economically and environmentally to be an urban extension of El-Tor city. It is also possible to establish a new community with various kinds of development activities that provides more job opportunities from El-Tor and other small communities in South Sinai governorate and/or from the crowded Nile Valley communities. For future work, new scenarios for land use suitability may be developed for additional suggested land use activities such as locating new industrial areas for producing ornamentation rocks or new suitable areas for agricultural and cultivation activities.

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ble 3. Weight ranks for the criteria used for the land-use suitability analysis – Second Scenario

Layer	Distance Rank in relation to suitability										
	0	1	2	3	4	5	6	7	8	9	10
gneous Rock	≤ 1	1–1000	1000–3000			3000–5000			5000–10 000		> 10 000
Sedimentary Rocks	≤ 1	1–1000	1000–2000		2000–3000				3000–5000		> 5000
Sandy Plain					> 2000			1000–2000	1–1000		< 1
Gravelly plain		> 1									< 1
Wetlands	≤ 1	1–1000		1000–2000		2000–3000					> 3000
Vegetation	≤ 1	1–500		500–1000	1000–2000	2000–3000					> 3000
Dil and water fields	≤ 1	1–2000		2000–3000		3000–4000			4000–5000		> 5000
Farms and cultivations	≤ 1		1 – 1000			1000–2000		2000–3000			> 3000
Urban Areas	≤ 1	> 10000			5000–10000		3000 - 5000		2000–3000	1000–2000	1–1000
Road	≤ 1	> 10000	1 – 5			5000–10000	4000 - 5000	3000–4000	2000–3000	1000–2000	50–1000
'ater pipelines	≤ 1			> 5000		4000–5000		3000–4000	2000–3000	1000–2000	1–1000
Oil and Gas Pipelines	≤ 1	1–500			500–1000		1000 - 2000			2000–5000	> 5000
ainage Streams	≤ 1	1–50									> 50
man Resources	< 1	1–100	> 5000			2000–5000		1000–2000		500–1000	100 –500
Coastline		> 2000		1000–2000		500–1000		300–500	200–300	100–200	0–100
ral reefs coasts		> 2000		1000–2000		500–1000		300–500	200–300	100–200	0–100

Layer	Elevation values ranks for suitability										
	0	1	2	3	4	5	6	7	8	9	10
Elevation	500–2000		300–500				200–300	100–200	50–100	20–50	0–20

Layer	Slope values ranks for suitability										
	0	1	2	3	4	5	6	7	8	9	10
Slope		50–89		40–50		30–40	20–30		10–20	5–10	0–5

Layer	Flash flood index values ranks for suitability										
	0	1	2	3	4	5	6	7	8	9	10
Flash flood index	8–10		6–8		4–6	2–4					0–2

Layer	TDS amount in ground water										
	0	1	2	3	4	5	6	7	8	9	10
Water points		> 1500				500–1500					490–500