Airport site suitability and development based on multi-Criteria in Egypt

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Abstract

This study offers a siting approach and major help for decision-makers in Egypt and other nations when it comes to airport location choices. This research is about how a multi-criteria approach was employed in the decision-making process for a new airport in Egypt. It presents a practical way for discovering suitable locations in urban planning using remote sensing and Geographic Information Systems, which benefits both sustainable and economic development. The methodology of site detection depends on multiple-criteria analysis for choosing the optimum suitable sites. The most significant factors considered for this analysis are topography, urban areas, and geological characteristics. The study's constraints, such as distance from existing airports and land use, have been taken into account and will be explained later. Finally, a sensitivity analysis was conducted to decide the validity of the criteria used and to select the best site among the suggested locations based on the highest suitability score for each proposed location. The study results obtained five optimum suitable locations which are mentioned respectively Fayoum, the new Administrative Capital, Ras Sedr in South Sinai governorate, Siwa and Al Minya, which could help in the improvement of the aviation field. According to this study, a multi-criteria evaluation approach was utilized to assist decision-makers in selecting acceptable airport sites in Egypt. GIS allows for multi-criteria evaluation, which combines various sorts of criteria to arrive at the optimal decision. The weighted linear combination was used consistently in the multi-criteria evaluation in order to generate a suitability map.

Key words GIS, MCDA, Suitability analysis, Airport sites selection

1. Introduction

Most countries were suffered from the problem which is how to select the best location for constructing airports. The substantial population growth in developing countries, especially in Egypt, lead us to search for alternative methods or innovative ways to provide the best vital locations for establishing national projects, as airports [15]. Due to continuous unplanned urban encroachment, it has been noticed in the last few years that many buildings have been constructed within the critical zones surrounding several airports. According to standardizations, several of these structures are actual obstacles for air navigation to ICAO standardization. These obstacles are also affecting the development plans and future expansions of some Egyptian airports [14]. This condition affects aviation traffic and makes some runways or even airports unusable, resulting in the airport being downgraded from international to national airport in some cases or rendering some runways unusable. Some airports encountered numerous issues as a result of poor site selection planning, resulting in serious problems with airport operation systems, resulting in closure and significant economic losses that impacted national income. Due to the airport's location within an urbanization region, such as Al-Nozha airport, this has an impact on air traffic and aviation navigational aids during take-off and landing. It negatively affects the safety of passengers. Also, sometimes it's figured out after the establishment of some airports that their location falls nearby planning new urban cities which is considered human obstacles that obstruct the aviation movement, also the cost of the airport land site is sometimes massive, so that it leads to its closure and replanning the entire process.

In another case when airports lie nearby seashores affects the aviation movement regarding the climate change and other factors [2]. The main goal of this research is to improve this situation and choose the best airport locations. The site selection process is divided into many stages, with the first involving geospatial analysis of previously gathered data and features relating to the location that are more easily handled. GIS may integrate spatial, attribute data, and some modules in GIS propose the integration of a powerful decision support system with analytical tools such as multi-criteria optimization methods, spatial analysis, and statistical tools. It provides significant support for the comparison of alternatives in getting best suitable sites. Multiple criteria considered for GIS modelling in order to achieve sustainable developments in many regions.[4] Environmental, economic, and social demands, as well as community and governmental interests, as well as specialized needs such selecting suitable zones for industry and housing, may be included in these criteria. This causes delays in making the appropriate decision for studies of projects such as a building, an apartment complex, a football stadium, an airport and universities. A successful site selection process may reduce operational cost. The optimum location for new airports sites were identified by defining the criteria, these criteria are topography, urban areas, and geological characteristics. the constraints of this study are the distance from existing airports and the hydrology study.[14]

The relative significance weighting for each criterion was calculated using MCDA method. Each map layer was built by overlaying assessments of each criterion map to form the final

appropriate map. The study region was divided into high and low appropriate zones based on the findings. To assess the correctness and suitability of the candidate locations, a field site check was conducted. In this research, an innovative methodology for locating the best sites in Egypt that could be used as airport new suggestions is proposed. The suggested methodology aims to create a GIS-based model based on the multi-criteria decision analysis (MCDA) in Egypt.

2. Study area

Egypt is a North African country located in the northeast. The study area covered the entirety of Egypt in general. Palestine is to the north, the Red Sea is to the east, Sudan is to the south, Libya is to the west, and the Mediterranean Sea is to the north. Between (25° 000' E and 37° 000'E) and (22° 000' N and 32°000'N) is the study region. Fig. (1) shows the SRTM color-coded DEM map with 30 m spatial resolution that covers the study area and was utilized for elevation and slope terrain criteria. The elevations in Egypt were ranged from -80 m below sea level to 2501 m above sea level. As shown in the topographic map, the higher elevations are mainly concentrated along the Red Sea, South Sinai and El Uweinat which located in the south west of Egypt.
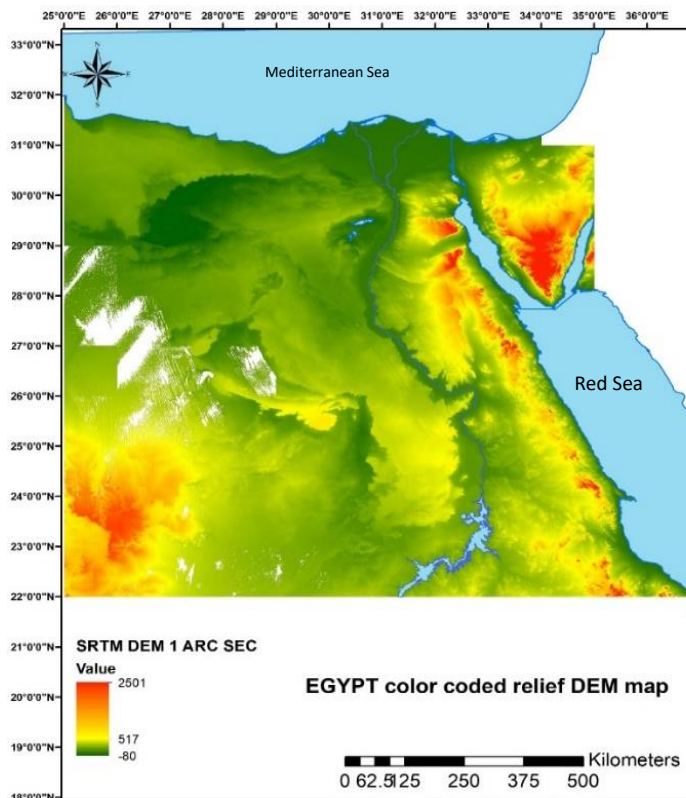

Fig. (1): Digital Elevation Model (DEM) for Egypt after categorized

3. Airports Site Selection Criteria

According to the International Civil Aviation Organization (ICAO) which responsible for determine the criteria to choose the best location for the construction of an airport. The factors influencing on the choice of site for the establishment of airport are:

1. Elevation differences from   Digital Elevation Model (DEM)
2. Weather conditions and wind system
3. Easy access to the airport
4. Susceptibility to airport expansion
5. The presence of Airport near the established airports
6. Economic Generation Airport [Among these criteria: Soil map , Climate data.
7. Satellite imagery and the region's principal highway
8. How far away or close to natural obstacles or man -made obstacles
9. The ability to provide the airport with navigational aids and their efficiency

4. Data Source

. 4.1 GEOMETRICAL CRITERIA

1- As a topographic data source, the shuttle radar topography mission SRTM digital elevation model dem was used, along with terrain slope criteria received from the United States Geological Survey (USGS). [23]

The DEM has 30 m resolution, The datum of the data is WGS-84. To identify the topography and the difference in ground levels to reach the best areas with an approximate level. It is described one of the most essential variables through which the land tendencies, major flood drains, and critical areas, streams for rainwater harvesting were obtained, so that they can be avoided when choosing the best location for the airport. The ArcGIS were used in slope analysis and classifications. The DEM was then transformed into a slope raster dataset, with percentage values for slope values. [19]

2. The location of all existing airports.

3. The obstacle around the airport area must be studied to protect the limitation surfaces from any features at the required height in this area4. Navigational aids have specifications and characteristics according to ICAO in order to work more efficiently, must be taken into account in order to assist the aircraft during   landing and take-off

4.1.1 Hydrology Study

Using an elevation raster or DEM as input, it is able to automatically designate and quantify a drainage system. GIS software spatial analyst extension toolbox's hydrology modelling provides methods and tools to explain the physical components. Users can identify sinks using the hydrological tools. choose a flow direction compute buildup of flow build stream networks and demarcate watersheds applied GIS to model the rainfall-runoff process [17].

4.2 ECONOMIC CRITERIA

4.2.1 Main roads networks Distance from airport

In a vector layer, the region's principal roadways are stored using the WGS84 Geographic Coordinate System.The official website of the General Authority of roads[8]

The Arc GIS digitizing tools was used for converting the scanned map image to vector data set line feature layer. All road classes were vectorized in layer feature data set in order to analyze with distance buffer spatial tool. The suitability analysis overlay the raster criteria so, the roads network vector data was converted to raster for raster calculator function using ArcGIS tools.

4.2.2 Distances to electricity network (power grid proximity)

GIS sector in the Ministry of Electricity and Renewable Energy (MERE) produce the Egyptian unified power network map [20]. Spatial data from power grid network map should be prepared for the ArcGIS tools. Through the MCDA a process of combination and transformation the geographical data (inputs) into a resultant decision (output) were applied. A vector map data was prepared for the Egypt electricity network. To be utilized using the ArcGIS tools, the vector data was converted to raster one which was used in suitability analysis.

4.2.3 Soil suitability criterion

Egypt's soil association map was collected from the Wageningen soil survey institute [22]. The texture, depth, and color of the soil in the area are illustrated on the soil map. This map's data is in raster format. The ArcGIS tools was utilized to georeferenced the map using the map grids and the digitizing tool was used to vectorized all the soil class areas.

4.3 CONSTRAINS

Through conditions which are required to create the airport and standards, the constrains are following conditions: -

1. All significant water bodies were excluded from the analysis.
2. The reserved area around an airport must be clear of obstruction in order to protect the operation of aircraft which are considers obstacles limitation surfaces (OLS) according to ICAO
3. Navigational aids which help the plan to landing and take-off
4. All urban areas are also considered exclusionary and all new urban communities
5. An airport should ideally be located on relatively flat ground in general.
6. Access to appropriate infrastructure to serve an airport must be considered. The proximity to infrastructure such as water
7. Stay away from high trees for the forest because of their impact on increasing wind shear and then increase aerobic bumps
8. Constrains such as industrial areas, agriculture proposed areas, natural reserves areas and tourism areas.

5. Methodology

A verification study based on (DEM) and GIS is required when choosing the best location for a new airport [15]. MCDA (which assists decision-makers in examining alternatives based on numerous criteria and uses decision procedures to aggregate those criteria to rate or rank the alternatives) MCDA is an example of this type of analysis. Economic and technical criteria are important considerations during the preliminary site screening.

The 30 m spatial resolution digital elevation model (SRTM) data is primarily utilized as a topographic data source, with terrain slope criterion created from a topographic ratio. Other additional spatial data such as transmission line network, road network, water bodies, and some constraints of land use were analyzed from an economic point of view [21].

The weighted averages principle is used by WLC. The decision maker assigns weights to each criterion based on their relative importance. As indicated in Equations, the weighting is done by multiplying the factor's weight by its standardized membership value. WLC creates a suitability map by assigning a weight to each factor and then summing the results. WLC is based on the equation below [21].

$$S = \sum w_i . x_i \qquad (1)$$

where S is suitable, w_i is factor i's weight, and i x is factor i's criterion score [21].

The following were the steps in a GIS-based mapping process for the best location of Egyptian airports.[23]

1. Defining the Airport criteria and suitability factor.
2. Data acquisition, preparation, and verification.
3. Rasterization and classification.
4. Each criterion is reclassified and given an appropriateness rank value.
5. Assigning weights to criterion
6. Preparation a GIS analysis model
7. Create a GIS-based analysis mode

    The following flowchart illustrates a methodology that contains Data Analysis, Acquiring, preparing, and verifying data raster map classification and creation Reclassification and awarding an appropriateness rank, as well as the weighting of criteria, are all steps in the processing process., Creating a map for best airport locations and Raster calculator analysis these parts will be explained in detail in the following sections
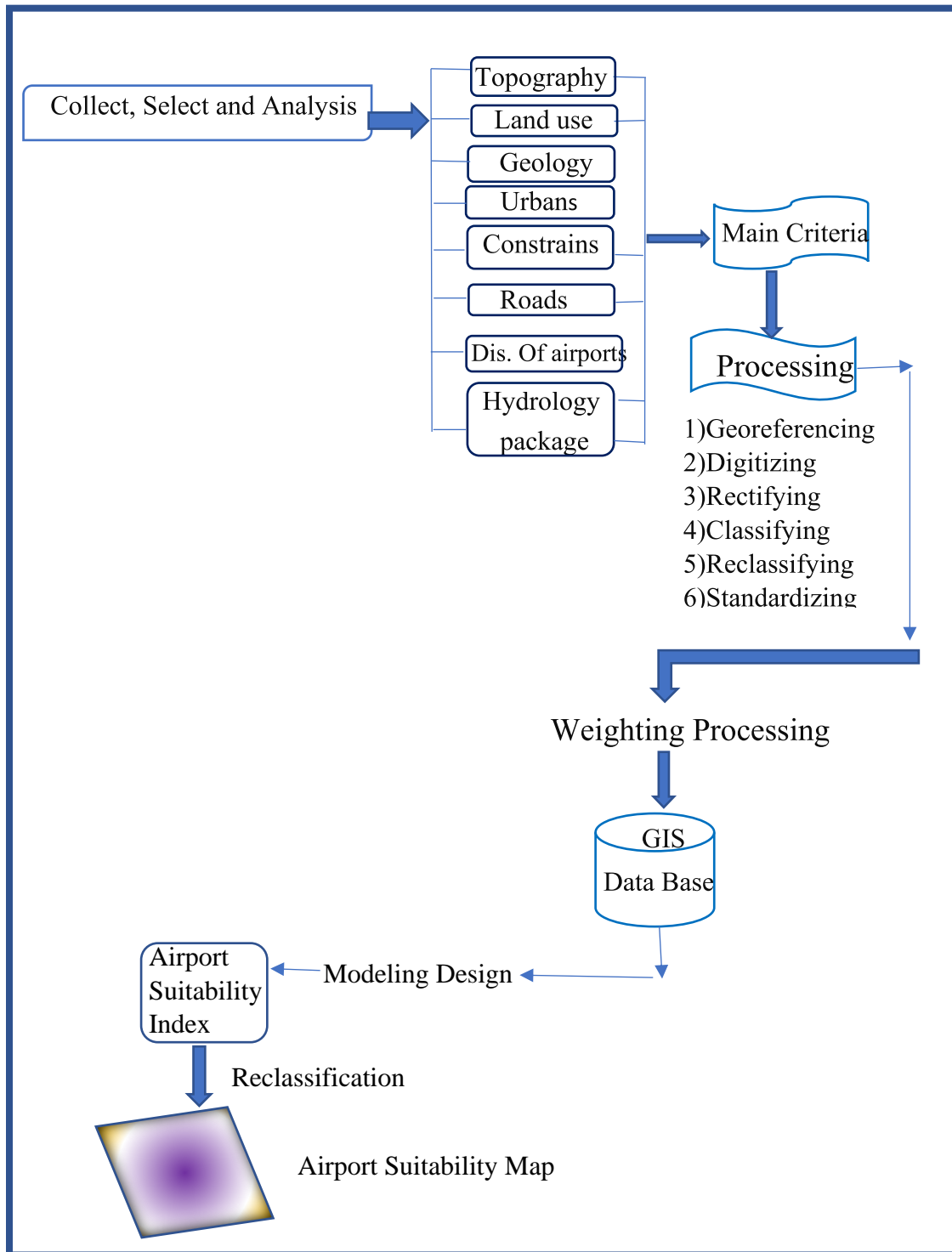
Collect, Select and Analysis

Topography
Land use
Geology
Urbans
Constrains
Roads
Dis. Of airports
Hydrology package

Main Criteria

Processing

1)Georeferencing
2)Digitizing
3)Rectifying
4)Classifying
5)Reclassifying
6)Standardizing

Weighting Processing

GIS Data Base

Airport Suitability Index

Modeling Design

Reclassification

Airport Suitability Map

Fig. (2): The flow chart of the methodology stages

5.1 Data Analysis

The suitability criteria were determined using global studies as well as the characteristics and environment of the location under investigation.

1. The first factor which effects on the choosing suitable site is the Elevation which has been exported from Digital Elevation Model SRTM DEM 30 m spatial resolution. This DEM is color coded relief map 1 arc sec after downloaded from US Geological Survey (USGS) obtaining DEM for Egypt start to make analysis to obtain maps for elevation and slope and make hydrological analysis. The hydrological analysis using DEM should be at the datum WGS84. figure (1)

2. The slope is an important criterion given the mountainous terrain consequently natural disasters such as landslide avalanches and rock-fall are more frequent in areas with steep slopes. furthermore, areas that are flat along steep slopes are also vulnerable to natural hazard. Identifies the slope (gradient or steepness) from each cell of a raster. The slope is generated from a topographic ratio, which represents the ratio of the elevation difference between two points divided by the horizontal straight distance between the two points. The slope is derived from the Digital Elevation Model (DEM), Then classify the map by higher degree and the steep slopes is less in degree class for this analysis slope with values 1 was considered unsuitable, slope with values 5 was considered suitable as shown figure (8) modifies or reclassifies the values in a raster

According to the slope classification, there are four slope percentage classifications. Table 1 shows the classification of slope in four zones. figure (9)

Table (1): Slope Classification

No.	Slope class	Weight
1	flat	10
2	undulating	7
3	rolling	5
4	mountainous	2

The available cartographic soil association map of Egypt was acquired from the soil survey institute at Wageningen [22]. By using ArcGIS tools to make georeferencing and digitizing to vectorized all the soil class areas. Only once suitability modelling is finished is the soil suitability criterion regarded a predictive prediction. Due to incompatibility of weight assignment for each soil class, the soil criterion is not included in the suitability analysis. figures (3) and (4)

3. Basic concepts in the Hydrological analysis

3.1 Hydrology is Filling Method Correcting the DEM, it is important that eventually sinks or pits are removed from the DEM to avoid discontinuities in the flow network. The sinks could be caused by errors in the sampling points, during the generation of the DEM (false sinks), or it could be naturally sinks in the terrain (true sinks) [17].

3.2 Flow Direction tool is Used for getting the flow direction of water ways, Creates a raster of flow direction from each cell to the neighbors with the steepest downslope. Then Each cell is given a raster of accumulated flow.[15]

Flow Accumulation produces a raster of cumulative flow to every cell, which is calculated by adding the weights of all cells that flowed into every other downward slope cell.

3.3 Stream Order gives a numeric ordering to segments of a raster depicting linear network branches in order to show the order of each of the segments in a network.

Locating wide network among basins demarcates the drainage basins within the study frame. The incoming flow direction raster is examined to identify all related cells in a same drainage basin. The drainage basins are made by recognizing the pouring points (where water would flow out of the raster) at the analysis window's boundaries, and also sinks, and then determining the contribution region just above pour point. As a result, a raster of drainage basins is created.

Assigns a number order to portions of a raster that represent linear network branches. The output of Stream Order will be of greater quality once the input stream raster and input flow direction raster are retrieved from the same surface [17]. If a stream raster is extracted from a dataset of rasterized streams, the output might not be accessible because the path may not correlate with the position of the stream cells on a cell-by-cell basis [6]. Finally, locates the largest streams by points. This criterion considering constrains, make buffer to a proper distance from the best location [17]. figure (4)

4. Making buffer around the existing airports in Egypt by distances (10 ,20,30,40 km) using ArcGIS tools. figure (6)

5. One of the most important factors that directly affect air navigation is the path of migratory birds because of its negative effects and risks on air navigation. The International Civil Aviation Organization specifies the specifications and requirements to be taken into account and has been issued in Annex 15. figure (7)

6. The constraints criteria will be used to reduce the limitation regions that are included in the model and are specified by particular attribute values. Costly areas, for example, should then be categorized as no data and eliminated from the suitability analysis. in addition to the nature reserves scattered in Bahariya Oasis, the Sinai Peninsula, Farafra, and Siwa. It was necessary to sit out industrial areas, new cities, tourism areas, the roads and railways such as the Al-Sokhna Al-Alamein railway, all water bodies and the agricultural expanded area as 1.5 million feddans located in the Western Desert that's due to Egypt's development vision figure (5).
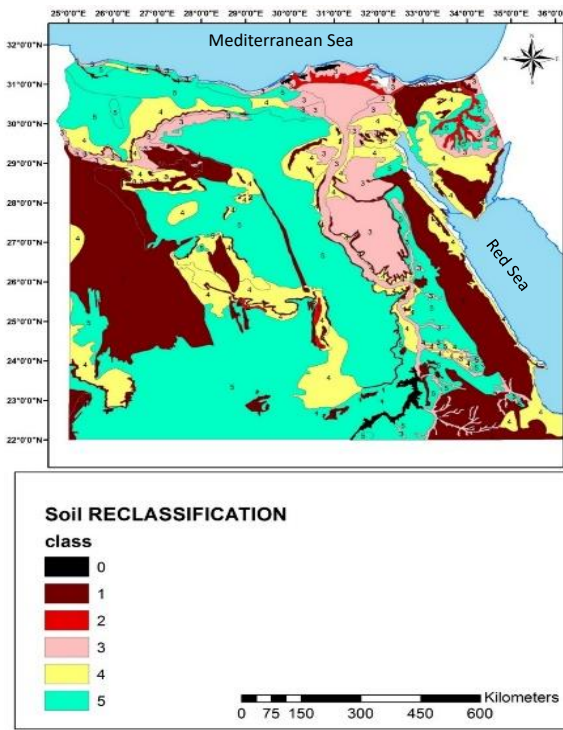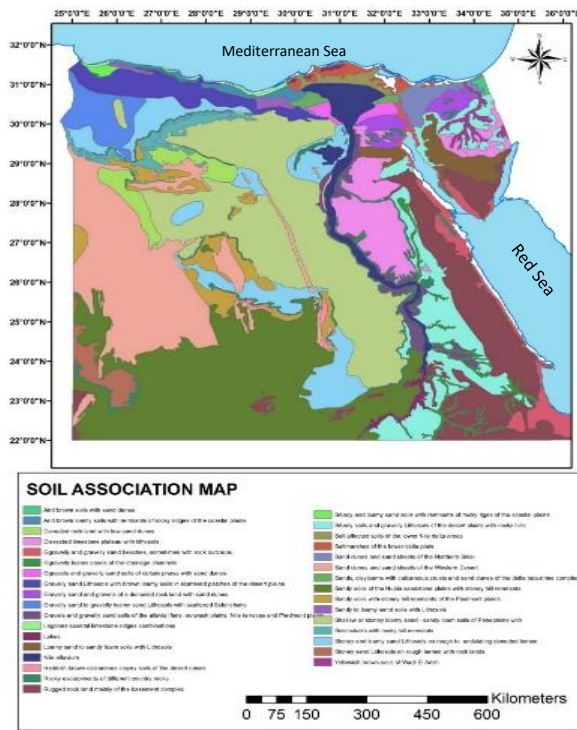
Fig (3): Soil association map after georeferencing and digitizing

Fig (4) : Soil association map after classification
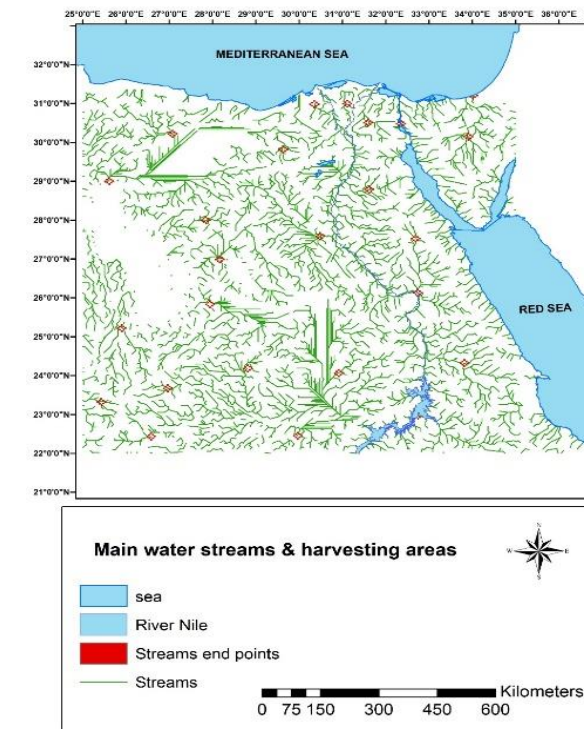

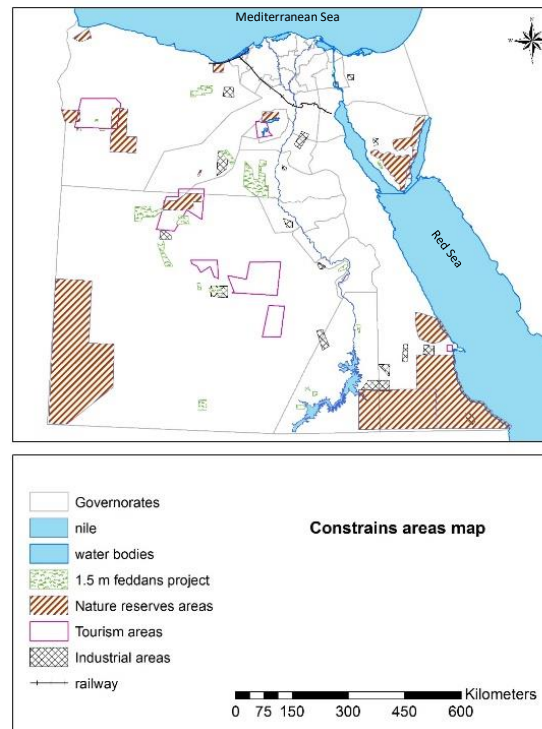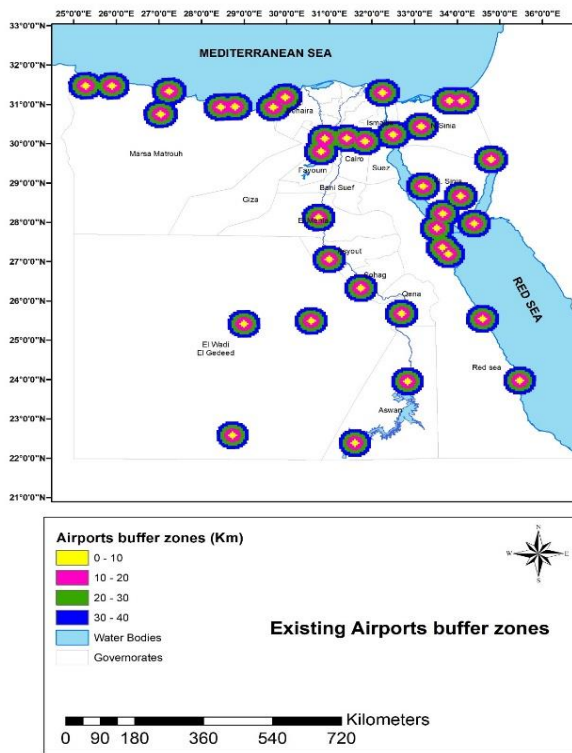Fig (5): Streams with harvesting Points

Fig (6): Constrains areas

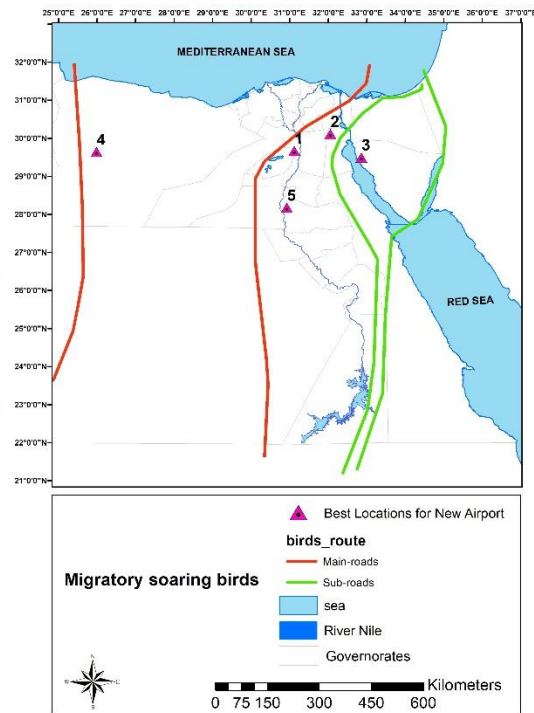Fig. (7): Airports after reclassification   Fig. (8): Migratory soaring birds

5.2 Obtaining, preparing, and verifying data

The worldwide installed Airports characteristics are utilized to assign each criterion a suitability factor for the Airports suitability criteria screening. Table 2 outlines the proposed appropriateness factors that were allocated to each criteria data type based on global studies and taking into account Egypt's unique environment and characteristics:

Table (2): Data from the airport's suitability model was used.

Criterion	Suitability factor	Data Used
Site Slopes Slope of ground surface (degree)	20	SRTM DEM 1 arc sec.
Distance from airports	20	Raster map (location for existing airports)
Weather conditional	15	Raster using hydrology analyst tools
Distance from national highways (km)	15	Roads Network Map
Distance to the national power grid(km)	15	Electricity Map of the Network
Soil Suitability	NA	Soil classification map
Usage of the land, urban area, reservoirs	NA	Urban characteristics shape files

5.3 Raster map classification and creation

The requirements to create the suitability model using the proposed methodology, each criterion's layers required to be converted to a raster data layer with the same cluster size as the srtm dem cluster (30 m x 30 m). ArcGIS spatial analysis tools was used to convert all vector layers to raster by assigning the criterion factor value as a buffer zone distance around the criterion feature. The buffer distances were classified with color-coded tone raster layer function on the proximity distance to the line feature shows the criteria proximity classification with color-coded raster maps for the elevation, geology, and proximity to electricity networks as an example for each model criteria.[21]

5.4 Suitability ranking and reclassification

After the data sets were turned to raster data layers, the reclassification tool was used to reclassify them. The suitability values ranged from extremely high to extremely low, and each raster cell's sum was calculated. The reclassification values varied from 1 to 10, with 10 representing the most ideal places for airports and 1 representing the least suitable. Locations that did not fit into one of the ten reclassified groups were reclassified as no data, as shown.

5.5 Assigning weights to criteria and processing

According to a questionnaire specialized in civil aviation, university professors and long experienced specialists in the field of civil aviation, the weights and priorities were determined and the special criteria for choosing the best locations for the airport listed in Table 3

Table (3): View survey results

criteria	Survey (1)	Survey (2)	Survey (3)	Survey (4)	Survey (5)	Survey (6)	Survey (7)	Survey (8)	Survey (9)	Survey (10)	mean
Site Slopes Slope of ground surface (degree	25	15	30	25	25	20	25	25	20	20	23
Distance from airports	20	30	25	20	20	25	25	10	15	15	20.5
Weather conditional	15	20	20	25	30	20	30	15	20	15	21
Distance from national highways (km)	10	5	5	10	10	15	5	15	15	15	10.5
Distance to the national power grid(km)	20	15	10	10	5	10	5	15	10	15	11.5
Development costs	10	15	10	10	10	10	10	20	20	20	13.5
											100

The relative significance of each criterion to other criteria is expressed via criterion weighting. The most important criterion was given more weight in the overall evaluation. To get the weights, just ask the decision-maker to assign values between 0 and 1 or 0 and 100 to each thematic data layer. Table 4 shows the criteria weights used in the ArcGIS math algebra tool for processing and appropriateness analysis.

5.6 Creating a map for best airport locations

The suitability model was designed using the weighted linear combination (WLC), which is a typical approach of suitability MCDM. The weighted average assignment is used in this method. The significance of the allotted each criterion's weight was multiplied by the scaled value given to that alternative on that criterion, followed by a summing of the data sets for all criteria to produce an evaluation score. This technique was chosen because it is simple to apply in a GIS utilizing map algebra operation and it is transparent in assisting decision-making. The raster calculation tool in ArcGIS software analyses the scores and runs the equations, then generates the final standardized new score raster based on equations (1)

Table (4): Criteria and weights that were used

| Criteria category	criterion	Criterion factor	Suitability Rank index	Suitability degree	Suitability weight
Technical	Site Slopes Slope of ground surface (degree	<2.8	10	High	30
		3-5	7	Medium	
		5-8	5	Low	
		>10	2	N.A	
	Distance from airports	<10	3	N.A	25
		20	6	Low	
		30	8	Medium	
		>40	10	High	
Economical and Environmental	Weather conditional	<2.5	3	N.A	15
		5	5	Low	
		7.5	7	Medium	
		>10	10	High	
	Distance from national highways (km)	10	10	Low	15
		20	5	Medium	
		30	3	High	
	Distance to the national power grid(km)	10	9	Low	15
		20	6	Medium	
		30	3	High	
	Development costs		N.A	N.A	N.A
Constrains	Land use, urban area, reservoirs		N.A	N.A	N.A
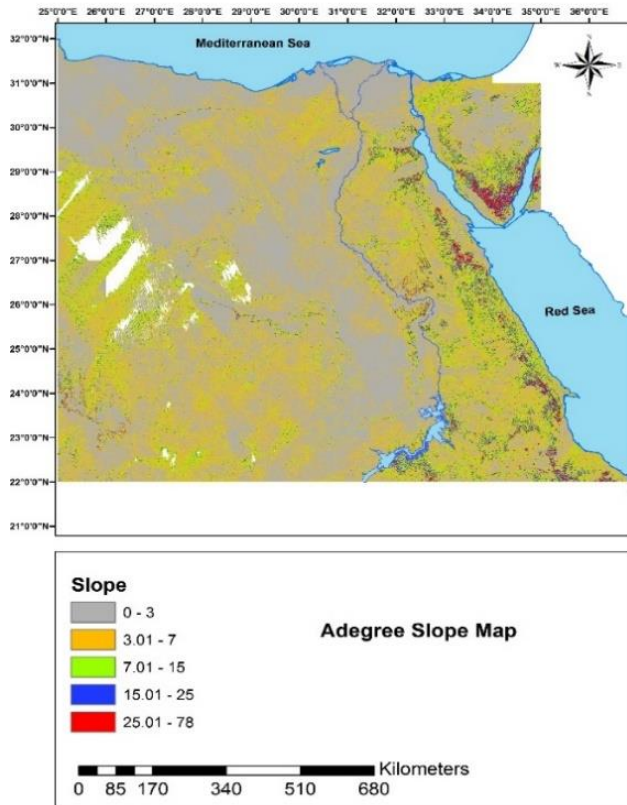
Fig. (9): A degree slope map for Egypt after categorized
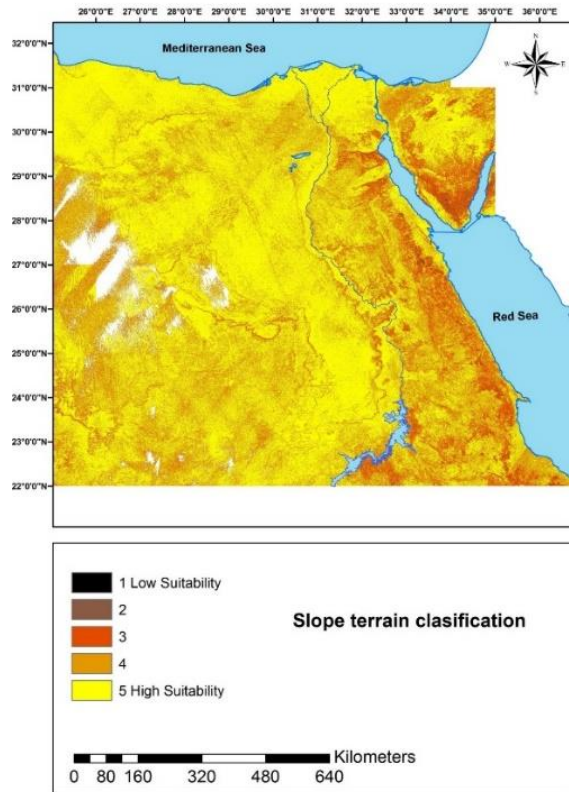

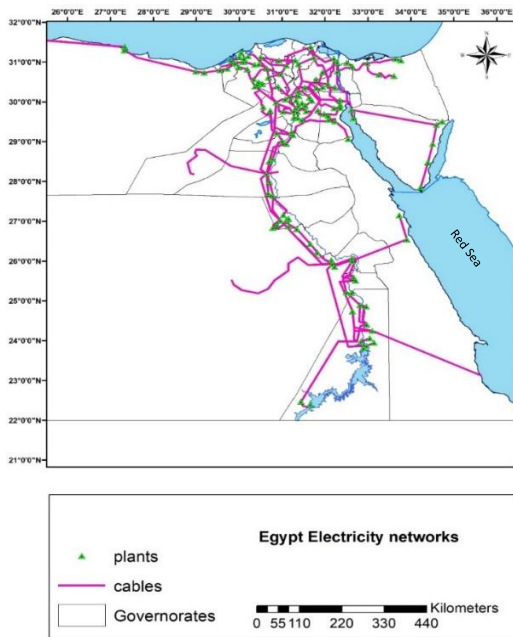Fig. (10): Slope map for Egypt after classification

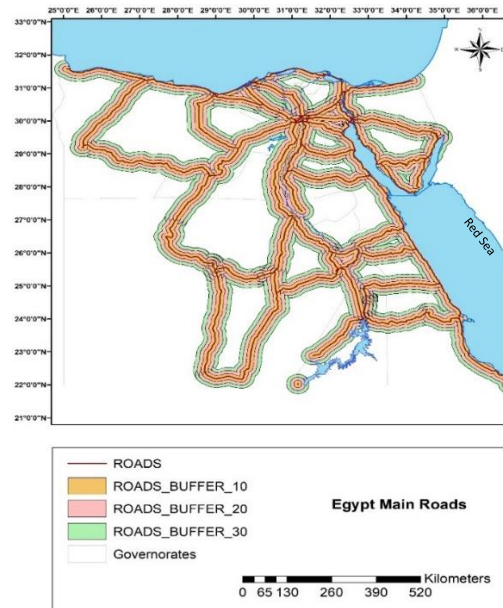Fig (11) : Egypt Roads networks map after georeferencing and digitizing

Fig (12): Egypt Roads networks map after georeferencing, digitizing and buffering

6.7   Raster calculator analysis

The results for optimum suitable sites to locate Suggested airports are a raster format map , it was developed with new suitability values indicated the suitability of each allocated criteria cells, shows a map of final airport suitability sites through Egypt. In the produced map the green area is the best location for the establishment of the airport, and the red one represents the excluded areas for the establishment of the airport. A three level of suitability was classified (high- medium – low suitability) and after analysis and studying the raster calculator map the results give five suitability sites as shown in figure (13)
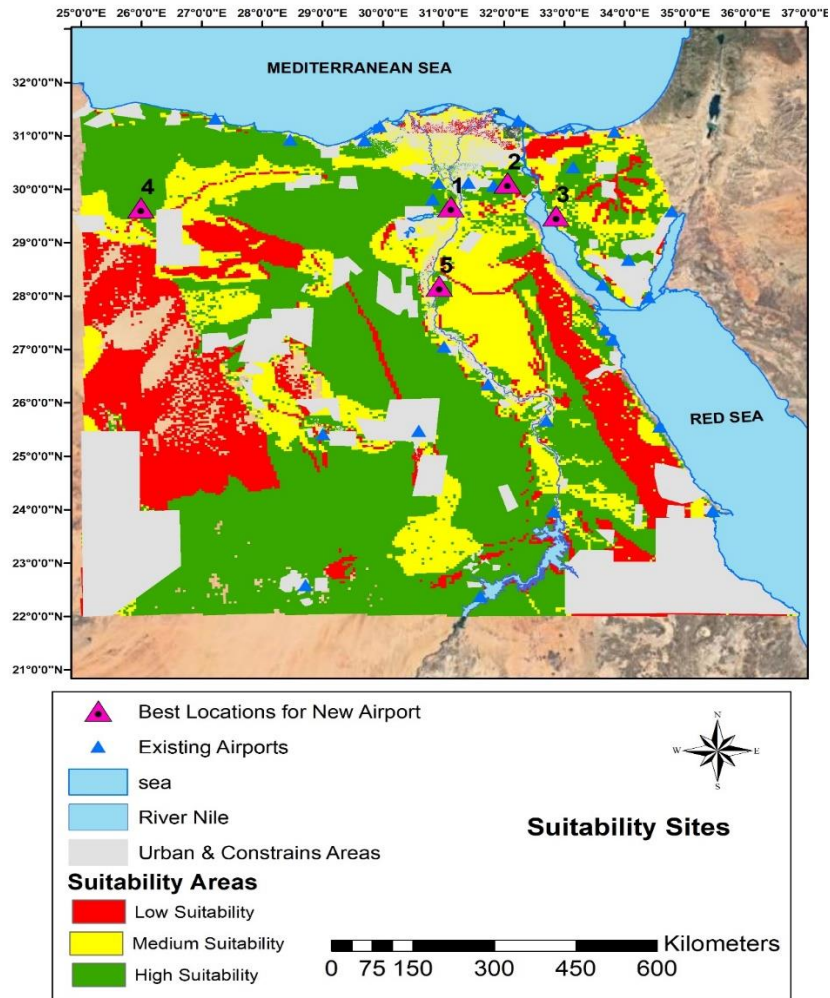

Fig (13): Egypt airports Suitability sites with the existing airports

This research is to choose the optimum locations for airports by applying the integration of Geographic Information System – Multi Criteria Decision (GIS-MCDA) as a weighting method. The criterion presented in this work were based on national and international norms linked to site selection, and they took into account environmental,

social, and economic factors. Data preparation, GIS analysis, and the decision-making procedure were among the methodology components.

The result of this study depends on the different types of data which were collected from different sources such as Digital Elevation Model (DEM), map of soil, Satellite Imagery (Landsat 7) and distance between existing airports …etc.

All the input layers were transformed to raster layers and reclassified to be entered into the weighted overlay to produce the suitability index map.

6. Results

In this study the results for the suitable sites to locate the proposed new locations, a raster map was created with a new suitable value that indicated the suitability of each allocated criteria cells. For all airports around the country, the new output suitability values used the same scale of suitability from 1 to 10, with 1 being the least suitable and 10 being the most suitable. A three-level of suitability was categorized (high-medium and low suitability) green areas were among the most suitable places to establish an airport (high suitability). It's obtained from processing five suitable candidate sites illustrate that the range of land suitability index for the intended study zone did not change, whereas some changes were visible in the number of pixels in certain locations. Airspace around an airport must be clear of an obstruction in order to protect the operation of the aircraft. The green areas show that it is the best for the establishment of the airport and for being non-residential areas or agricultural surface and with the regular slope, in addition to the distance is far from the mountainous areas to avoid wind shear. Following the calculations, and choosing the most optimal places to construct an airport therefore, the second step of the analysis is based on the non-geographic stage on a good engineering, technical and economic basis which is called site investigations. shown in figure (14).

Table (5) : Illustration and Description of the five suitability sites for Airports areas

	Description	Suitability Rank
1	It will serve Fayoum governate, it's far from 6 October airport about 52 km and far from Sphinx airport (West Cairo) about 70 km, it will serve about 15 million people.	7:9
2	It will serve the new Administrative Capital and the old and the new cities of Suez, it's far from Qatamia Airport about 35km.	8:10
3	It will serve El-Tor, Sant Catrein and Bardwell, it's far from AL-Tor airport about 122 km and far from Sant Catreen airport about 113 km and far from Bardweel airport about 135km.	7:9
4	It will serve Marsa Matrouh governate (Siwa city) far from Marsa Matrouh airport about 227km serves a population of about 33,000 people in Siwa	8:10
5	It will serve Al Minya governate, it's far from Asyut airport about 127km	7:9

The five-scenario selected by Multi Criteria Decision (GIS-MCDA)
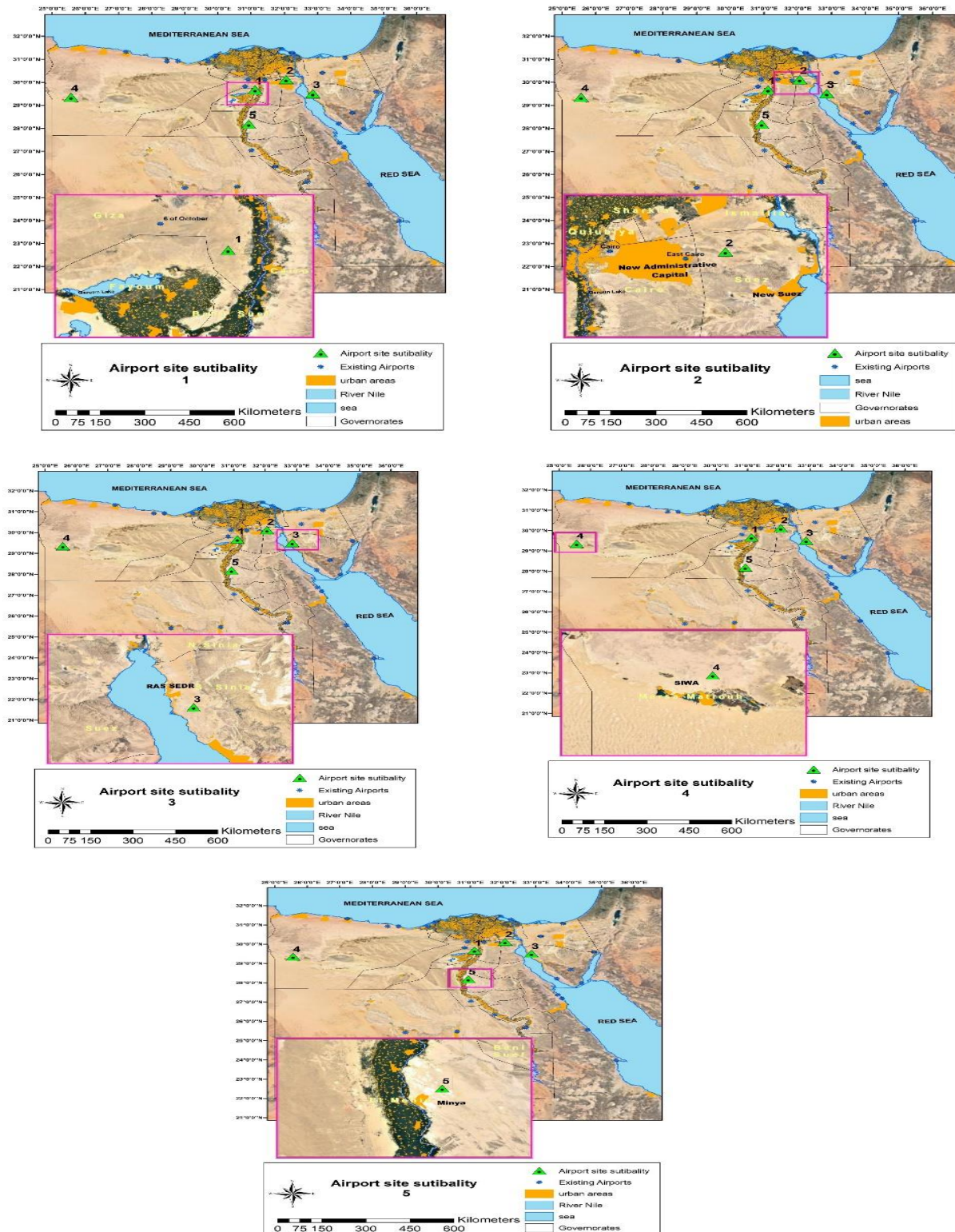

Fig. (14): The optimum sites selection

7. Conclusions and Recommendations

In Egypt, a multi-criteria evaluation technique was utilized to assist decision-makers in selecting viable airport sites. GIS allows for multi-criteria evaluation, which combines various sorts of criteria to arrive at the optimal decision. Using the multi-criteria evaluation, a difficult problem can be made easier to solve, and an ambiguous conclusion can become more accurate. WLC was used consistently in the multi-criteria evaluation in order to generate a suitability map. For the multi-criteria evaluation, many characteristics such as land cover, soil texture, and slope were considered. A 30-meter resolution LANDSAT satellite image was used to derive land cover. slopes map was produced from DEM, while the soil map was digitized from the soil map of Egypt's soil association map. Furthermore, the results of these criteria were reclassified into numerical values ranging from one to ten in order to provide a single scale for each layer with a resolution of 30 meters.

The study concludes several points, including: -

1- Using GIS and remote sensing technology, the optimum locations for the relevant maps were found to keep putting up the airport in Egypt.

2- As a case study, when selecting a location for the construction of an airport. The GIS was utilized in two ways. First, it was used to enter, store, organize, and analyze the data that was accessible. Second, the ability of GIS to analyze, visualize, and query data can be employed in the selection of sites required prior to a set of criteria.

3- The use of GIS to identify suitable sites for the establishment of the airport. Possible that provides us with the time and cost.

4- The multiple maps can be delivered from DEM like maps of elevation, slope, hydrology package .... etc.

This study recommends the construction of the airport in the places that have appeared in the green appropriate map for the best suite of the places where it's flat and with a little slope

The necessity of the use of GIS and remote sensing in field studies to provide databases include topographic characteristics, soil and land use, and updated on an ongoing basis, and the production of accurate maps according to the desired goal of the study.

1- The necessity of activating the role of GIS and remote sensing in the field of selection of appropriate sites, because this technology has a major role in facilitating the planning and selection of the best sites process, thus the selection of appropriate sites with a high degree of accuracy.

2- All urban areas are also considered exclusionary for obvious reasons.

3- An airport should ideally be located on relatively flat ground in general.

4- Houses can be purchased at fair market value, roads can be rerouted, can be moved, and none of these possibilities come without added cost.

Access to appropriate infrastructure to serve an airport must be considered. The proximity to infrastructure such as water Stay away from high trees for the forest because of their impact on increasing wind shear and then increase aerobic bumps.

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