Wind Speeds Estimation on the Ground Level for Windmills Site Selection

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Abstract

In the last few years, the world toward attention to the renewable and clean energy sources in order to reduce the environmental pollutions and reduce the coast. Therefore, the windmills technology was essential in these applications. In this paper, the climatic data and geographic information system (GIS) facilities were used to study and produce the wind speed map on the ground level for Iraq country. Many Field data, (climatic monitoring) from the periods, (1953-1970) and (1971-2010) were collected and prepared. The data source was the Iraqi metrological department, this establishment operates and control wide climatic stations distributed around country. Many image processing and remote sensing techniques were used to present the results. The full Iraq photomap of Landsat TM (bands 1, 3, 5) with 28.5m in spatial resolution was used to overlay the results. The output of research was a photomap that locates the best sites for windmills .The locations have been selected through certain criteria. The results indicate that the Nasrya, Basrah, Nukhaib, Alhai and Hadeetha are promising places for establishing wind turbine due to the best wind velocities values.

Keyword: windmill, wind speed, site selection.

تخمين سرعة الرياح بالمستوى الأرضي لاختيار مواقع طواحين الهواء

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الخلاصة

توجهت أنظار العالم في السنوات القليلة الماضية نحو إيجاد مصادر جديدة للطاقات المتجددة والنظيفة وذلك للتقليل من آثار التلوث البيئي. لذلك فان استخدام تقنيات طواحين الهواء تعتبر أساسية في مثل هذا النوع من التطبيقات. في هذا البحث، فان البيانات المناخية وإمكانيات نظم المعلومات الجغرافية قد استخدمت لغرض دراسة وإنتاج الخارطة الصورية للرياح بالمستوى الارضي في العراق. تم جمع بيانات مناخية حقلية للفترات الزمنية (1953–1970) و (1971– 2010) والتي تم إعادة تصنيفها وتحضيرها. ان مصدر البيانات المستحصلة هو مديرية الأنواء الجوية العراقية، ان هذه المؤسسة تشغل وتدير مجموعة واسعة من المحطات المناخية موزعة على مساحة البلد. تم استخدام عدة طرق صورية وتقنيات الاستشعار عن بعد لغرض إخراج النتائج. تم استخدام صورة فضائية من القمر الصناعي لاندسات بدقة 28.5م. ان ناتج البحث هو خارطة صورية تظهر توزيع الرياح وتحدد أفضل المناطق لإنشاء الطواحين الهوائية. لقد أظهرت النتائج ان الناصرية، البصرة، النخيب، الحي، وحديثة هي مناطق واعدة لإنشاء الطواحين الهوائية نسبة الى السرعة المطلوبة للرياح.

Introduction

The electricity is generated mostly from oil and fossil fuels. A public policy of extending electrification to more segments of society as well as rising demand from industry has whittled down the traditional excess supply.

The clean energy race is on. The investment and finance that countries are jockeying for a leadership position in this growing and increasingly competitive sector. Countries with clear, consistent and constructive clean energy policies are powering investment forward.

Clean energy investment levels increased rapidly in the last few years, and wind energy remains the leading recipient of clean energy investments **[1]**. In 2010, $ 95 billion was invested by Group of Twenty members (G-20) in the wind sector as shown in figure 1.

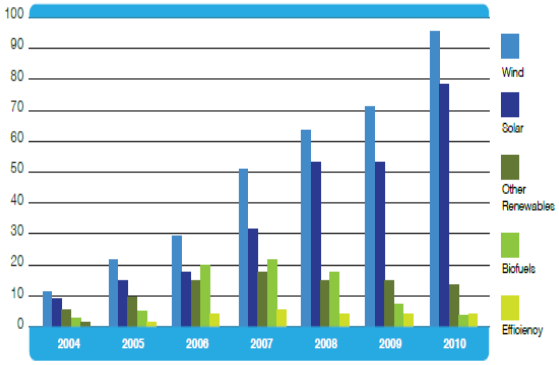

Figure 1- G-20 Investment by Technology 2004-10 (Billions Of $)

Today, one of the main problems that the societies are facing is energy generation and sustainable utilization. Most of the energy resources currently relied on are finite and will be depleted because of the increasing demand. In addition, there have been serious local air, water, and soil pollution problems as a result of the consumption of various energy resources. It has become clear that continuing to use fossil fuels is not wise not only due to the global impacts on climate system, but also due to both short-term and very long-term impacts on society and the ecosystem (Elliott, 2007) **[2]**. While consumption of fossil fuels are increasing regardless of their adverse impacts on the environment; today, world's agenda focuses on sustainable energy systems in terms of both reliability for economic development and benefits for the environment. According to Tester et al. (2005) **[3]**, the definition of sustainable energy is the combination of providing energy equally to all people and protecting the environment for next generations.

This paper introduces a geographic information system (GIS) model that serves as the first step toward the development of an integrated decision support system for studying the impact of investments in renewable energy in Iraq region, See figure 2.

Applying the study to the Iraq region, in particular, allows for the precise discovery of resources based on constraints appropriate within the bounds of this particular region. This allows for the development of wind and solar farm locations in this region to be a priority of the model, regardless of whether or not higher quality, or lower cost, resources are available in other regions.

The Benefits of GIS for impact assessments

- GIS is a useful tool to convey and present information by overlaying geographically referenced data.
- GIS can provide a composite picture of the receiving environment (including sensitive areas, resources, pressures, etc **[4]**.
- GIS can be used to store and display the environmental baseline data for SEA.
- GIS can be used to sample, analyze, store and visually present indicators **[5]**.
- GIS can map the cumulative impacts **[4]**.
- Alternatives can be modeled with GIS.
- GIS can identify spatial indicators that will facilitate the monitoring of mitigation measures and SEA results **[6]**.
- A database of baseline information can be used in future decision-making processes

Studied area

Iraq lies between latitudes 29° and 38° N, and longitudes 39° and 49° E (a small area lies west of 39°). The top photomap has the top at 37°22'17'' N, left at 38°48'33''E, right at 48°36'15''E and bottom at 29°06'10''N. Spanning 438,317 km^2, it is the 58th-largest country in the world, as shown in figure 2. Iraq mainly consists of desert but near the two major rivers (Euphrates and Tigris) are fertile alluvial plains. The north of the country is mostly composed of mountains; the highest point being at 3,611 m . Iraq has a small coastline measuring 58 km along the Arab Gulf

The local climate is mostly semi arid, with mild to cool winters and dry, hot, cloudless summers. The northern mountainous regions have cold winters with occasional heavy snows, sometimes causing extensive flooding.

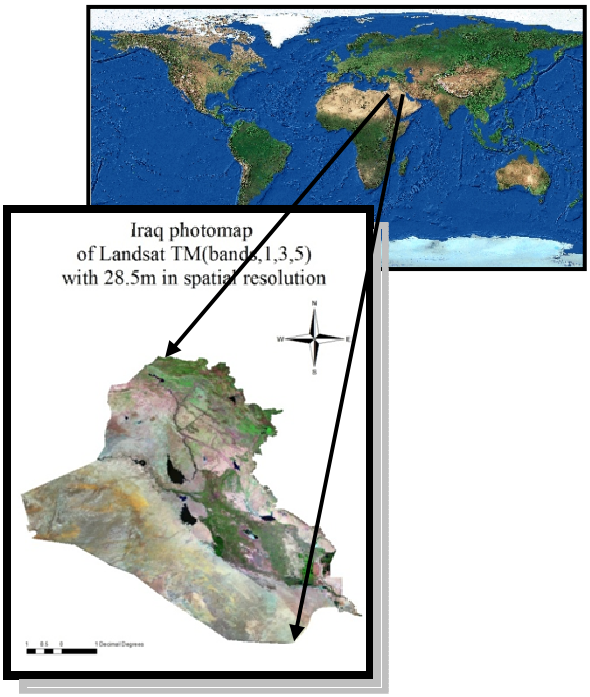

Figure 2- The Studied Area Iraq

Methodology

The main goal of this research is to estimate the locations that have the required element (wind speed) to establish a wind turbine, either farm or local single turbine. ArcGIS is the tool that satisfies the need to finish the research, because of the ability of displaying the attribute data on the geographic map with the ability of calculate and interpolate the data all over the entire map.

The first step in our work is preparing the satellite image for Iraq. TM Landsat scene with 28.5m spatial resolution was prepared for the studied area. The second step establishes a shapefile to determine the border of the Iraq region and administrative border of the provinces. Third step attach metrological stations on the map. Since meteorological conditions vary from year to year, average wind speeds for the periods (1953-1970) and (1971-2010) were collected. The mean wind speed for the two periods is attached to the layer of Iraq. We create a new layer established from the estimation of wind speed all over the area by using inverse distance weight (IDW) interpolation. The output layer is classified with respect to the value of wind speed. The output layer was converted to vector then the areas for each class were calculated.

arcGIS from ESRI was used to issuance the output of this paper. The software arcMAP was mainly used to complete this research. IDW interpolation method was chosen to establish the wind map because of the lower root mean square error (RMSE) comparing with the other interpolations methods included with arcGIS software. Contour and Geostatistical analysis was applied for calculating the estimated wind speed classes areas.

Results

Figure 3 shows the locations of the available metrological stations, the distribution of the stations over the selected area (Iraq) is a good symmetry. The wind speed for these stations was collected for two periods, old (1953-1970) and new (1971-2010). The average wind speed was calculated for the two periods, the result shows in figures 4 & 5 as a bar height refers to the places that have good wind speed as average. he difference between figures 4 & 5 are appeared mostly in the north stations, but the distribution of the wind speed is almost the same over all the country.

The distribution of metrological stations over the selected area is well distributed. Interpolation methods are different in applications because of the theory of each. The results of Inverse Distance Weight (IDW) method are more accurate for our data **[7]**. From the result of interpolated data we can estimate the wind speed in every point on the selected area.

The annual mean wind speed for each station is calculated to configure the best areas to study. These locations are at naserya, Alhai and basrah and in the west Iraq at nukhaib and Hadeetha. They have highest wind speed in the studied area, as shown in figure 6.

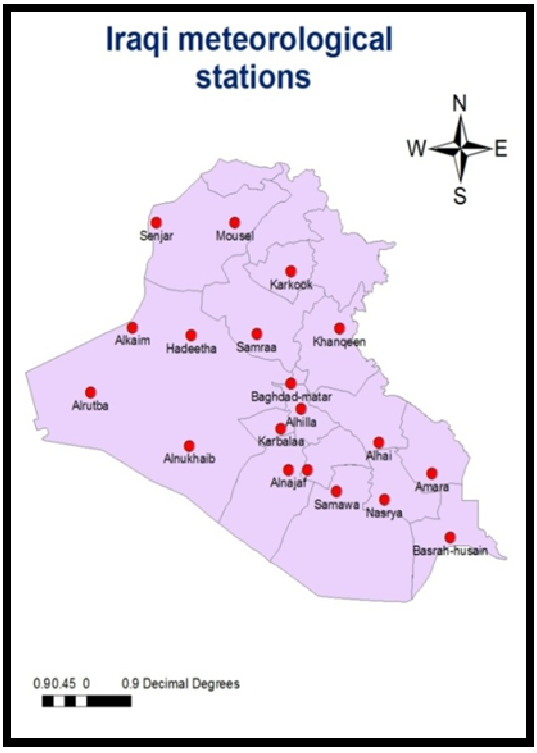

Figure 3- Metrological Stations Locations

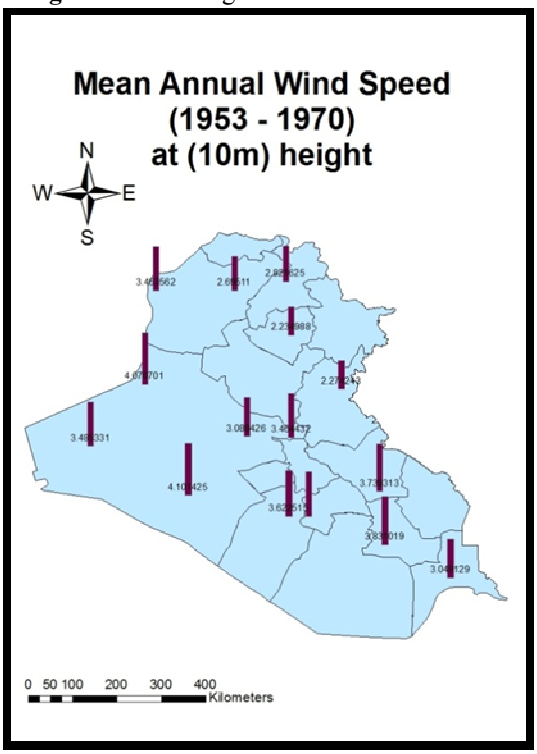

Figure 4- Average Wind Speeds For Period (1953-1970).

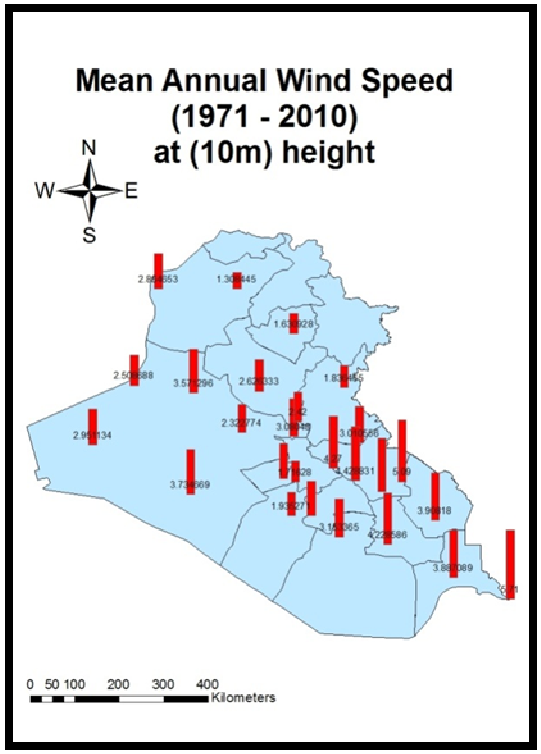

Figure 5- Average Wind Speeds For Period (1971-2010).

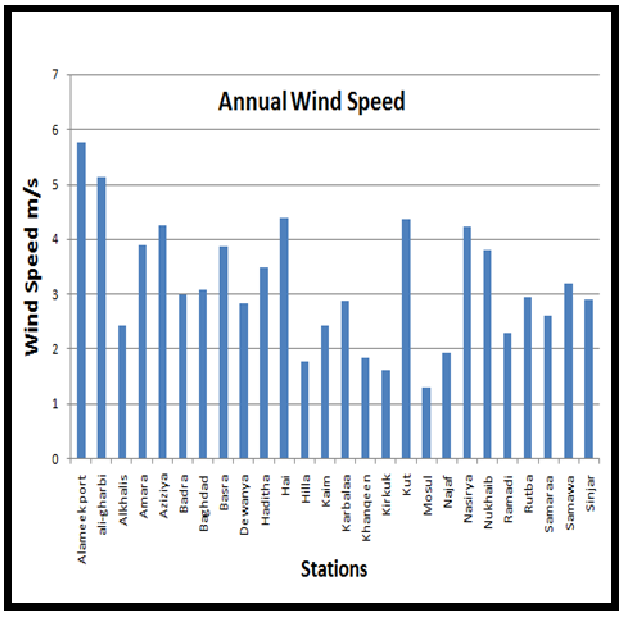

Figure 6- Annual Mean Wind Speed Data.

The surface layout of the wind speed is established in figure 7. Classified color is showing the areas that have the proper wind speed, to locate a good place for the windmills farms.

As shown in figure 7, a suitable average wind speed is shown in south Iraq at naserya, Alhai and basrah and in west Iraq (at nukhaib and Hadeetha). These places have promising characteristic of wind speed magnitude.

Geostatistical analysis method was applied to the output map i.e., the estimated wind speed map produced by IDW interpolation. The figure 8 shows classified map produced by applying Geostatistical analysis method to make the map Calculable for the spatial parameters. Area for each class are calculated and set as percentage from the entire area of the country. Table (1) shows the result of Geostatistical calculation. Figure 9 shows the contour for the estimated wind speed presented by IDW interpolation.

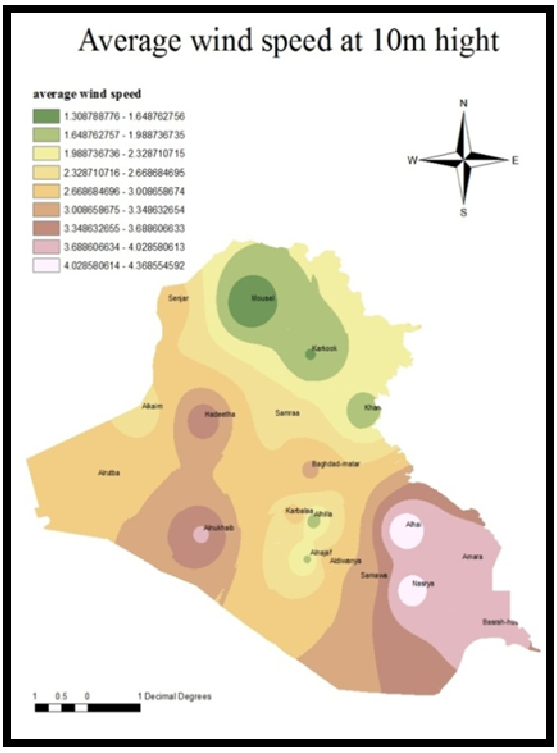

Figure 7- The Estimated Wind Speed By IDW Interpolation

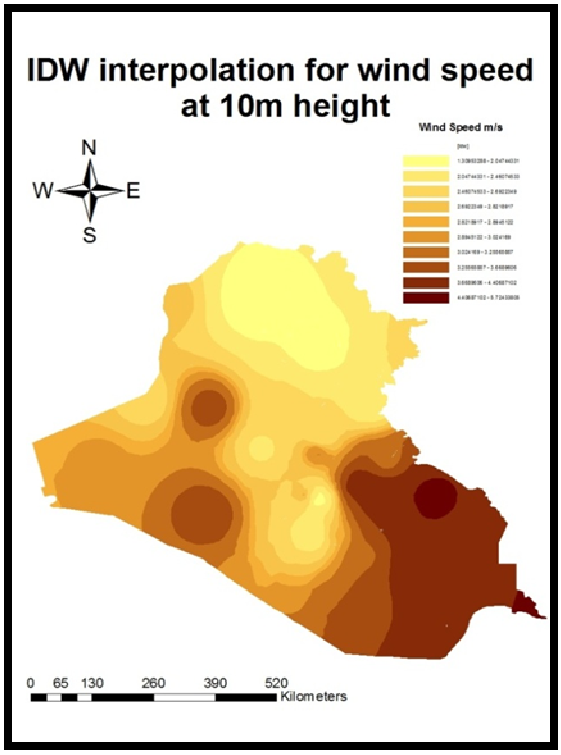

Figure 8- Geostatistical Analysis Results For IDW Interpolation

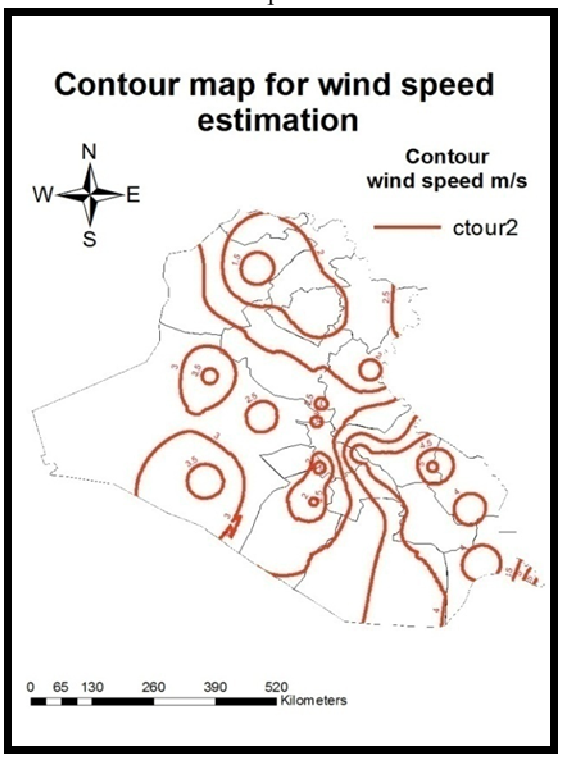

Figure 9- Contour Map For Estimated Wind Speed

Table 1- The Percentage Calculated Area For Each Class

class	Wind speed Value_Min m/s	Wind speed Value_Max m/s	area m^2	percentage of the total area
1	1.309533	2.047443	41800000000	9.608819885
2	2.047443	2.460745	52900000000	12.1604443
3	2.460745	2.692235	57300000000	13.17189903
4	2.692235	2.821892	36300000000	8.344501479
5	2.821892	2.894512	24700000000	5.677939023
6	2.894512	3.024169	55300000000	12.71214688
7	3.024169	3.255659	40800000000	9.378943811
8	3.255659	3.668961	42200000000	9.700770315
9	3.668961	4.406871	76500000000	17.58551965
10	4.406871	5.724338	7217182108	1.659057487

Conclusion

In the studied area (Iraq region) there are a promising locations to establish windmill farms depending on the appearance of windy climate in many places. The locations were selected through certain criteria. The suitable areas for generating power through winds are shown in class 9&10 in table 1. Class 10 is more sufficient but most of these area is laying in a narrow place (south of Basrah near Albaker port), while class 9 have less wind speed but its areas laying in an open areas (Nasrya, Alhai, Nukhaib, Haditha and north of Basrah).

Class 7&8 could be used as second choice for windmills, but still these areas could generate power from wind. The areas in these classes had less economic efficient with respect to classes 9&10.

The Nasrya, Alhai, Basrah, Nukhaib and Hadeetha were promising places for establishing wind turbine due to the best wind velocities.

Acknowledgments

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