Optimal Localization of Wind Turbines Using the Weighted Overlay Model by Application to the Red Sea Governorate by ArcMap 10.3 Program

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Abstract:
Egypt currently has a high reliance on wind energy, as it only accounts for 12% of the total 20% of electricity produced by renewable sources. Due to the availability of the necessary resources and sites to establish wind energy at Egypt's level, it is necessary to give wind energy priority and increase dependence on it. To do this, it is necessary to develop a model for determining the regions that are suitable for locating wind farms, taking into account a number of variables, in order to make effective use of this resource and use it as a guide when locating wind energy projects in Egypt in the future, which aims to reduce greenhouse gas emissions to address the issue of climate change and progressively wean the world off of reliance on conventional energy sources by reaching the proportion of the contribution of renewable energy to 42% of the total electrical energy Product in 2035 (Mariel, Meyerhoff , & Hess, 2014). Through a proposed form, the research will highlight the key factors to take into account when choosing wind turbine locations, and the GIS application will be used to create the form and eliminate any maps.

Keywords:
Renewable energy - Wind energy - Wind turbines localization - Red Sea Governorate - the Weighted Overlay model - GIS modeling.

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1. Introduction:
One of the most cheap and environmentally friendly forms of energy is wind power. Following nuclear power as the second-leading source of carbon dioxide emissions, analysis of the effects of Table 1 , revealed that wind plants had the lowest operating these plants, component manufacturing procedures, waste disposal, and the environmental impacts associated with the production of electricity for all sources of electricity production, as shown in levels of carbon dioxide emissions.

Table 1: Analysis of the environmental effects of producing electricity
Source: (International Energy Agency report, 2010)

Technology	Wind stations Carbon dioxide (t/mS) emissions	Life cycle effects (before and after production)			Effects of electricity production		
		Air	Water	Land	Air	Water	Land
coal-fired ultracritical steam cycle/ Ultra super critical plant	0.777	The following comparative reference technology					
natural gas cycle station	0.403	positive	positive	positive	positive	positive	positive
Nuclear power stations	0.005	positive	Variable /Unconfirmed	Variable /Unconfirmed	positive	Negative	positive
Thermal solar power stations	0.017	positive	positive	positive	positive	Negative	Limited
solar photovoltaic (PV) station	0.009	positive	positive	positive	positive	positive	Limited
Wind stations	0.002	positive	positive	positive	positive	positive	Variable /Unconfirmed

1- Factors for selecting areas for wind turbine settlement
In order to choose the optimal location for wind turbine localization, many factors affecting this decision will be analyzed and grouped into three groups, which are the main pillars of sustainable development - the economy, social and the environment. (Kazak, Hoof, & Szewranski, 2017)
Exploiting wind power requires occupying large tracts of land of about 2 km for each of 5:9 MW installed Compared to solar power, a 2 km area requires each of 40:50 MW installed But in Egypt the vast tracts are available and will not be considered a barrier.

1-1 Social factors for choosing the regions that are suitable for wind turbine settlement

includes the location of wind turbines and their direct or indirect effects on human life and human health (Crichton & J.Petrie, 2015) People living near the light of the year have problems caused by turbines**:**

The shadow flashes caused by rotor blades, sunlight reflections, and excessive noise distances between 400 and 800 meters have a very large effect on human health. A study of a population of a region located next to a wind turbine found that it negatively affected 52% of the population. For distances from 800 to 1600 meters, the impact was on 32% of the population. For distances ranging from 1600 to 3200 meters, adverse health effects were reported by only 4% of the respondents in the sample. (Hanning C, 2009) Therefore, from the previous analysis, the buffer zone between population and wind turbines must not be less than 500 m in populated areas.

1-2 Environmental factors for choosing suitable areas for wind turbine localization

1-2-1 Wind velocity: Wind potential is not only proportional to wind speed, but also to the wind speed cube, meaning that if the wind speed at one location is twice as fast at another, the underlying energy contained in the first site's wind will be eight times greater than that at the slower site. In general, wind speed should be at least 6.9 m/s at 80 m/s of the Earth's surface, so that generating energy from the wind is economically feasible, but power can be generated at speeds up to 3 m/s. (El-Ahmar, El-Sayed, & Hemeida, 2017)

Wind categories are determined according to three basic factors: average wind speed at site, maximum storm speed over 50 years, and standard deviation of air speed variation of a standard speed of 15 m/s measured at the elevation level of the spherical axis as shown in Table 2. (International Energy Agency Report, 2010)

Table 2: Summary of average and maximum speeds and perturbation ratios
Source: (International Energy Agency report, 2010)

WTG Class	I	II	III	IV
V_{ave} average wind speed at hub-height (m/s)	10.0	8.5	7.5	6.0
V_{50} extreme 50-year gust (m/s)	70	59.5	52.5	42.0
I_{15} characteristic turbulence Class A	18%			
I_{15} characteristic turbulence Class B	16%			

1-2-2 Air density: The cooler the site at temperatures, the more air density it has and the more energy contained in the wind.

1-2-3 Circular area (Feather turnover area): The air will pass through the turbine, i.e. the turbine area of the wind turbine, so it is important to increase turbine blades and thus increase turbine blades.

The capacity factor study is then analyzed, which is the proportion of actual electricity produced by a wind plant compared to what it would produce while operating at full capacity throughout the year to measure the efficiency of the plants where:

- If the wind speeds doubled, the energy content of the wind increases eight times.
- If the diameter of the turbine increases twice, the energy of the turbine is increased four times.
- If the turbine rises one meter, the energy produced is often increased by 1%.
- Each one is a square kilometer that can hold 5-9 megawatts of medium-capacity turbines**.**

Table 3: Highest capacity factor averages in Arab countries
Source: (International Energy Agency report, 2010)

The state	Algeria	Egypt	Iraq	Libya	Morocco	Oman	Saudi Arabia	Syria	Tunisia
Capacity factor**%**	20	34	20	22	31	28	20	20	20

1-2-4 Energy in wind: The amount of wind energy depends on air density, area and cube of wind velocity, where the average change in air density is calculated due to seasonal changes in air temperature over time**.** (Effat, 2017)

	(m/s)		(m2)	(kg/m2)		
Wind energy=	(**wind speed) 3**	*	(**area of the diameter** * **of the plumage**)	**(air density)**	*	**(1/2)**
	V3 instantaneous velocity, not average velocity		**A= π r2**	**ρ = p/(R*T)** p = Pressure (pa) R = gas constant (287 j/kgk) T = air temperature(K)		

Equation 1: calculate amount of electrical energy in the wind

Source: (International Energy Agency report, 2010)

1-2-5 Topography: At least 50 m as wind speed increases proportionally with the rising terrain.

1-2-6 Biodiversity: Away from the migration paths of birds.

1-2-7 Keep away from airports and air traffic systems: to avoid interference of waves.

1-2-8 Distance from ranges of reserves: and natural habitats.

1-2-9 Soil studies: distance from problem soils and areas of cultivation.

1-2-10 Distance from danger zones: active faults, natural hazards, moving sands, cliff areas, torrents and flood extent.

1-2-11 Wind trends: and their relation to the movement of sand dunes and their effect on the components of turbines.

1-2-12 Temperature: Wind turbines operate efficiently at 40 degrees Celsius according to international specifications.

1-2-13 Regression: Slope angles above 5° lead to turbulent wind patterns causing turbine instability. Additionally, building on higher slopes increases costs so regression angles will be classified into three categories of more favorable, less than 5° and appropriate from 5 to 15° and inappropriate for slopes greater than 15°**.**

1-3 Physical factors for choosing areas suitable for wind turbine localization

1-3-1 Road network and movement: The availability of a paved road network to support the development process as wind turbines require regular maintenance so there must be high communication and also for security reasons, as the distance between them and the main road is no more than 2500 m.

1-3-2 Availability/connectivity of the region to a supporting infrastructure network for this development.

1-3-3 Location of the area next to the coastal areas: It is considered one of the best sites due to the sea winds.

1-3-4 Impediments between turbines and wind direction: They reduce wind speed and efficiency of wind turbines and, by extension, energy production efficiency such as high buildings, forests and hills.....So every time the slope of the area is flat, the wind speed is higher, so you have to do a land-use survey in a range of at least 5 km around the wind turbine areas.

1-3-5 Zone Connection to the Unified Power Grid: To integrate wind turbines into the current power system means that the closest location to the current power transmission networks has obtained the maximum number of points, where significant losses of electricity occur in the event of increased power transmission distances through cables where it must not exceed 2000 m **.**(Tegou, Polatidis, & Haralambopoulos, 2010)

1-3-6 Distance from existing construction: a separation distance of at least 1500 m should be left to allow for future extension of construction**.**

1-4 Economic factors for choosing areas suitable for wind turbine settlement

Economic factors consist of those elements that directly affect returns on investment in this area and may be:

The natural conditions of a site that affect the volume of power produced, human elements, existing technical infrastructure or other development, wind conditions due to natural terrain, rising terrain and slope land, and the risk of investment in flood or landslide risk areas and in the proximity of power transmission grids as well as telecommunications networks (Y.Himri, S.Rehman, B.Draoui, & S.Himri, 2007).

Taking into account the ever-increasing climatic changes, one of the most common effects of climate change is floods, droughts and landslides, and for this reason maps of the extent of floods and the risk of landslides have been studied and analyzed for this region.

1-5 Excluded areas not suitable for wind turbine localization

An exclusion zone is an area which is not suitable for wind turbine settlement and where it is excluded to protect the effects on the environment, communities, and construction. These zones are summarized as follows:

- Areas having an altitude higher than 200 m above sea level.
- Hill and cliff areas more than 15% slope.
- Buffer zones 2.5 km from urban areas.
- buffer zones within one kilometer of a rural community.
- Buffer zones 2 km away from important places.
- 1.0km of safe zones around tourist

destinations.

- Safety zones 3 km from airports.
- 0.5km buffer zones around highways.
- Nature safety zones are within 200 meters of water bodies and major rivers.

(Bennui, Rattanamanee, Puetpaiboon, Phukpattaranont, & Chetpattananondh, 2007)

2- Wind turbine specifications used in the study

Turbine technology, which is the primary controller in the quantity of energy produced to improve the economics of wind projects, is the key component of wind farms or plants.

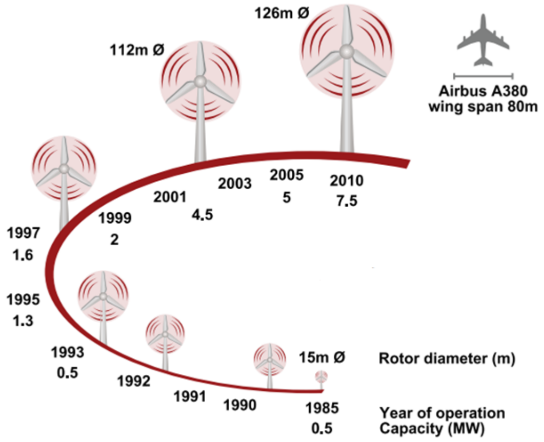

Figure 1: Evolution of turbine capabilities and diameters

Source: (International Energy Agency report, 2010)

One of the largest commercial wind turbines is the Enercon E-126, a German turbine that generates 6 megawatts of energy, can reach 7.5 megawatts, with a spinal center height of 135 m, with a feather spin diameter of 126 m and a maximum height of 198 m.

Any wind turbine may not benefit more than 59% of the energy available by wind. It may be reduced after taking into account the efficiency of the conversion of energy through the various components of the turbines. Turbines usually begin to produce electricity when the wind speed reaches 4 m/s and is called the entrance speed. (mahmoud, beda, & ashraf, 2012)

The average Egyptian household consumes 300 KW per month and, assuming 6.5 m/s wind speed, the 15 KW turbine meets its needs.

Turbines shall be placed in rows and shall be perpendicular to the prevailing wind direction for the majority of the time of the year. The distance between turbines shall be 3:5 times the diameter of the turbine and the distance between rows 7:10 times the diameter of the turbine, to give the wind a chance to compensate for the decrease in speed resulting from its collision with the turbines.

Table 4: Wind turbine types

Source: (International Energy Agency report, 2010)

Types	**Small wind turbines (micro turbines)**			**Large wind turbines**	
Electrical power	From 20:500 W Charging Recreational Boat and Car Batteries	From 1:10 KW Pump water	From 400:100 KW Home apps	Danish Concept Classic Turbines (with a traditional multi-stage gear box)	Gearless Turbines without a gear box

3- Suggested model

- Overlay Analysis is the process of combining data or information from multiple datasets to arrive at new information.
- Among the most powerful and commonly used tools in a geographic information system (GIS) is the overlay of cartographic information. In a GIS, an overlay is the process of taking two or more different thematic maps of the same area and placing them on top of one another to form a new map.
- Overlay Operations Several basic overlay processes are available in a GIS for vector datasets: point-in-polygon, polygon-on-point, line-on-line, line-in-polygon, polygon-on-line, and polygon-on-polygon one of the overlay dataset must always be a line or polygon layer, while the second may be point, line, or polygon the new layer produced following the overlay operation is termed the “output” layer.

3.1. The input dataset and the process:

- To model the spatial problem a schematic diagram was drawn for the study objective, the affecting parameters, the input datasets needed to reach the study goals and the process followed Figure 2.
- A number of processes were performed to prepare these layers for being used as an input in an overlay weighted model.
- As shown from Figure there are (11) elements have been selected to be thematic layers for the overlay weighted model analysis and Each element has some classifications and corresponding weight values which affect the model final decision.
- Remote sensing and (DEM) from (STRM) maps Digital images of (Landsat-8) satellite (LCO 8-L1TP-RT) sensor with a high resolution (1 Km) were used. These images were downloaded from the American Survey

website Data Interface (USGS) at the Global Land Cover Facility and imported to (ArcGIS10.3) Environment with correct georeference.

- To reclassify these maps the reclassify function was applied A value of 10 was assigned to the most suitable range and 1 to the least suitable range. All the layers should have the same range of classes (1 to 10).

- Weighted Indexing table.

Each raster is assigned a percentage influence according to its importance. The weight is a relative percentage, and the sum of the % influence weights must add up to 110 Each cell value is multiplied by their percentage influence then added to create the output raster A weighted indexing table has been adopted to suggest the ideal location as shown in Tables 5

Table 5: A weighted indexing table

layer		weight the importance of the study in relation to the model	weigh (as percent)
1	wind_speed_direction	9 out of 10	8%
2	urban_elements_development	6 out of 10	5%
3	solar_radiation	7 out of 10	6%
4	topograpic_categories	8 out of 10	7%
5	soil_types	5 out of 10	5%
6	vegitation_index	6 out of 10	5%
7	risk_basin-area	4 out of 10	4%
8	shadow_categories	4 out of 10	4%
9	earthquake_danger	3 out of 10	3%
1	slope_categories	7 out of 10	6%
11	energy_quantities	8 out of 10	7%
Total current status of studies		67	61%
Total Suitability Value		110	100%

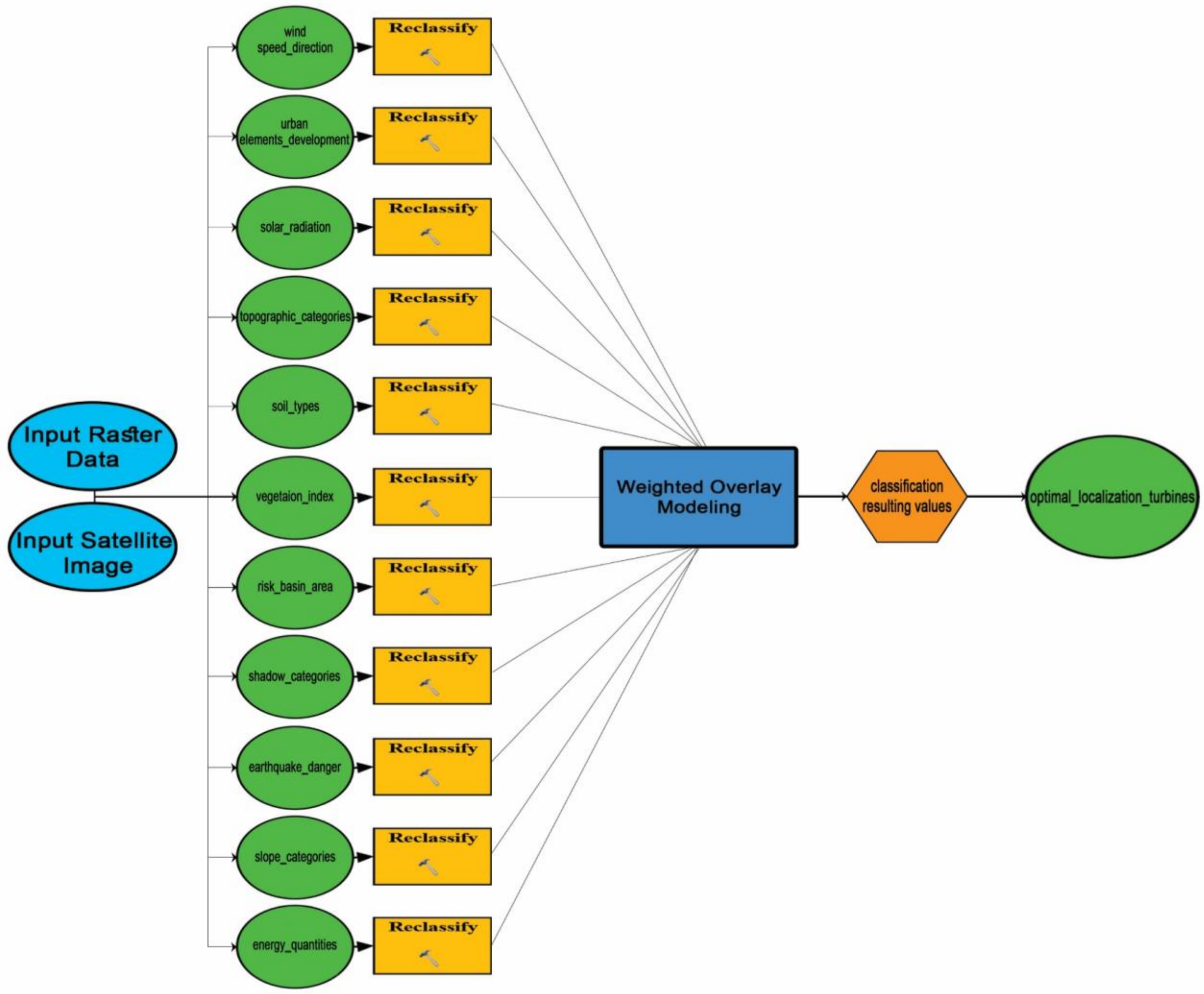

Figure 2: The model builder for determining the most suitable sites for building wind turbines within using (GIS), where the model was built by the program (ArcMap 10.3)

4- Application of the proposed model to the study area (Red Sea Governorate)

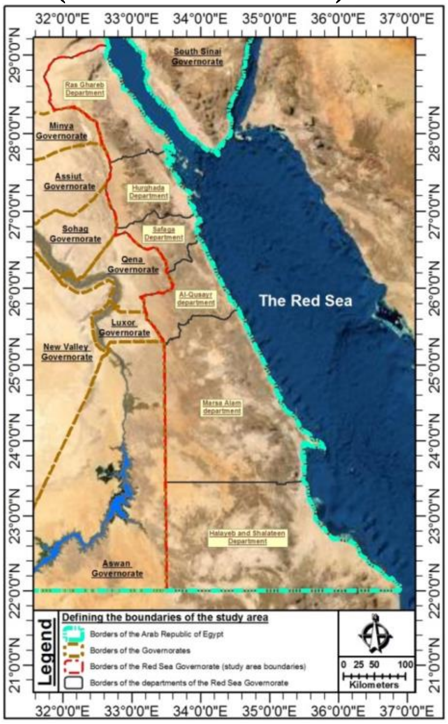

Figure 3: the study area

The Red Sea governorate is located in the region of South Upper Egypt and is bordered to the north by the governorate of Suez, to the south and east of the Red Sea, and to the west by the governorates of Assiut, Sohag, Qena, and to the south by the international borders with Sudan, Luxor and Aswan. The area of the governorate of the Red Sea is about 119,099 km2. The total population of the governorate is about 360,000 inhabitants in 2018**.**

The strip of coastline along the Red Sea is considered one of the best areas in the world suitable for wind power generation, as it is flat and narrow, which makes the wind blow to it strongly and regularly. According to studies, the expected energy to be generated by wind will reach 20,000 megawatts. This is one of the large projects proposed on the coastal strip to produce electricity from wind, especially in the areas of Al-Za'farana and Jabal Al-Zeit. Egypt is harvesting 554 megawatts of new and renewable energy from the giant wind farm in Al-Za'farana region, where one third of the output of the High Dam is produced.

More energy sources are yet to be tapped. The research, in response to the International Renewable Energy Agency's (IRENA) recommendations, will clarify reasons and possibilities to accelerate the adoption of clean energy, bringing renewable energy sources to 57% of the world's energy by 2030.

The spatial location of the (Red Sea Governorate) in relation to the Arab Republic of Egypt the area of study by Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community as shown in Figure 3: the study area.

The model was applied to the Red Sea Governorate to determine suitable sites for wind turbine farm settlement taking into account the different dimensions and elements of the model. The following studies and factors are included in the model to determine suitable sites for wind turbine localization**.**

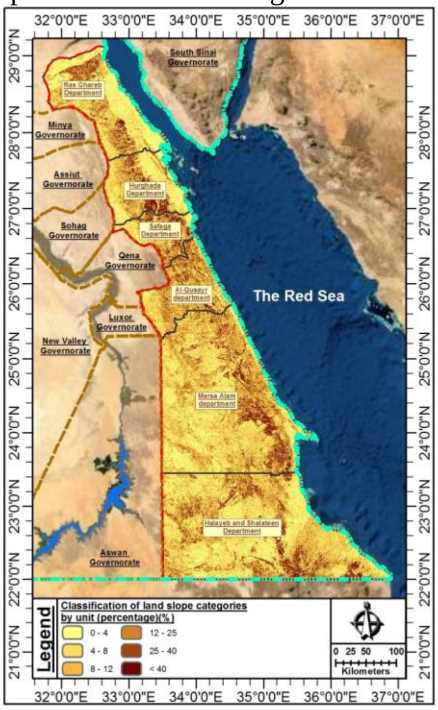

Figure 4: The slope map of the study area

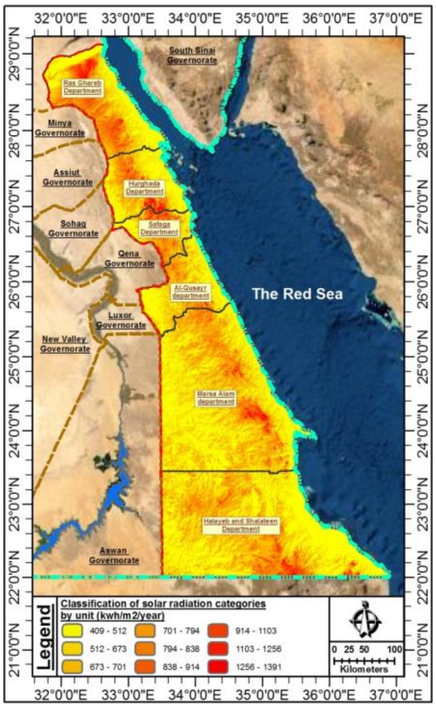

Figure 5: Solar radiation map

Citation: Donia Nahla (2023), Optimal Localization of Wind Turbines Using the Weighted Overlay Model by Application to the Red Sea Governorate by ArcMap 10.3 Program, International Design Journal, Vol. 13 No. 2, (March 2023) pp 119-130

Classification of **(**Red Sea Governorate**)** slope classes by satellite visual of the digital elevation model (dem)- from the site https://earthexplorer.usgs.gov with a tool (surface) in Arc tool box by (GiS) program.

As shown in Figure 4, the highest declination areas shown in brown are the Red Sea Mountain Ranges, where it is difficult to localize wind turbine areas, preferably the flat areas with a slope angle of less than 5°, the first class recommended in yellow.

Classification of solar radiation classes by site https://solargis.com/maps-and-gis-data/download/egypt by (KmL) boundaries of the study area (Red Sea Governorate).

Figure 5, shows the categories of solar radiation, as the location of the turbines must be in the areas with the lowest solar radiation, in order to keep the components of the turbines (turbine blades) from being damaged due to high temperature exposure**.**

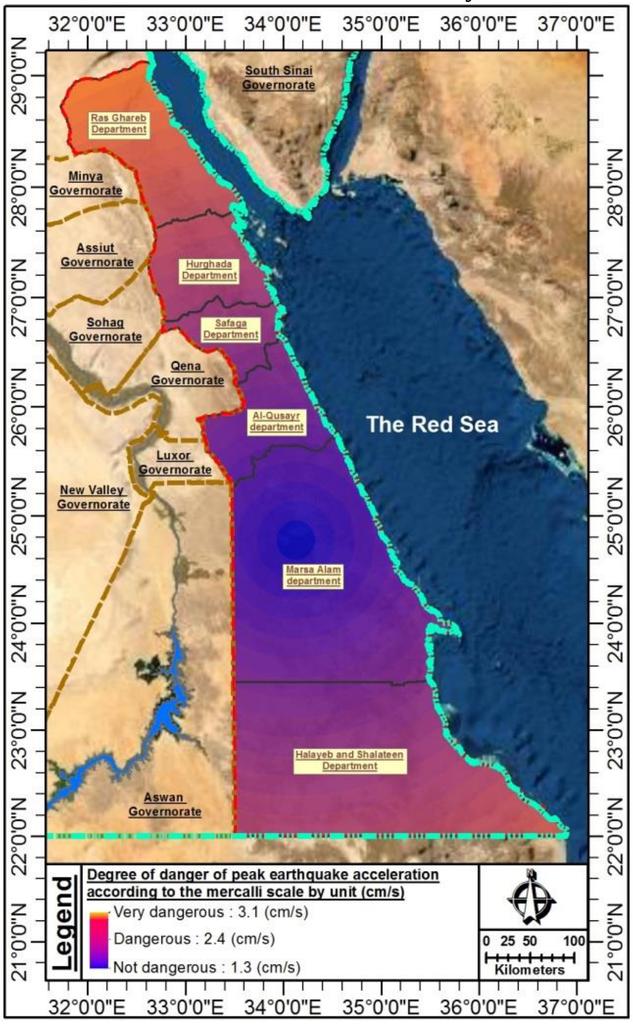

Figure 6: Map of peak earthquake acceleration

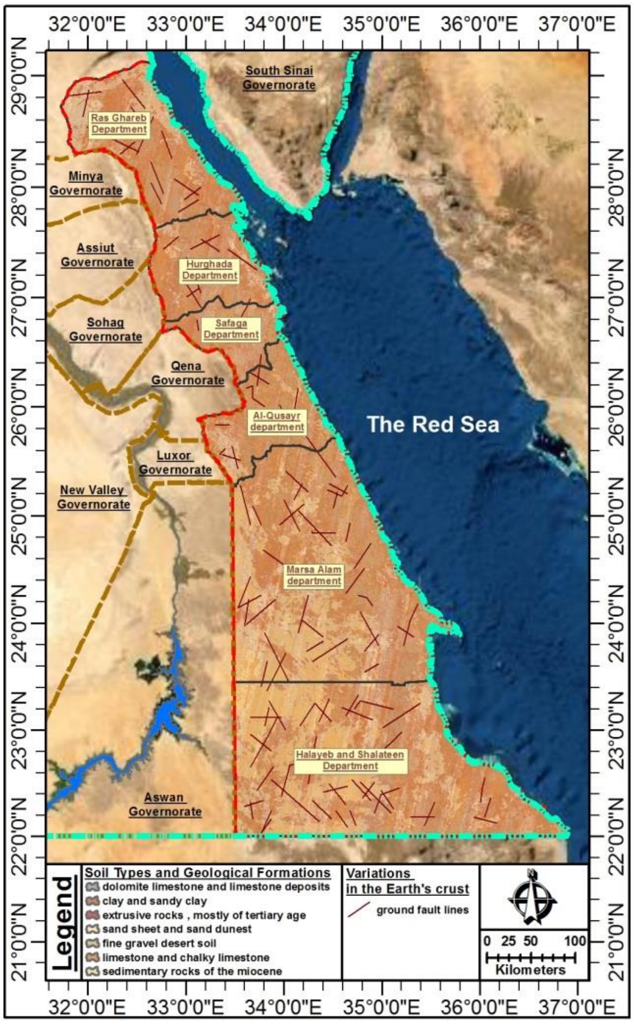

Figure 7: Soil map and geological formations and land faults

Analysis of the observed values from environmental monitoring stations, which were downloaded from the site http://www.sfu.ca/geog355fall02/ccheuka/data.html - showing the spatial distributions for the Peak earthquake values of the Earth's underground for (Red Sea Governorate) , It is classified according to the Mercalli scale in **(**cm/sec**)**.

Figure 6 illustrates the areas most at risk of earthquakes that it is best to steer clear of when wind turbines are localized to keep the turbines from whatever consequences could occur in the event of a severe earthquake and so that no significant economic loss occurs.

Selection of (17) different sites in the **(**Red Sea Governorate**)** for soil sampling sites for the ability to choose non-identical places by the difference in the digital elevation model using the (GiS) program through the variation in the satellite visual classifications.

Figure 7 illustrates the soil classification and significance of remoteness from problematic soil and weak soils that are not suitable for wind turbine localization and also for fracture zones that pose a threat if not taken into account.

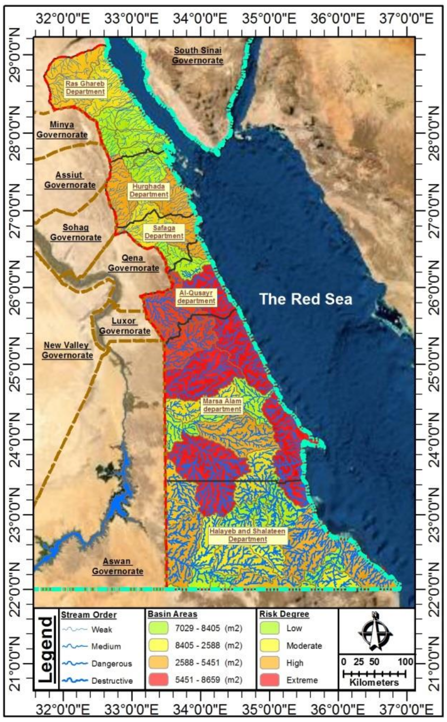

Figure 8: Map of the risks of floods and drainage basins

Streams of water torrents and drainage basins areas in the (Red Sea Governorate) by analyzes of the digital elevation model using the (GiS) program and the classification of streams degrees according to the method of the scientist, strahelr.

Figure 8 illustrates the classification of ranges at risk of flooding and flooding, where it is necessary to move away from threatened areas when wind turbines are localized so as not to cause economic loss.

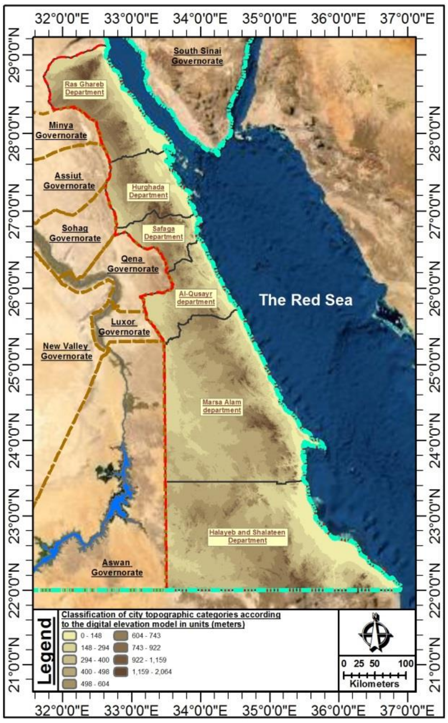

Figure 9: The topography map of the study area

Analyze and classify the values of the digital Digital elevation model - (dem) - from the site https://earthexplorer.usgs.gov - showing the spatial distributions for the topographic values of the Earth's surface for (Red Sea Governorate).

Figure 9 topography shows the Red Sea governorate with elevations ranging from 145 m to 2000 m above sea level but most of the area is considered low to medium altitude.

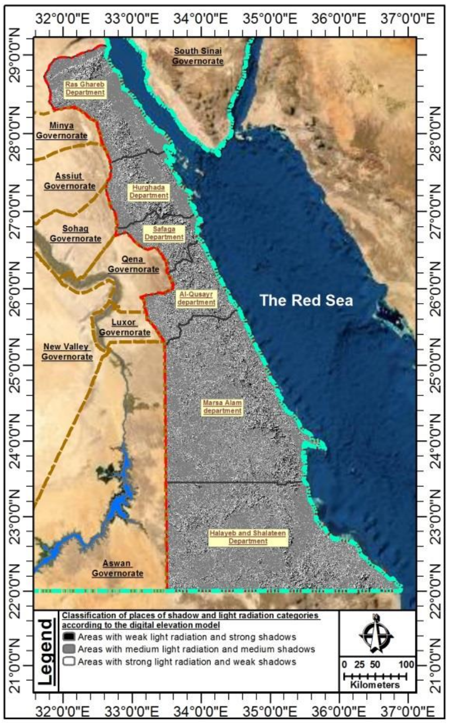

Figure 10: Map of the areas of shadows and light

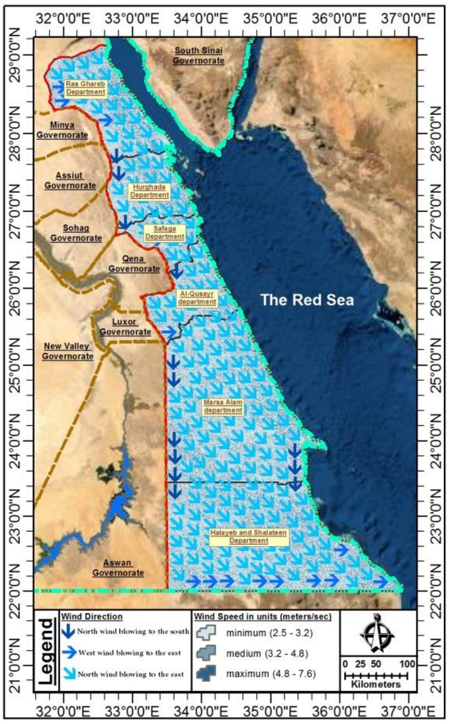

Figure 11: Wind direction and speed map

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Analyze and classify the values of the digital Digital elevation model - (dem) - from the site https://earthexplorer.usgs.gov - showing the spatial distributions for the hillshade values of the Earth's surface for (Red Sea Governorate).

Figure 10 shown the areas of shadows and light Shadows areas have the highest wind speed and are the best location for wind turbines, And areas of light are the best for tourist uses.

Analyze spatial data of the atmospheric environment and derive wind speed and direction in the study area, (Red Sea Governorate) from a site https://www.earthdata.nasa.gov/learn/find-data - Shows the spatial distributions of wind direction and shows wind speed in (meters/second).

Figure 11 shows the wind speed categories in the governorate ranging from 2.5 to 7.6 m/s. In addition, most of the wind trends in the governorate are southeastern from the Mediterranean Sea.

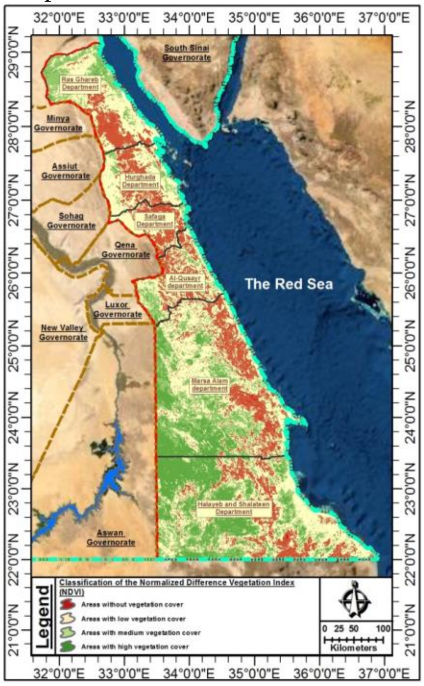

Figure 12 : Map of vegetation areas

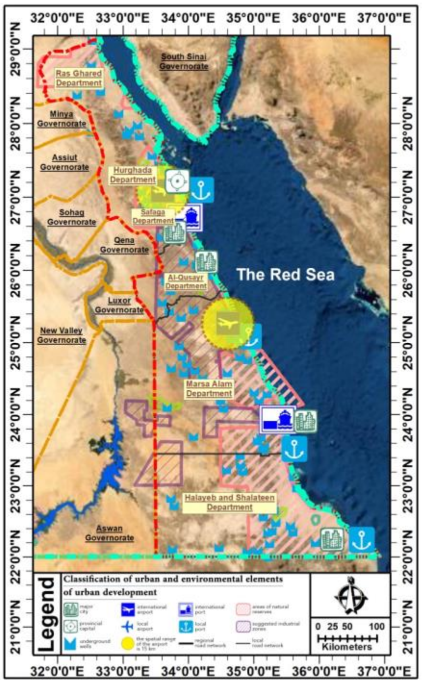

Figure 13 :Urban factors for selecting suitable areas for wind turbines

Classification of the Normalized Difference Vegetation Index (NDVI) by the Landsat satellite type (LCO 8-L1TP-RT) visual image gate of image for year (2022) , Bands of classification image in (GIS) are (R,G,B)-(5,4,3)- by image analysis options.

Figure 12 shows vegetation where wind turbines should not be localized to areas with high density of vegetation to preserve biodiversity and reduce negative impacts on the environment.

Analysis of the environmental and urban elements based on open source data from the site https://extract.bbbike.org/ by (KmL) boundaries of the study area (Red Sea Governorate) and data from environmental monitoring stations for the Red Sea Governorate , and work to sign the different spatial layers of the study area, including road networks, major cities, and proposed and current economic projects.

The physical factors in the model mentioned in the earlier paper are taken into account and are described in Figure 13 and include the locations of existing airports, ports, road network, and.....Etc., which affects the choice of wind turbine sites.

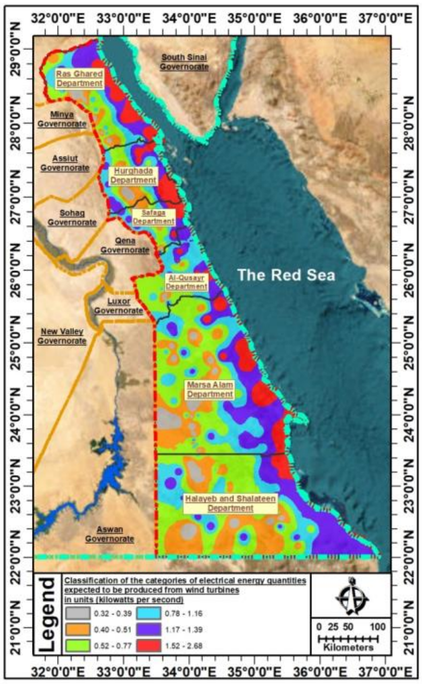

Figure 14: The amount of electrical energy expected to be produced

Calculate the amount of electrical energy expected to be produced according to equation 1 The amount of energy expected to be generated = distance of

rotation of wind turbine blade * air density * wind speed * numerical constant (0.5)
(2*3.14*40)*(1.25)*(2.5)*(0.5)=
392.5kg*m2/s2 = 0.39 kilowatt per seconds
(2*3.14*40)*(1.25)*(3.2)*(0.5)=
502.4kg*m2/s2 = 0.50 kilowatt per seconds
(2*3.14*40)*(1.94)*(3.2)*(0.5)=
779.7kg*m2/s2 = 0.77 kilowatt per seconds
(2*3.14*40)*(1.94)*(4.8)*(0.5)=
1169.5kg*m2/s2 = 1.16 kilowatt per seconds
(2*3.14*40)*(2.31)*(4.8)*(0.5)=
1392.6kg*m2/s2 = 1.39 kilowatt per seconds
(2*3.14*40)*(2.31)*(7.6)*(0.5)=
2205.03kg*m2/s2 = 2.68 kilowatt per seconds
By using the Algebra Map tool in ArcMap 10.3 According to the criteria (distance of rotation of wind turbine blades, atmospheric air density in the study area and wind speed rates) and transferring the output from kinetic energy (kg * m 2 / s2) and conversion in (joules) unit so that we can convert it into an amount of electrical energy in unit (kilowatts per second).

And as shown in Figure 14, the highest regions of the amount of energy generated by wind, without looking at the rest of the factors, are the regions of color in red, which are close to the Red Sea coast, and as we go deeper, the less energy we can expect.

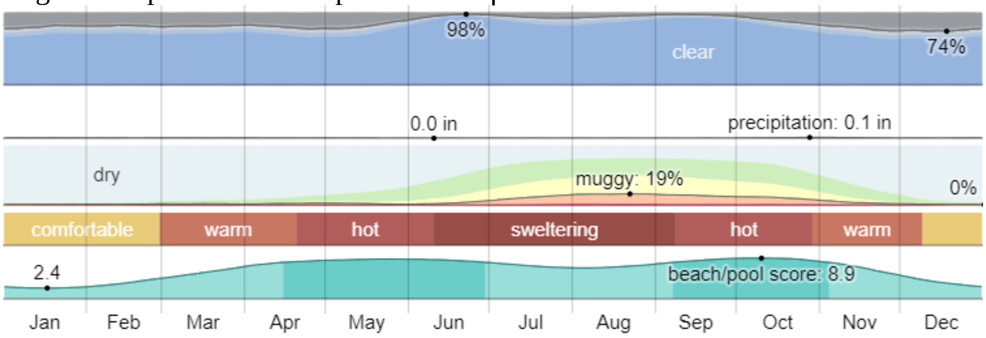

Figure 15: climate analysis in the study area

As shown in **Error! Reference source not found.** This section discusses the wide-area hourly average wind vector (speed and direction) at 10 meters above the ground. The wind experienced at any given location is highly dependent on local topography and other factors, and instantaneous wind speed and direction vary more widely than hourly averages, The average hourly wind speed in Hurghada experiences significant seasonal variation over the course of the year.

The windier part of the year lasts for 4.4 months, from May 23 to October 4, with average wind speeds of more than 5.9 meters per second. The windiest month of the year in Hurghada is September, with an average hourly wind speed of 6.5 meters per second.

The calmer time of year lasts for 7.6 months, from October 4 to May 23. The calmest month of the year in Hurghada is November, with an average hourly wind speed of 5.0 meters per second.

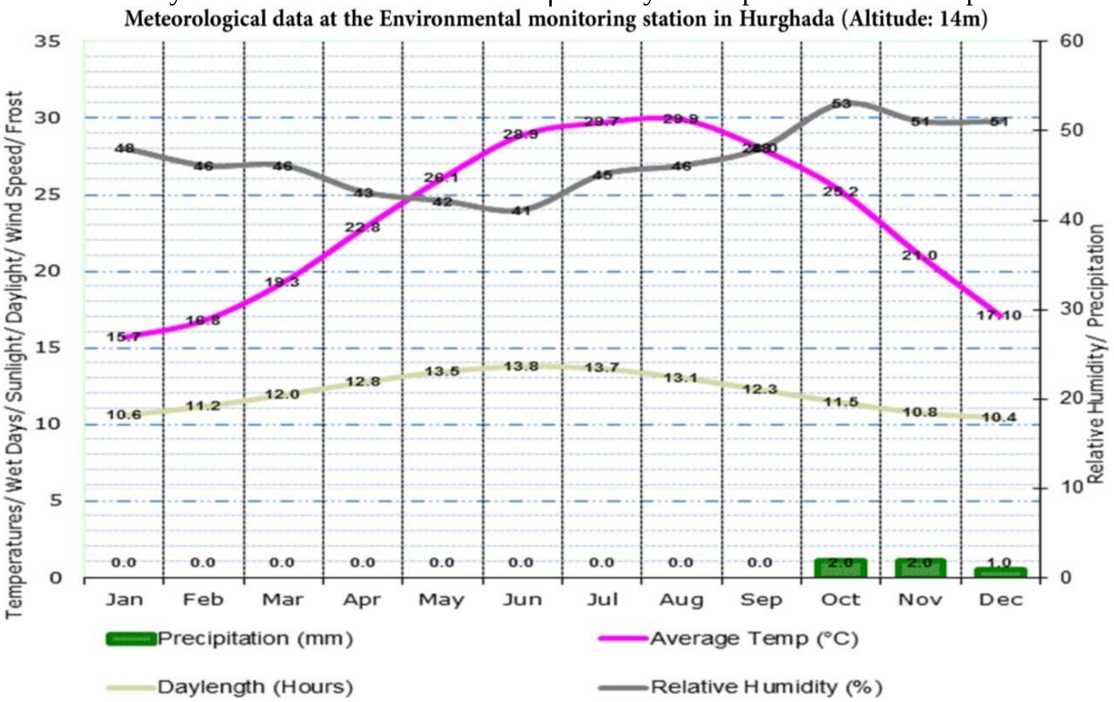

Figure 16: Compilation of atmospheric environment indicators

Citation: Donia Nahla (2023), Optimal Localization of Wind Turbines Using the Weighted Overlay Model by Application to the Red Sea Governorate by ArcMap 10.3 Program, International Design Journal, Vol. 13 No. 2, (March 2023) pp 119-130

As shown in Figure 16 Average Temperature in Hurghada, The hot season from May 26 to September 22, with an average daily high temperature above 33°C, The cool season from December 5 to March 9, with an average daily high temperature below 24°C.

And The muggier period of the year lasts for 4.6 months, from June 21 to November 9, during which time the comfort level is muggy, oppressive, or miserable at least 7% of the time. The month with the most muggy days in Hurghada is August, with 8.5 days that are muggy or worse.

The month with the fewest muggy days in Hurghada is January, with 0.2 days that are muggy or worse.

5- Final classification of ranges

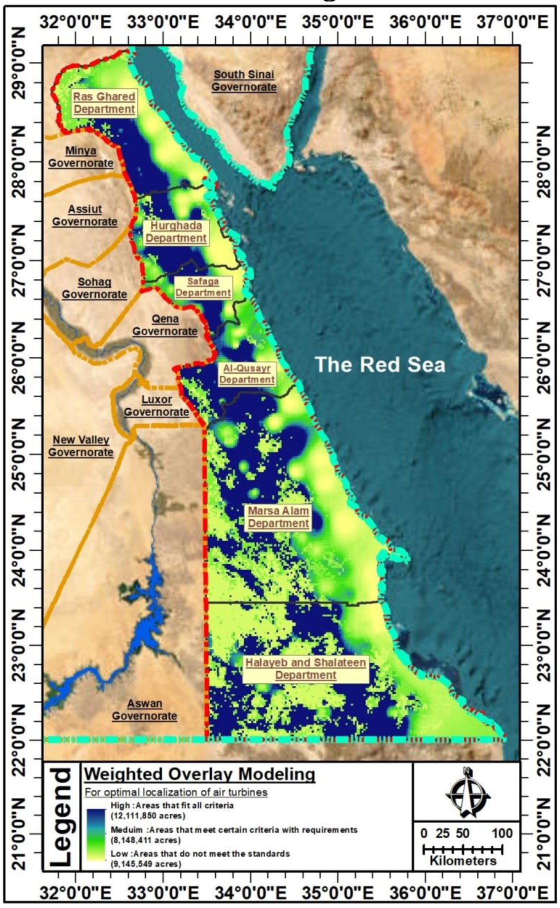

Figure 17 : overlay weighted modeling

All of the above factors (tendencies, topography, earthquakes, land cover, and......etc.) for the selection of the most suitable locations for wind power generation, which represent the highest stability for the project and the highest production of electric power according to the model used through the GIS program. We note that the highest areas as shown in Figure 17 are shown in blue and have an area of more than 12 million acres.

Conclusion:

Reliance on a new and renewable energy source is a very important factor in promoting the concept of sustainability in the management of the energy sector and the selection of suitable areas for the use of energy according to each type of energy. This is considered one of the most important factors for achieving environmental and economic efficiency, optimizing the use of the resource, and ensuring the least impact on urbanization, biodiversity, and human life.

The research discussed the optimal location factors for settling wind turbines to achieve the highest productivity, lowest impact on the environment, and highest economic efficiency through a model that was implemented through the GIS program on the Red Sea governorate, through which regions were classified into categories according to convenience for the localization of wind turbines.

In order to integrate all the factors, the fit analysis was used and included determining which range was the highest appropriate in each localization factor according to the predetermined targets.

The generated model is completely dynamic and this means that due to each factor weight change the model automatically reacts as it is not necessary to reconstruct the model gives GIS the ability to adjust factor weights at any time by simply changing their values while all calculations are performed automatically and a new result is presented to the user.

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