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Multi-Criteria Analysis of Wind Power Station Distribution Along the Red Sea Coast of the Kingdom of Saudi Arabia Using GIS (1985-2017)

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Abstract: The strategic placement of wind power stations is scientifically critical for exploiting their full capacity. This research aims to compare the spatial characteristics of wind speed across four city sites at the Red Sea coast in Saudi Arabia. These cities are Al-Wajh, Yanbu, Jeddah and Jazan, all of which have operational wind power stations that serve as our case study. Data from 1985 to 2017 were analysed, focusing on diurnal and seasonal mean values of average wind speed, maxi-mum wind speed and prevailing wind direction. These data were sourced from meteorological sta-tions located in the aforementioned cities. We employed geographical information systems tech-niques to evaluate and suggest optimal locations for potential wind power stations. These tools were integrated with statistical methods to analyse the climatic data, which further served the objectives of the study. The database for this study was built upon 14 layers, each layer determining which areas were suitable or unsuitable for wind power station placement. Amongst the examined cities, Jeddah had the largest suitable area, measuring approximately 13826.8 km^2. Conversely, Jizan had the smallest suitable area, spanning just approximately 738.7 km^2

Keywords: Wind power station; Multi-criteria Decision; GIS; Kingdom of Saudi Arabia; Red Sea.

1. Introduction

As traditional energy sources are projected to deplete in the coming decades, the world has begun to explore clean, alternative power sources (Yuksel & Kaygusuz, 2011). Renewable energy sources are not cause physical pollution where it is cleaner, efficient and ecologically friendly such as hydro, solar, and wind ((Shrestha, et al., 2022, Baban and Parry, 2001). Renewable energy technology is varied and diverse that makes it suitable for islands, villages and urban areas. Furthermore, they are abundant in nature and do not jeopardize any natural resource wind energy, known for its affordability, abundance and environmental friendliness, is emerging as a significant supplier of power both now and in the future (Mohammedi, et al., 2017). However, the fitful nature of wind power production presents a challenge (Villacreses et al, 2017).

Several countries, including China and the USA, have already turned to wind power as a primary alternative to traditional energy. These two nations accounted for more than 60% of the new wind power capacity generated in 2019 (GWEC, 2019). In addition, wind power usage has increased in the European countries (Borawski, et al., 2020) and in Asia (IRENA, 2019, Tahir, et al., 2021).

Multi-criteria decision-making methods (MCDM), when combined with geograph-ical information systems (GIS) methods, can effectively select suitable sites and estimate energy potentials. MCDM method is widely used as decision making process, where it provides a framework for assessing land suitability for specific developments and produces suitability maps through spatial modelling (Effat & El-Zeiny, 2022).

The Kingdom of Saudi Arabia has been actively exploring renewable energy sources, such as solar and wind power, for optical use. Wind energy, in particular, has received con-siderable attention owing to its competitiveness compared to other renewable energy sources due to its abundant availability (Ansari et al., 1986; Rehman et al., 1994; Alawaji, 1996, Al-Abbadi, et al., 1997, Rehman S, 2003, Al-Abbadi, 2005). However, they are en-countering significant challenges that are impeding progress.

The western coast of Saudi Arabia, with its diverse natural reliefs and climate fea-tures, is a promising site for urban, economic, and tourist development. The constant on-shore and offshore winds significantly influence the weather, climate conditions, and so-cial and economic activities in these regions. The coastal relief's gentle slope towards the sea enhances the speed and power of coastal winds, making them ideal for generating elec-trical and mechanical energy and establishing wind power plants.

This paper aims to pinpoint the optimal location for wind power stations along the Red Sea coast in the Kingdom of Saudi Arabia. Harnessing the power of wind through the wind power stations demand significant initial investment. However, the carefully selected location of wind farm is pivotal in ensuring its economic viability. Wind energy is an al-ternative clean resource and environmentally friendly that could achieve the goal of the Saudi government to generate 50% of energy from renewable sources by 2030(Vision 2030, 2024), that may help decision maker to select an optimal site to build wind farm.

It uses GIS and the MCDM method to develop a decision support model in four ma-jor cities: Wajh, Yanbu, Jeddah and Jazan. Owing to their geographical location, enclosed between the sea in the west and elevated land in the east, these areas experience alternating onshore and offshore winds. This alternation results in varying wind trends, speeds, power, temperature, and humidity, creating diverse ecological and climatic effects. Such wind en-ergy also has a significant impact on all social and economic activities practiced by the local population where it may reduce urban migration, and it can play a role in reducing poverty in the region

2. Literature Review

Wind power stations were studied and designed to reduce the impact of greenhouse gases. Saudi Arabia generates the majority of its power from fossil fuels (oil and natural gas). However, Saudi Arabia is making rapid progress in developing renewable energy, and its goal is to reach 50% of renewable energy generated from wind energy by 2030 (Vision 2030, 2023).

Dumat Al-Jandal Wind Farm in northwest Saudi Arabia in the Al Jouf Region, is a 415 MW onshore wind farm that will become the largest wind farm in the Middle East re-gion by 2030 (Marouani et al. 2023).

Wind power stations in Saudi Arabia were discussed in many papers using different methods, such as Rehamn et al. (2003), which studied wind power potential at 20 locations in the Kingdom of Saudi Arabia. Wind duration curves were developed to calculate the cost per kWh of electricity generated from three chosen wind machines.

Shaahid et al., 2014, analysed long-term wind speed data to study the economic fea-sibility of developing a wind power plant at Taif, Western Province of the Kingdom of Saudi Arabia. The results indicated that wind electric conversion systems will not produce energy for about 46% of the year.

Baseer et al. (2017) investigated the best wind energy farm sites in Saudi Arabia us-ing GIS-based MCDM analysis based on different criteria like climatic, economic, aesthet-ic, and environmental. The most suitable sites are in the Eastern Province near Ras Tanura, Turaif in Al-Jawf region at the northern borders, and Al-Wajh in the western region.

Rehman, et al. (2020a) used a spatial interpolation technique to build an accurate wind map of Saudi Arabia, using a GIS-based multi-criteria decision-making model to se-lect suitable wind farms. The suitable sites were in the eastern region, located between Dammam and Hafr AlBatin, while the southern region had the scariest suitable area.

Rehman et al. (2020b) investigated suitable wind farm site selection in the Hijaz, the western region of Saudi Arabia, using a developed (MCDM) model. Based on data record-ed over a 30-year period, a wind map was developed. Ecological, environmental, and soci-oeconomic criteria data were used. The optimal site was 22 km2 near the Al-Wajh region.

Salah et al. (2021) investigated the monthly wind energy that can be generated from a wind turbine with a 100 m diameter and 100 m hub height. The Haql, Yanbu, Dholum, Guriat, Dhahran, and Arar regions have the potential to generate wind energy of more than 1000 MWh/month, which makes them ideal for wind turbine installation. The available wind energy in the 5 sites is over 15000MWh.

Albraheem and Al-Awlaqi (2023) present a wind farm site suitability analysis based on the Analytical Hierarchy Process (AHP) and (GIS) techniques in Saudi Arabia. The final suitability map is divided into classes. The results show that the total land area of ex-tremely suitable (Class4) is 48,995 km2, where the largest land is Al Mantiqah Al Sharqi-yah within this class, and the very suitable (class 3) is 197,800 km2, where Riyadh repre-sents the largest total land.

3. Methodology

3.1 Study Area

The Kingdom of Saudi Arabia boasts a long coastline along the Red Sea shore, ex-tending approximately 1,800 km from the Jordanian border in the north to the Yemeni bor-der in the south. This coast comprises approximately 77.3% of the Kingdom’s total coast-line, estimated at 2,230 km. (Al-Ruwaithi, 1982). The coastal plain consists mainly of nar-row, flat strips of sand and gravel, along with continental and marine sedimentary for-mations. Certain plain areas are covered by volcanic lava and numerous coastal lakes and bays are scattered throughout.

This long coast presents a remarkable diversity in its physical and climatic geogra-phy. The Red Sea Basin is located in hot tropical latitudes, with only a few parts north of the 30-degree latitude. The climate on the coast is very hot in summer and pleasantly warm in the winter.

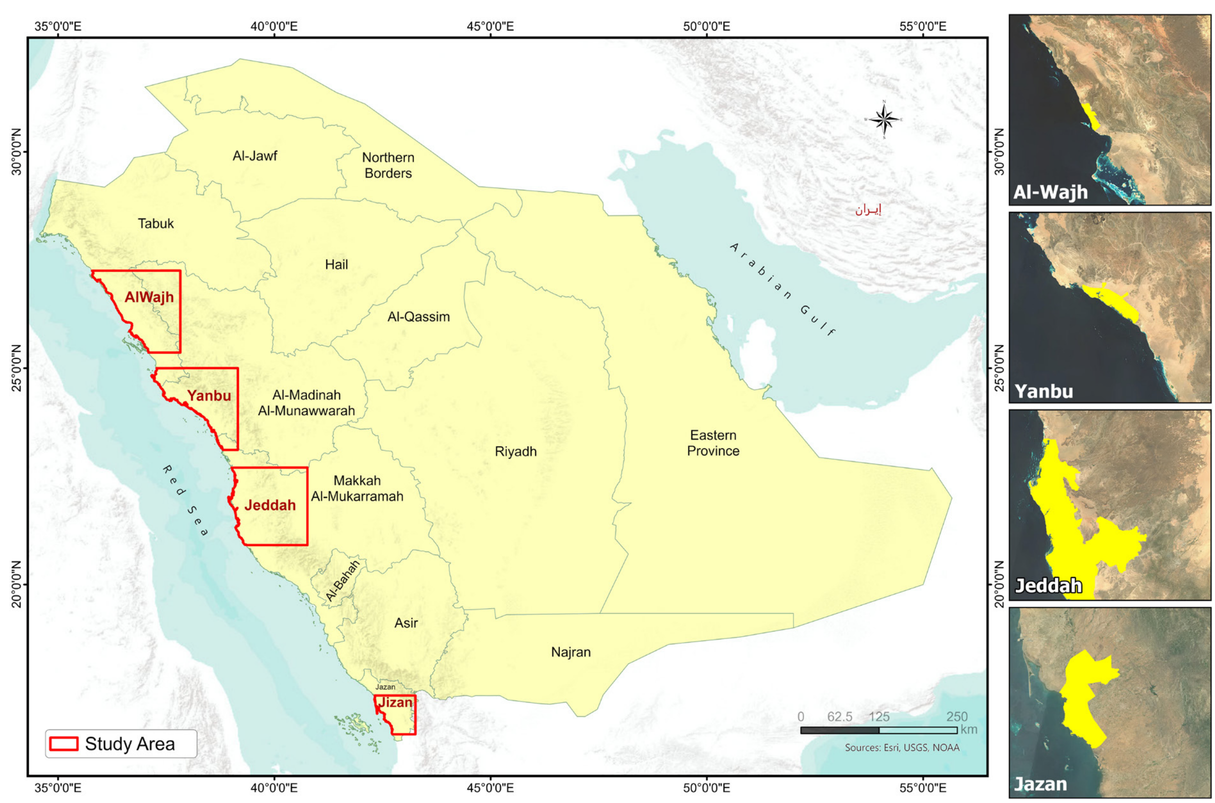


Figure (1). Study area

This climatic diversity makes the entire coast a promising urban, economic and touristic region. Nowadays, many vital cities and urban sites are concentrations along this coast. These cities serve as important industrial, commercial, touristic and agricultural centres. Many host seaports and active airports, linking them with the internal airports of the Kingdom and the rest of the world. On the other hand, some of these cities are medium or small and function primarily as fishing seaports.

This study investigates the prevailing surface wind systems and their characteristics along the Red Sea coast of the Kingdom of Saudi Arabia. For this purpose, the study focus-es on specific sites that represent the various regions of that coast. The selected sites in-clude Al-Wajh, Yanbu, Jeddah, and Jazan, as shown in Figure (1). Each site represents a large geographical area on this coast and possesses unique physical and environmental characteristics.

The mean temperature values in the study areas decrease from south to north. The highest mean is found in Jazan in the south, while the lowest one is in Al-Wajh in the north. Rainfall, though minimal, occurs primarily in autumn and winter and varies from season to season.

3.2 Wind Energy

The evaluation of wind energy potential relies heavily on reliable data regarding wind speed and power distribution. (Safari, 2011). This study aims to compile a compre-hensive data set of wind speeds across the target areas. Our methodology involved analyz-ing climatic data from the General Authority for Meteorology and Environment at four se-lected stations over 32 years (1985–2017). The data were validated regarding complete-ness, continuity, erroneous values, etc.

Previous studies have identified key factors influencing the economic feasibility of generating electricity via wind turbines (Arhens, 1982, Geerts, 1997). These factors include the following:

- The wind speed in the area where the turbine will be installed.
- The height of the turbine axis from the ground.
- The radius of the turbine fan.

The higher the wind speed and the larger the turbine fan's height and diameter, the greater the potential for electrical energy production. Wind turbines generally start to ro-tate at a minimum speed of approximately 3 m/sec (5.8 knots), but they begin to generate electricity economically when the wind speed reaches 5 m/sec (9.7 knots). (Arhens, 1982, Linacre & Greets, 1997).

Using this wind data and information on wind turbines, we calculated the potential electricity that could be produced at each of the study stations for every month of the year. This calculation considered the average monthly wind speed and the maximum monthly speed measured at the height of 10 m above the ground. Because the base area of the wind turbine fan varies greatly between turbines, ranging from less than 1 m2 to 80 m2, we as-sumed a medium base area of 1 m2 for each turbine base. Therefore, a value assumed for the turbine area in any given month, at any of the study stations, is multiplied by the monthly values of the selected station.

The wind energy (Watt/m2) was calculated using the following equation:

EP = C A ρ V3/2 (Linacre & Greets, 1997)

where:

EP = Electrical power generated (Watt).

ρ = Air density (1.225 kg/m3).

V = Wind speed (m/sec).

C = Wind turbine coefficient (0.40).

A = the area of the turbine fan base (m2), which is assumed in this study 1 m2.

3.3 Suitability Analysis

This study incorporated a comprehensive analysis of climatic, geographic and urban data using GIS and satellite imagery. This analysis aimed to identify the most suitable lo-cations for wind power stations within the four selected sites. The process involved pro-gressively eliminating less optimal areas, refining and focusing on the most promising re-gions (Noorollahi, et al., 2016). The MCDM method is widely used in many research (Spielmann et, al 2021, Isabel et al., 2023); it provides a framework that integrates eco-nomic, social, and environmental factors to get suitability maps through spatial models (Effat & El-Zeiny, 2022). It is breaking down a complicated decision problem that helps the decision maker (Ali et, al. 2017)

A geographical database model was designed to include all relevant layers deemed crucial for accurate site selection. This database was built using the Arc GIS program and comprised 14 layers. Each layer was assigned a weighted overlay, with the most influential layer receiving the highest value. It is critical to note that the sum of the relative weight values for all layers should not exceed 100%, as shown in Figure (2).

The wind velocity layer served as a base layer in the proposed model. Data from the Global Wind Atlas site was utilized to map wind speeds across the Kingdom of Saudi Ara-bia, as shown in Figure (3). Findings revealed that the average wind speed across the four study areas was around 10 m/s, which is highly favorable for generating electric power.

Valley streams were extracted from the digital elevation model with an accuracy of 5 m and managed using a model with an accuracy of 10 m, as shown in Figure (3). To cir-cumvent stream areas, the study excluded valley regions. These included main streams, estuaries and secondary tributaries that feed into the main streams. The road network and power lines were digitally rendered in polyline format according to data from the Saudi Electricity Company and the General Survey Authority. Preparations for urban area maps, geological maps and fault line diagrams were also undertaken, as shown in Figure (4). A noteworthy addition to the study was a layer representing the migratory paths of birds. This inclusion is aimed at preserving these routes and preventing potentially bird fatalities ow-ing to collisions with turbine blades

Subsequently, the study established appropriate rules for each layer, aiming to exclude inap-propriate areas. Utilising selects, buffer, clip and erase tools, the study identified suitable areas for establishing electric generation power stations and transitioned the data from vector to raster for-mat. This transition was crucial for setting criteria for weighted overlay. This process assigned a relative weight to each category within each layer individually, based on its importance and impact on the model. In other words, higher-ranked categories received greater relative weights.

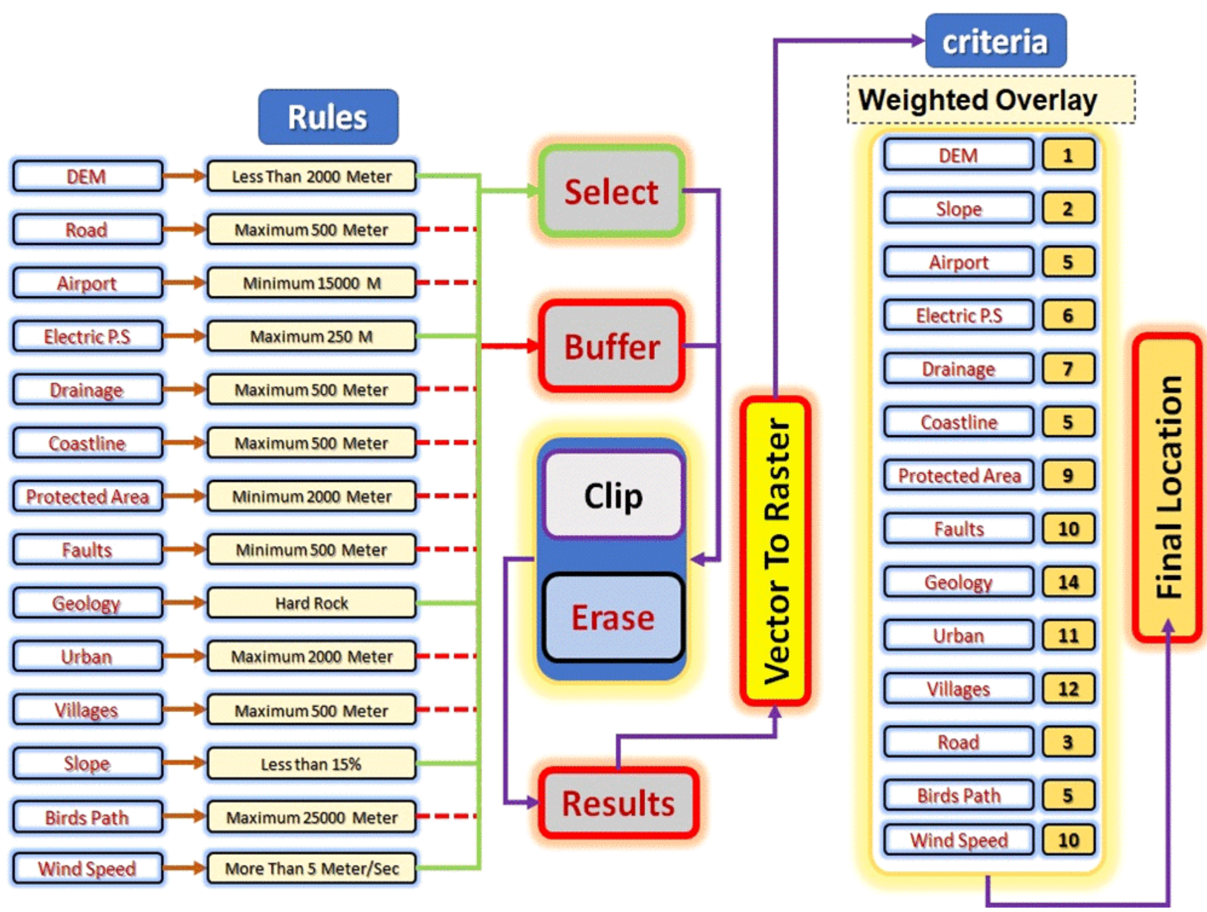


Figure (2). The conceptual model of the restrictive method (Modified after Van Haaren and Fthenakis, 2011)

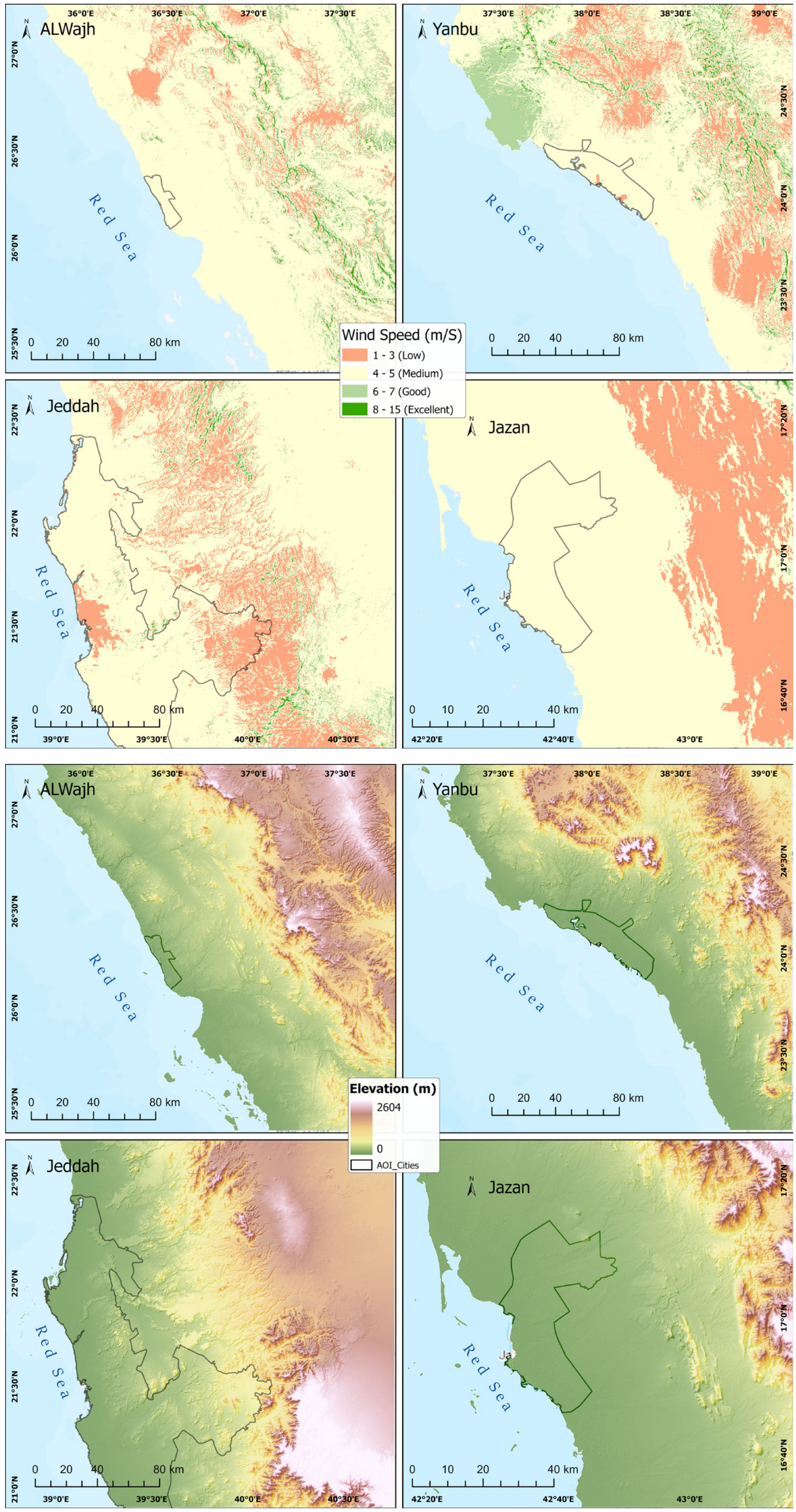
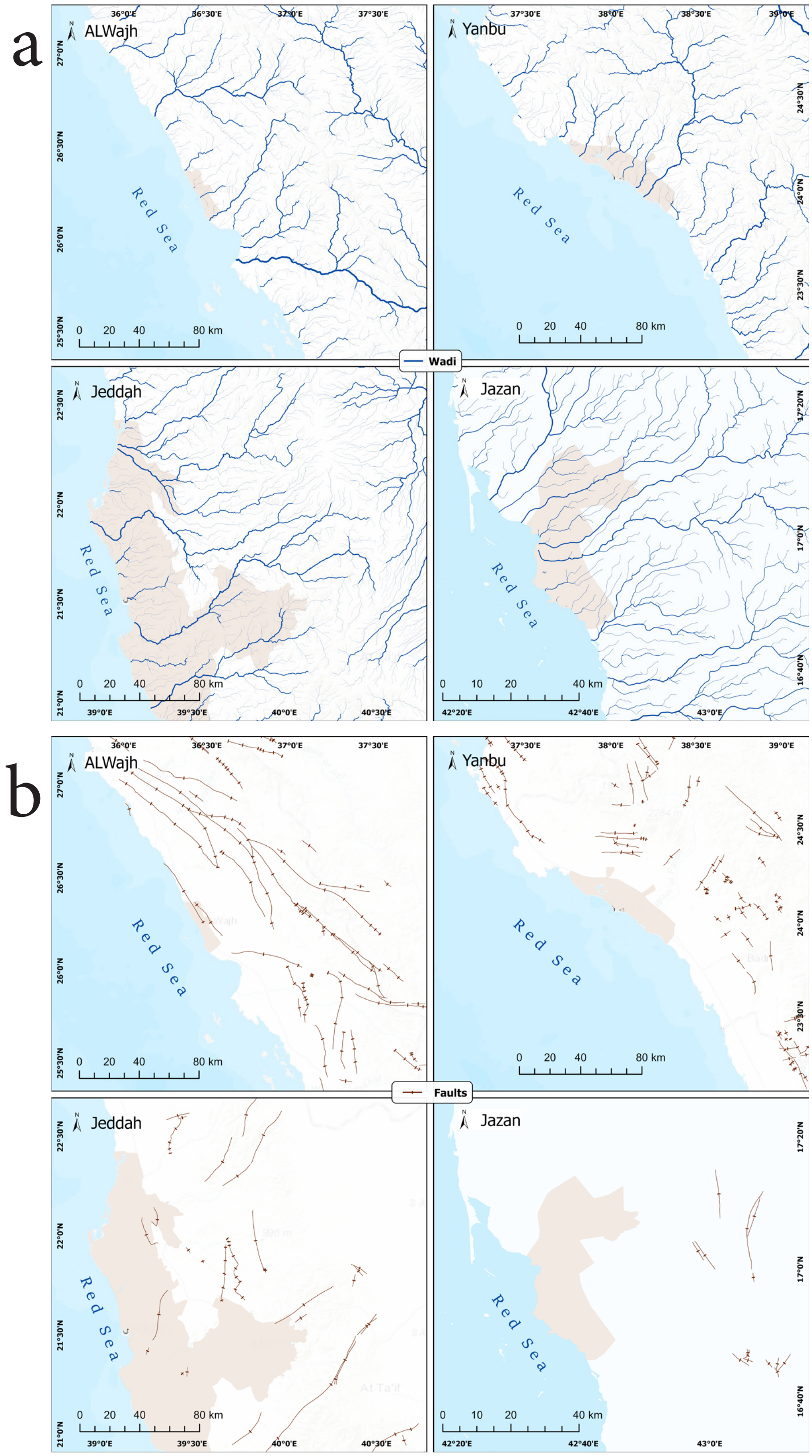


Figure (3). Digital elevation model and annual average of wind speed (m/s) (Wind Atlas 2020)


a
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Jeddah
Jazan
Red Sea
Wadi
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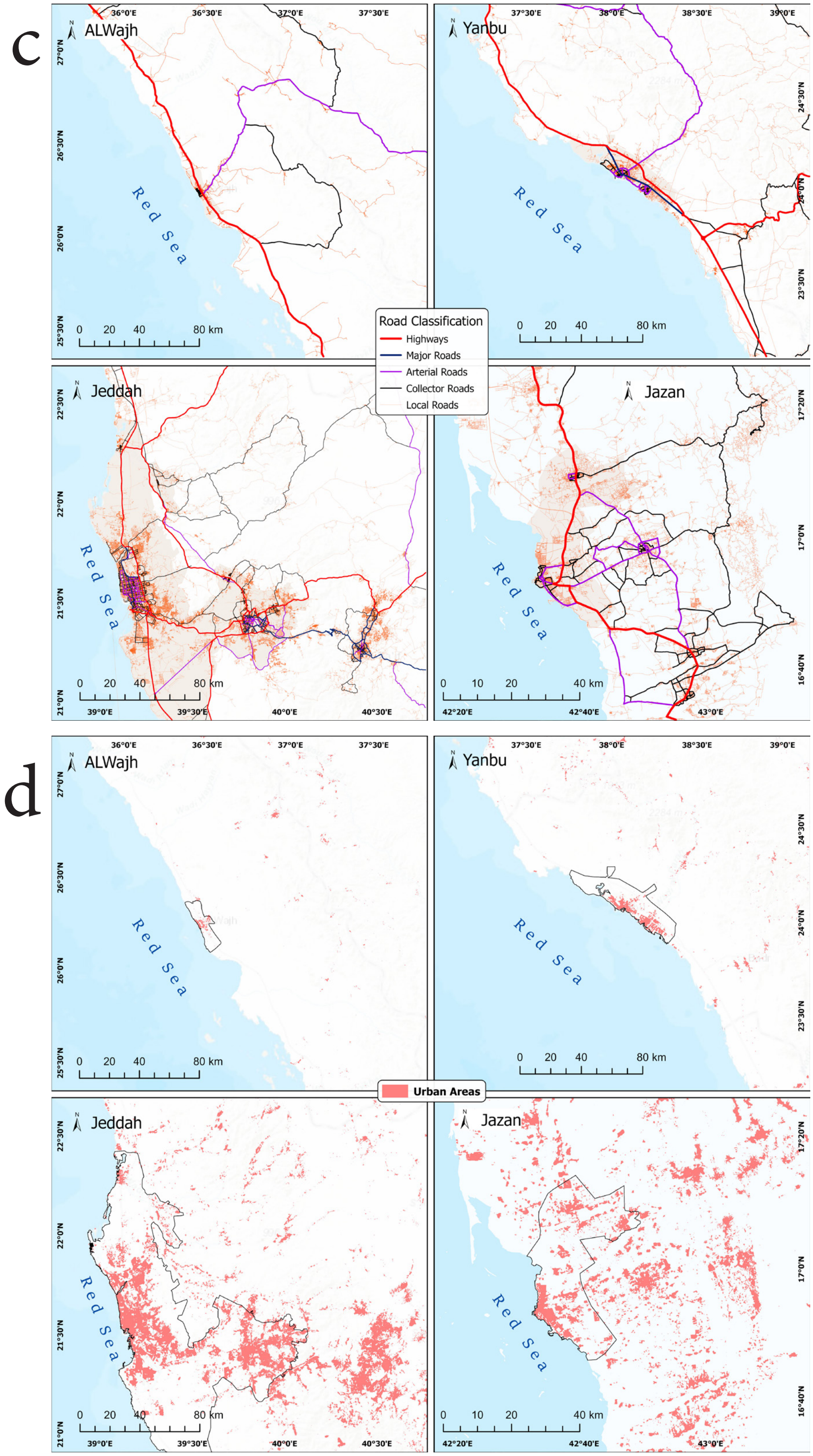
b
Faults


c
ALWajh
Yanbu
Jeddah
Jazan
Red Sea
Road Classification
Highways
Major Roads
Arterial Roads
Collector Roads
Local Roads
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0 10 20 40 km
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Urban Areas

e

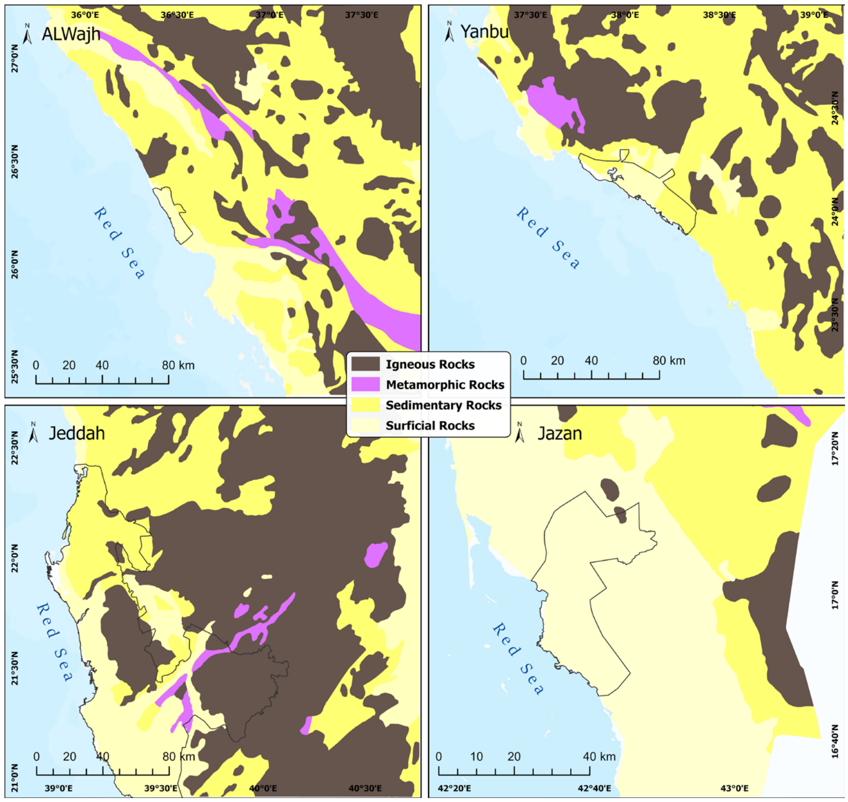


Figure (4). Criteria for site selection: (a) wadis (b) faults (c) road (d) urban area (e) geology

4. Results and Discussion

4.1 Wind speed and direction

Regarding wind speed and trends, the selected stations in the area exhibit noticeable fluctua-tions in trend frequency and speed from one season to another. These variations can be attributed to seasonal shifts in temperature and atmospheric pressure values, which are influenced by various atmospheric pressure systems that affect the area. The wind speed within the study area varies be-tween winter and summer owing to geographical location and site-specific factors. Therefore, this study focuses on wind speed variations across different seasons.

The maximum wind mean speed was recorded at the Al-Wajh station, reaching 4.74 m/sec in June (refer to Table 1). Conversely, the slowest wind speed was observed at the Jazan station, dropping to 2.87 m/sec in November. In addition, the Al-Wajh station reported the maximum wind mean speed during spring at 4.67 m/sec, while the lowest speed was recorded at the Jazan station during winter, clocking in at 2.94 m/sec.

The peak wind speed was registered at the Jazan station in summer, with a notable increase from 15.59 m/sec in June to a high of 20.87 m/sec in August. The Yanbu station reported a maxi-mum wind speed of 16.61 m/sec. It is evident from the data collected across the selected stations that both absolute and average wind speeds can generate wind-powered electricity, especially dur-ing the summer months.

The study area displays significant seasonal variations in wind speed, trends and frequency. These variations are directly correlated with changes in seasonal temperatures and atmospheric pressure values. This pattern suggests the existence of spatial and temporal variations in wind fre-quency and trends.

Table (1). Wind mean and maximum speed during months and seasons (m/s), (1985−2017)

Month / Station	Al-Wajh		Yanbu		Jeddah		Jazan	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max
January	4.01	15.88	3.17	14.09	3.71	14.68	2.92	11.18
February	4.49	16.21	3.51	14.03	3.87	13.78	2.98	11.01
March	4.72	15.65	3.79	15.42	4.09	14.84	3.01	11.97
April	4.62	15.10	3.82	15.96	3.88	14.81	3.07	14.40
May	4.68	15.26	4.07	15.74	3.85	13.20	3.06	15.34
June	4.74	14.26	4.60	16.02	3.96	12.94	3.27	15.59
July	4.32	13.26	4.57	16.65	3.63	12.44	3.74	18.53
August	4.49	13.62	4.60	17.15	3.76	13.03	3.51	20.87
September	4.66	13.75	4.09	14.79	3.49	12.22	3.1	18.64
October	4.07	14.15	3.27	13.28	2.96	12.05	2.93	16.52
November	3.77	13.28	2.95	13.84	3.09	13.14	2.87	12.08
December	3.82	14.47	2.93	13.81	3.49	13.26	2.93	10.57
Winter	4.11	15.52	3.20	13.98	3.69	13.91	2.94	10.92
Spring	4.67	15.34	3.89	15.71	3.94	14.28	3.05	13.90
Summer	4.52	13.72	4.59	16.61	3.78	12.80	3.51	18.33
Autumn	4.17	13.73	3.44	13.97	3.18	12.47	2.97	15.75
Annual Mean	4.37	14.58	3.78	15.07	3.65	13.37	3.12	14.73

The prevailing wind trends at each of the study stations vary both monthly and seasonally. The Yanbu station experiences prevailing westerly winds throughout the year, with a frequency of 375 occurrences, while the Jazan station records the same trend across all months, albeit with a lower frequency of 237 occurrences. The lowest annual frequency of westerly winds was observed at the Al-Wajh station, registering only 38 occurrences, as shown in Figure (5).

In Jeddah, the northern winds prevail are predominant throughout the year, with a frequen-cy of 173 occurrences. At the Al-Wajh station, wind trends not only vary from month to month but also differ significantly from other stations. The winds primarily come from the west–northwest during spring, summer and autumn.

The differences in the prevailing wind trends amongst the stations in the study area can be attributed to their unique geographical locations and the various wind sources impacting them.

The potential for electrical energy production was calculated considering both the mean and maximum wind speeds, as shown in Table (2). It appears that the wind-electro density is remarka-bly available at most study stations, especially during the summer and spring seasons.

The Al-Wajh station appears promising for wind energy production throughout the year, with the highest wattage recorded in the spring and summer seasons at 26.08 W and 23.50 W, re-spectively. Yanbu follows Al-Wajh closely, peaking in the summer at 24.55 W and dropping signif-icantly during the winter months to 8.63 W. The Jazan station plant scores the least annual power production, around 11.21 W in summer and 6.68 W in winter. However, when considering maxi-mum wind speed, the Jazan station shows potential for wind energy production, particularly in the summer and autumn seasons, with wattage peaking at1961.77 W and 1352.8 W, respectively. Yanbu follows Jazan, peaking in summer at 1200.94 W

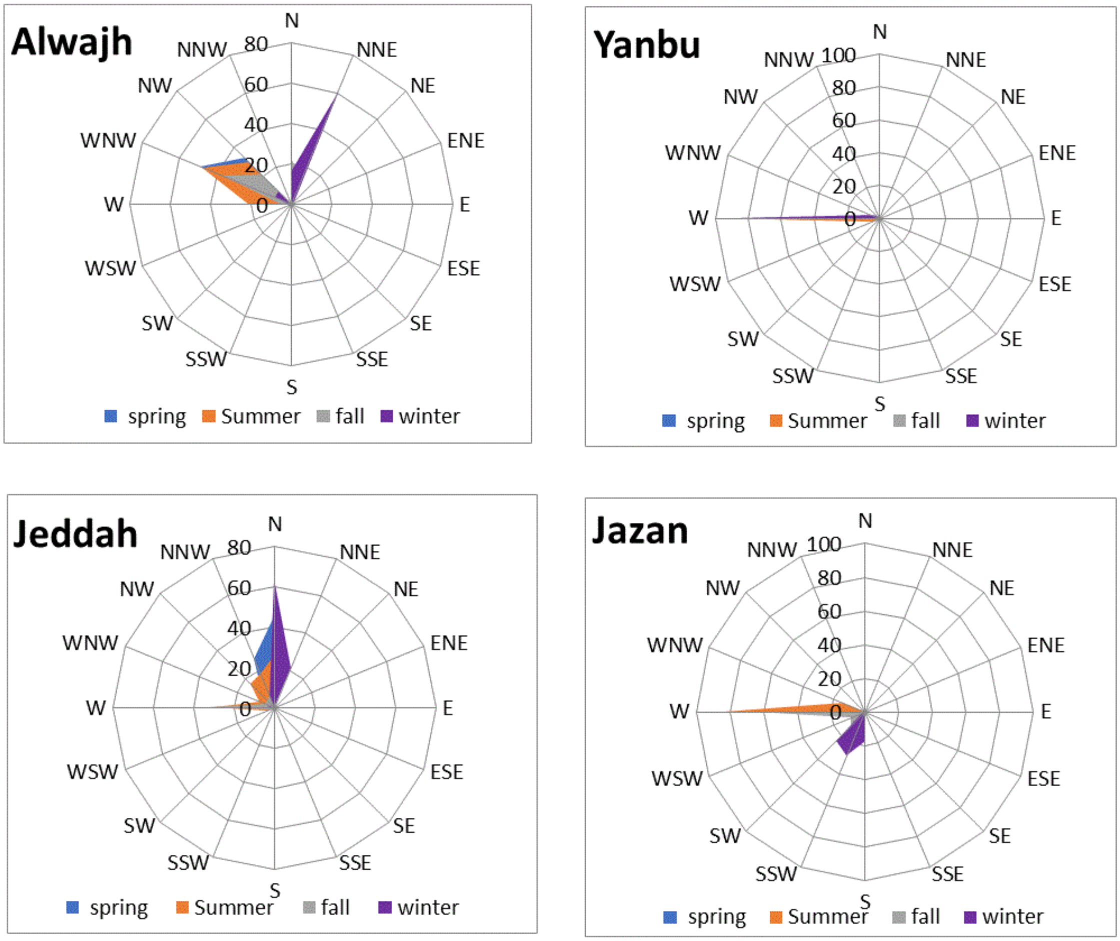


Figure (5). Wind roses (1985–2017) in the four stations.

and dropping considerably to 721.5 W in winter. Al-Wajh comes next to Yanbu, scoring peaking in winter at 1040.13 W. The Jeddah station plant records the least power production throughout the year, with approximately 536.87 W in summer and 526.03 W in autumn. This represents the lowest production of electrical energy using maximum wind speed. The annual mean is 645.77 W.

4.2 Suitability Model

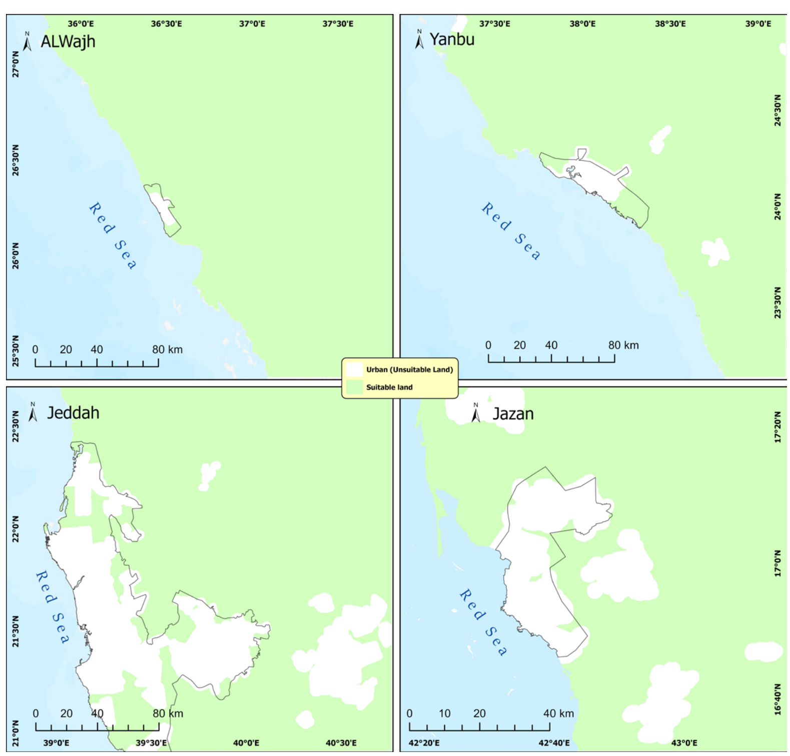
The study utilised MCDA analysis methods to identify suitable locations for wind power stations, as outlined in the methodology. As shown in Figure (6, 7), the analysis outputted a raster for each criterion (nature and urban criteria) indicate areas deemed suitable or unsuitable for such installations.

The proposed model's results, illustrated in Figure 8, highlighted potential sites along the Red Sea coast after excluding unsuitable land. The model's accuracy mainly depends on the DEM's accuracy (10m) and the maps' scale. These regions possess most of the natural features and characteristics necessary for wind power stations.

Eight evaluation criteria were used to be reclassified the study area to suitable and unsuitable area. A total of 25865km2 optimal sites for wind power stations were identified by eliminating unsuitability land for each criterion, distributed across various cities within the study area. Jeddah hosts 13826.8 km2 of these, accounting for 34.8% of the total. The city of Yanbu follows with 6325 km2, representing 21.2% of the total number, followed by Al Wajh, 4974.2km2 representing 13.6%, while the smallest is Jizan, 738.7km2 with 8.5%.

Table (2). Electrical-generating power by means and maximum wind speed (W) (1985–2017) per month and season

Station	Al-Wajh		Yanbu		Jeddah		Jazan	
	Mean	**Max.**	**Mean**	**Max.**	**Mean**	**Max.**	**Mean**	**Max.**
January	16.52	1137.2	8.12	752.99	13.17	846.24	6.54	392.63
February	23.15	1172.69	11.16	706.76	15.36	682.31	6.93	346.39
Mars	26.79	1005.43	13.96	930.15	17.57	917.8	7.1	439.95
April	25	921.62	14.4	1055.55	14.9	874.92	7.54	884.16
May	26.47	907.13	17.5	1004.95	14.47	595.48	7.38	1130.62
June	27.07	736.39	24.97	1039.89	15.81	544.76	9.1	1059.62
July	20.47	592.23	24.06	1239.99	12.23	494.79	13.64	1778.26
August	22.96	634.64	24.63	1322.93	13.47	571.05	10.89	3047.43
September	25.94	665.74	17.56	819.14	11.04	466.46	7.75	1858.06
October	17.44	841.97	9.05	651.93	6.66	491.04	6.5	1492.18
November	14.67	658.81	6.79	735.21	7.68	620.57	6.22	708.16
December	14.39	810.5	6.63	704.74	11.33	643.82	6.58	326.88
Annual Mean	21.74	840.36	14.90	913.69	12.81	645.77	8.01	1122.03
Winter	18.01	1040.13	8.63	721.5	13.29	724.12	6.68	355.3
Spring	26.08	944.73	15.28	996.89	15.65	796.06	7.34	818.24
Summer	23.50	654.42	24.55	1200.94	13.84	536.87	11.21	1961.77
Autumn	19.35	722.17	11.13	735.43	8.46	526.03	6.82	1352.8
Annual mean	21.74	840.36	14.90	913.69	12.81	645.77	8.01	1122.03



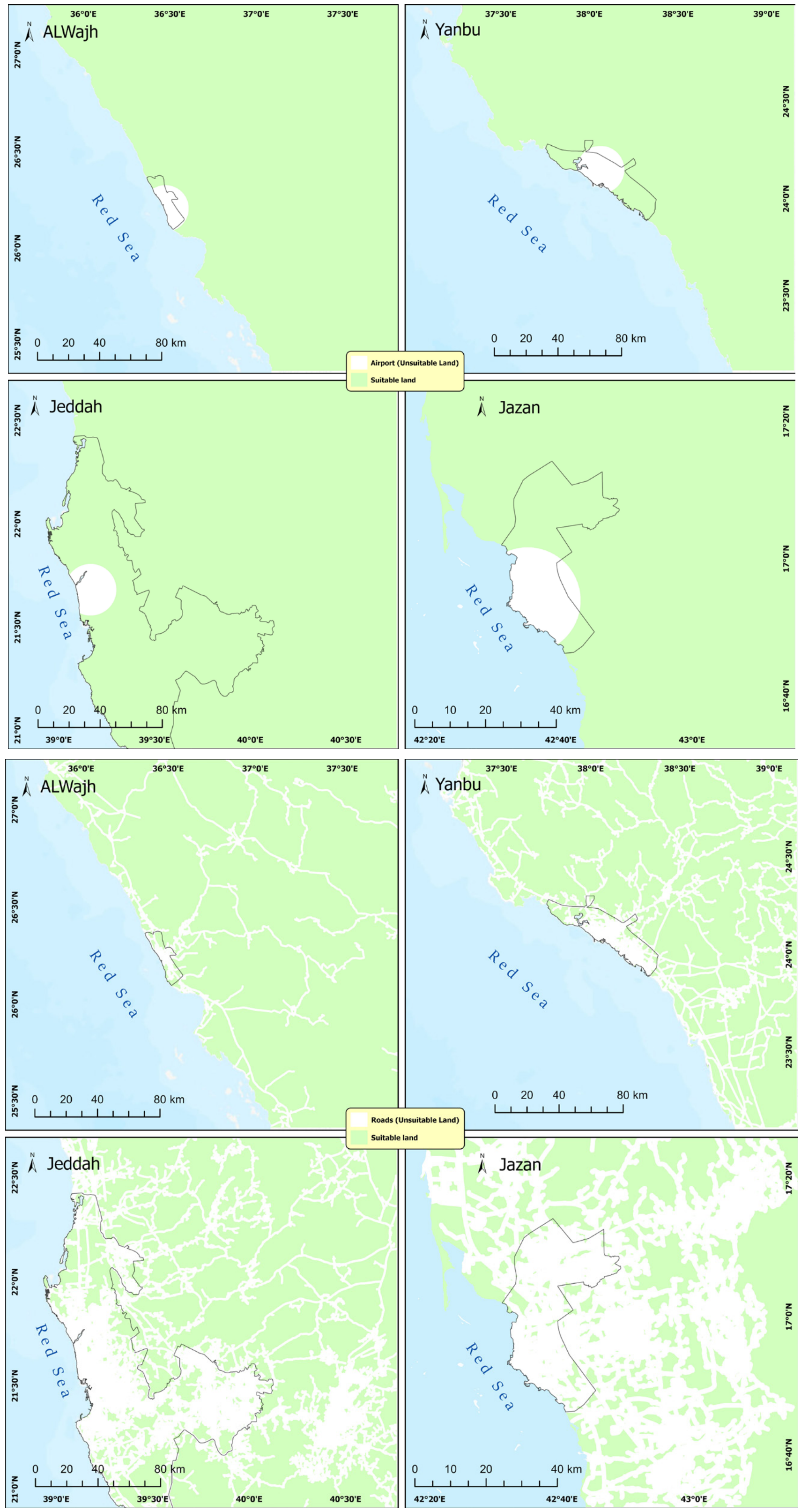
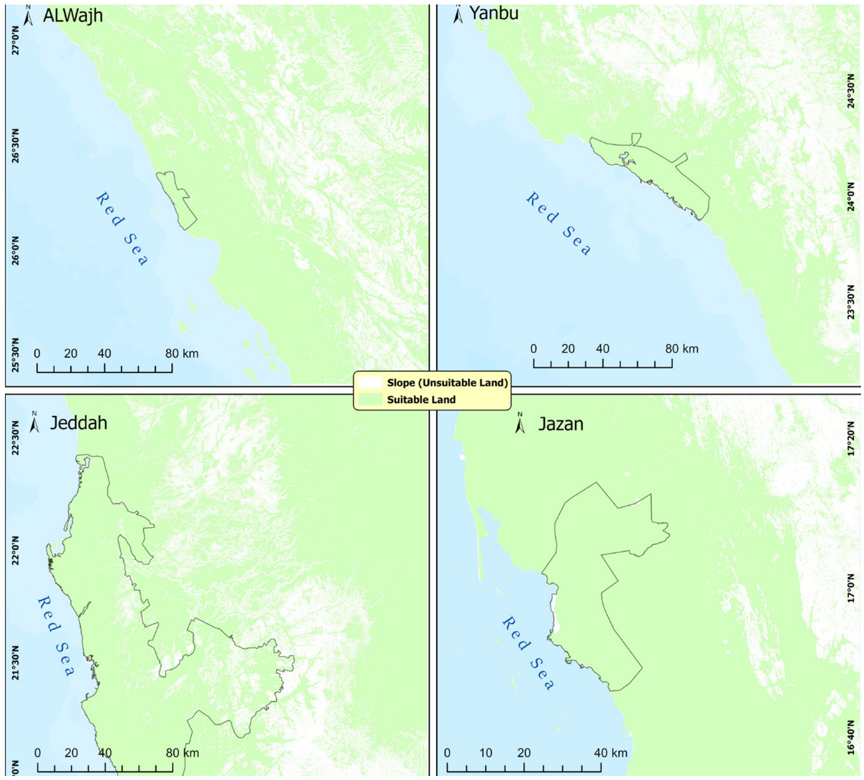


Figure (6). Suitable sites for urban criteria (Road, airport and urban area)


ALWajh
Yanbu
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Jazan
Red Sea
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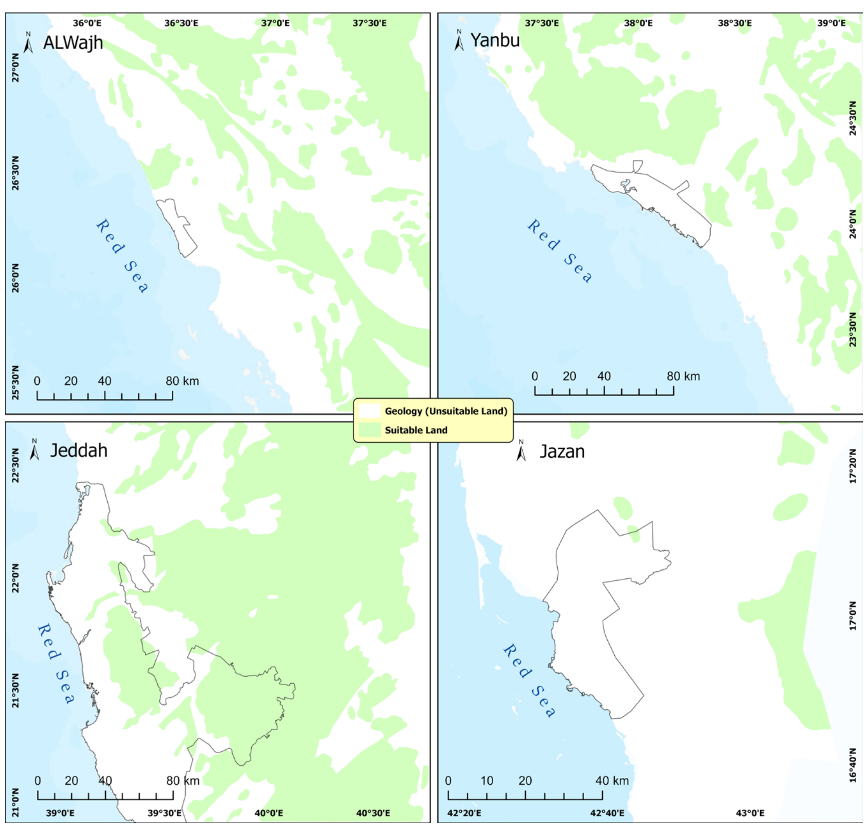
Slope (Unsuitable Land)
Suitable Land


ALWajh
Yanbu
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Jazan
Red Sea
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37°30'E
38°0'E
38°30'E
39°0'E
39°30'E
40°0'E
40°30'E
42°20'E
42°40'E
43°0'E
27°0'N
26°30'N
26°0'N
25°30'N
24°30'N
24°0'N
23°30'N
22°30'N
22°0'N
21°30'N
21°0'N
17°20'N
17°0'N
16°40'N
Geology (Unsuitable Land)
Suitable Land

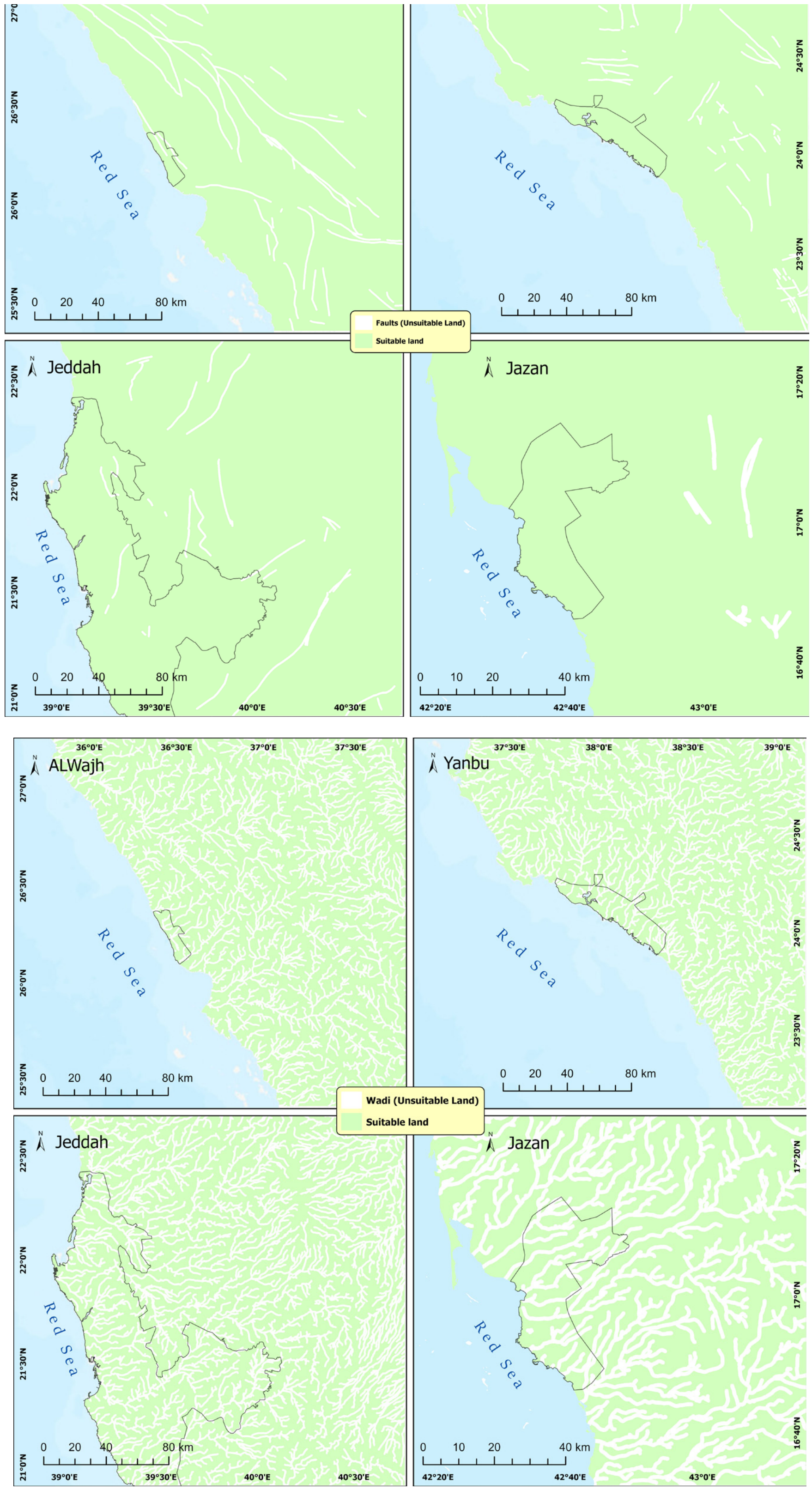

Figure (7). Suitable sites for nature criteria

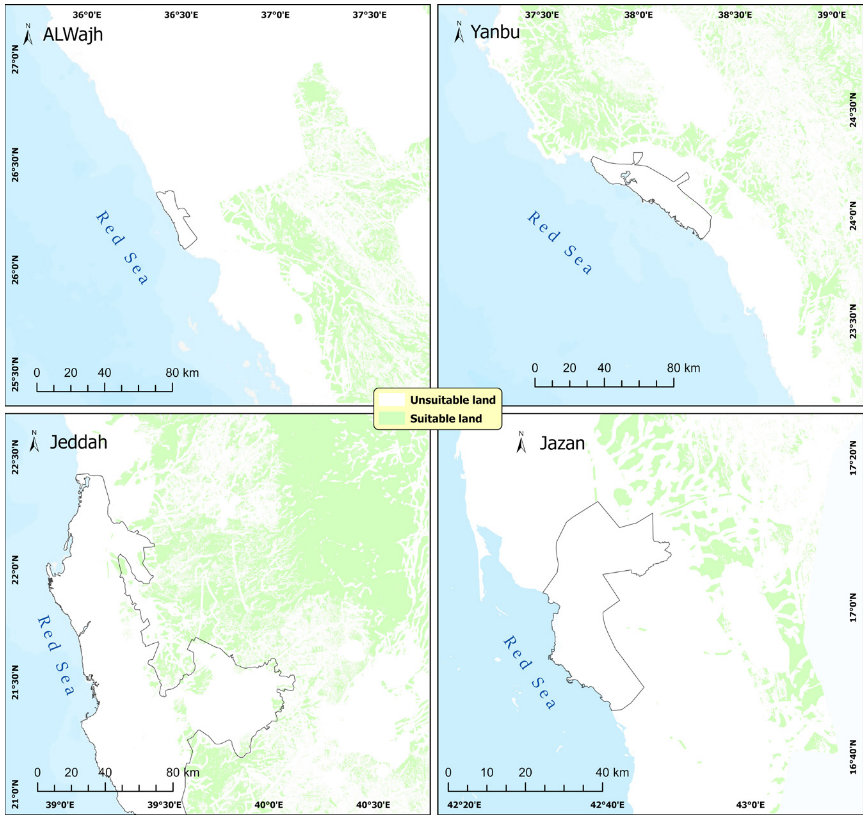

Figure (8). Suitable sites for wind power plants

In general, the four studied areas possess both natural and human resources that favour the establishment of wind power plants along large area.

The kingdom of Saudi Arabia can allocate part of its oil revenues to invest in renewable energy sources, particularly wind power, given the economic viability supported by low production costs.

However, some natural and technological challenges may impede the establishment of wind power plants. These include a lack of technical expertise, difficulties in energy storage, wind speed fluctuation, dust storms and the visual impact and noise generated by wind turbine that may cause complain of resident.

Despite these challenges, wind fan turbine generators remain economically viable owing to their low production costs and their suitability for generating electric power in certain locations. Consequently, they hold promising potential for future investment along the Red Sea coast..

5. Conclusions

Many districts in Saudi Arabia hold potential for renewable energy production. Most characteristics needed for wind power stations are available along the Red Sea.

Geographic information system is an effective way to utilize Multi-Criteria Decision-Making methods (MCDM) to identify suitable locations for wind power stations.

The Al-Wajh station holds potential for wind energy production throughout the year, with the highest watt scores recorded in the spring and summer seasons. The largest proportion of suit-able areas for establishing wind power plants was in the Jeddah city (13826.8 km2) and the least is in the Jizan city (8.5 km2). The results of this study can be used by decision-makers as a decision-aid tool.

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تحليـل متعـدد المعـايير لتوزيـع محطـات طاقـة الريـاح على طـول سـاحل البحـر الأحمـر للمملكـة العربيـة السـعودية باسـتخدام نظـم المعلومـات الجغرافيـة (١٩٨٥-٢٠١٧)

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قدم للنشر في ٧/ ٩/ ١٤٤٥ هـ؛ وقبل للنشر في ١٠/ ٤/ ١٤٤٦ هـ.

ملخص البحث. يعتبر تحديد مواقع محطات طاقة الرياح مهماً جداً في التخطيط الاقتصادي والعمراني؛ للاستفادة من طاقة الرياح بشكل فعال وكامل. يهدف هذا البحث إلى مقارنة الخصائص المكانية لسرعة الرياح في أربع مدن على ساحل البحر الأحمر في المملكة العربية السعودية؛ الوجه وينبع وجدة وجيزان، حيث تعتبر مناطق واعدة لتوليد طاقة الرياح وتتوفر فيها البيانات الأولية. تم جمع وتحليل بيانات متوسطات سرعة الرياح اليومية والفصلية من ١٩٨٥ إلى ٢٠١٧، وتم تحديد سرعة الرياح القصوى واتجاهها السائد في المحطات المناخية، ومن ثم تم توظيف تقنيات نظم المعلومات الجغرافية لاقتراح وتقييم أنسب مواقع محطات طاقة الرياح باستخدام تحليل متعدد المعايير في نظم المعلومات الجغرافية بالتكامل مع الحسابات الإحصائية للبيانات المناخية. تم بناء قاعدة بيانات جغرافية تتضمن ١٤ طبقة رقمية من ضمنها: سرعة الرياح والارتفاعات والمناطق العمرانية والأودية. وتضمنت النتائج المناطق المناسبة وغير مناسبة لمحطات طاقة الرياح في كل الطبقات. وأظهرت نتائج المقارنة أن جدة واعدة في إنتاج طاقة الرياح حيث تتمتع بأكبر مساحة مناسبة بحدود٨ , ١٣٨٢٦ كم٢، بينما أتت جازان بأقل مساحة مناسبة بحدود ٧ , ٧٣٨كم٢.

الكلمات المفتاحية: محطات طاقة الرياح، تحليل متعدد المعايير، نظم المعلومات الجغرافية، المملكة العربية السعودية، البحر الأحمر.