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Placement of Wind Farms Based on a Hybrid Multi Criteria Decision Making for Iran

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Abstract: In the current century, energy is become as one of the most critical issues in human's life. Due to global warming, air pollution and the other problems caused by fossil fuels, one of the appropriate sources which is renewable and is invested is wind energy. Iran has a good potential to use wind energy based on its geographical features. Therefore, to have the best productivity to employ wind energy, location of farm winds in a suitable site is a delicate issue. This research applies a hybrid MCDM method for prioritizing potential cities in Iran to install wind farms. In this regard, Step-wise Weight Assessment Ratio Analysis (SWARA) is employed to rank criteria and Weighted Aggregates Sum Product Assessment (WASPAS) is utilized to evaluate alternatives. In this study 68 cities are detected as high potential places for this aim. Eventually, the most appropriate city is identified as the best place to install wind farms. The results of this research draw a conclusion for decision making and planning of energy management in top level of managing requirements of countries in all aspects.

Keywords: Wind Farms, MCDM, SWARA, WASPAS, Iran.

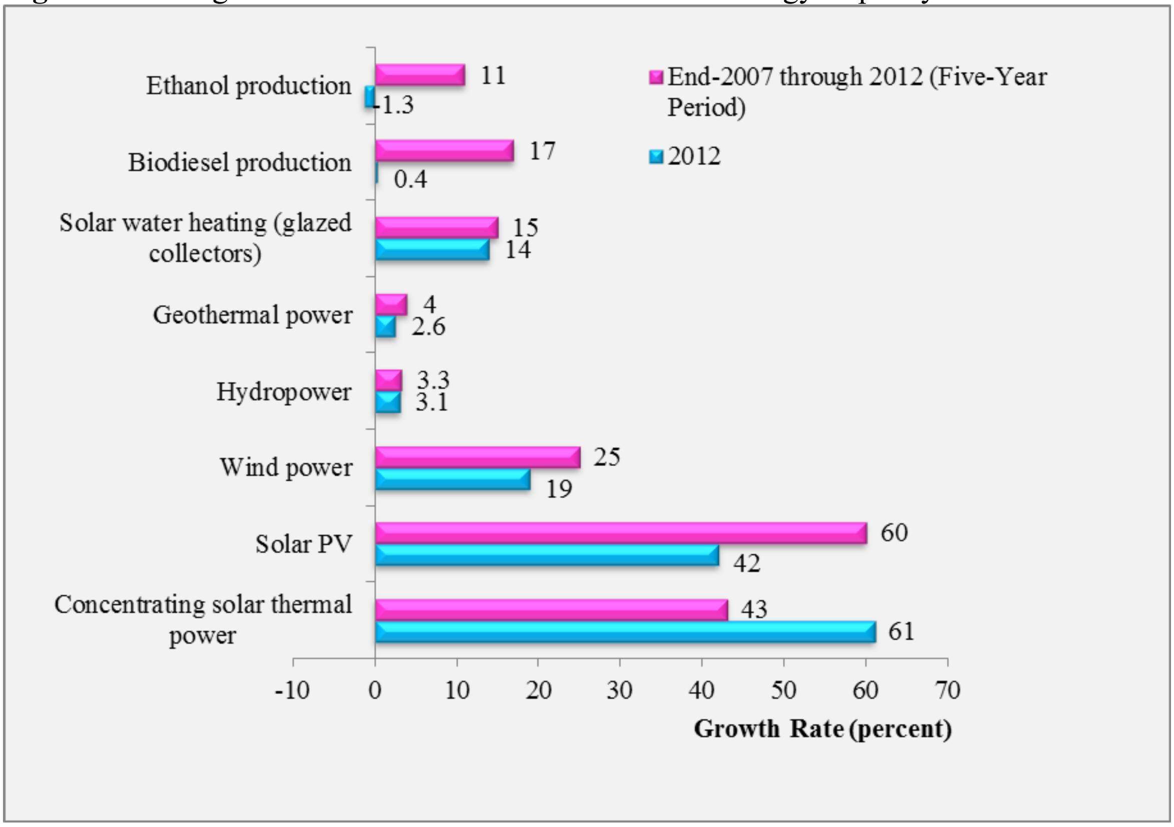
1. Introduction

Based on historical records, Egyptians were the first nation harnessed the wind energy to travel along the Nile River in 5000 B.C. [1]. In 200 B.C Chinese used vertical-axis windmills to grind with reed sails which were woven in Iran. These windmills were widely spread in the Middle East for preparation of food ingredients in eleventh century. After that, European merchants inspired by this technology and imported it to Europe. The Dutch improved the technology and applied it to flow away liquid from swamps and lakes Rhine River Delta. During the industrial revolution windmills fade away in the U.S and Europe, but in 1890s a new technology which is called wind turbines appeared in Denmark [2].

In recent decades electricity is deemed one of the most important parts of every country in terms of development and improvement of its infrastructures. Even though electricity generation heavily depends on fossil fuels, these resources are exhaustible. The other problem is that our green planet will be devastated and will encounter catastrophic disasters if the current situation continues. The aforementioned concern has its roots in recent technological invention which phenomenally has changed the technology of energy sector by spreading more effective and cheaper tools [3].

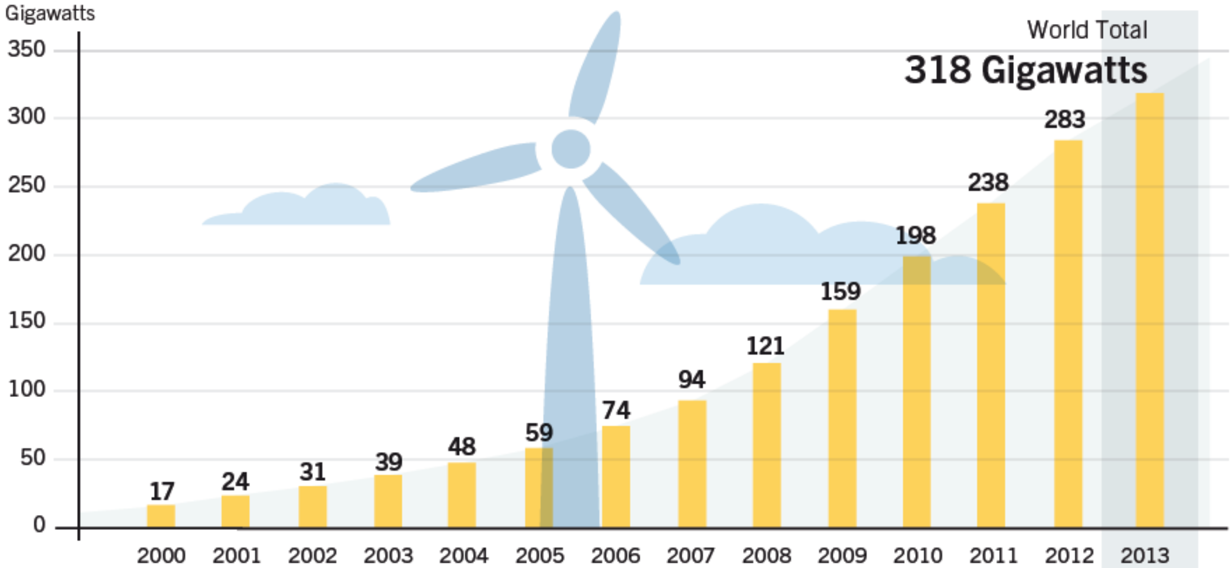
The rapid growth of wind technology has resulted in considering one of the best viable alternatives for fossil fuels [4]. Moreover the galloping rate of renewable energy for electricity generation is considerable and this portion increased to 19% and the global capacity surpassed 1560 (GW). In other words, it has increased more than 8% over 2012. The investment in renewable energy by the end of 2013 is about 214.4 billion USD in which the portion of wind farms is about 80.1 billion USD. To have a better clarification, figure 1 shows the Average Annual Growth Rates of Renewable Energy Capacity and Biofuels [5].

Figure 1. Average Annual Growth Rates of Renewable Energy Capacity and Biofuels.



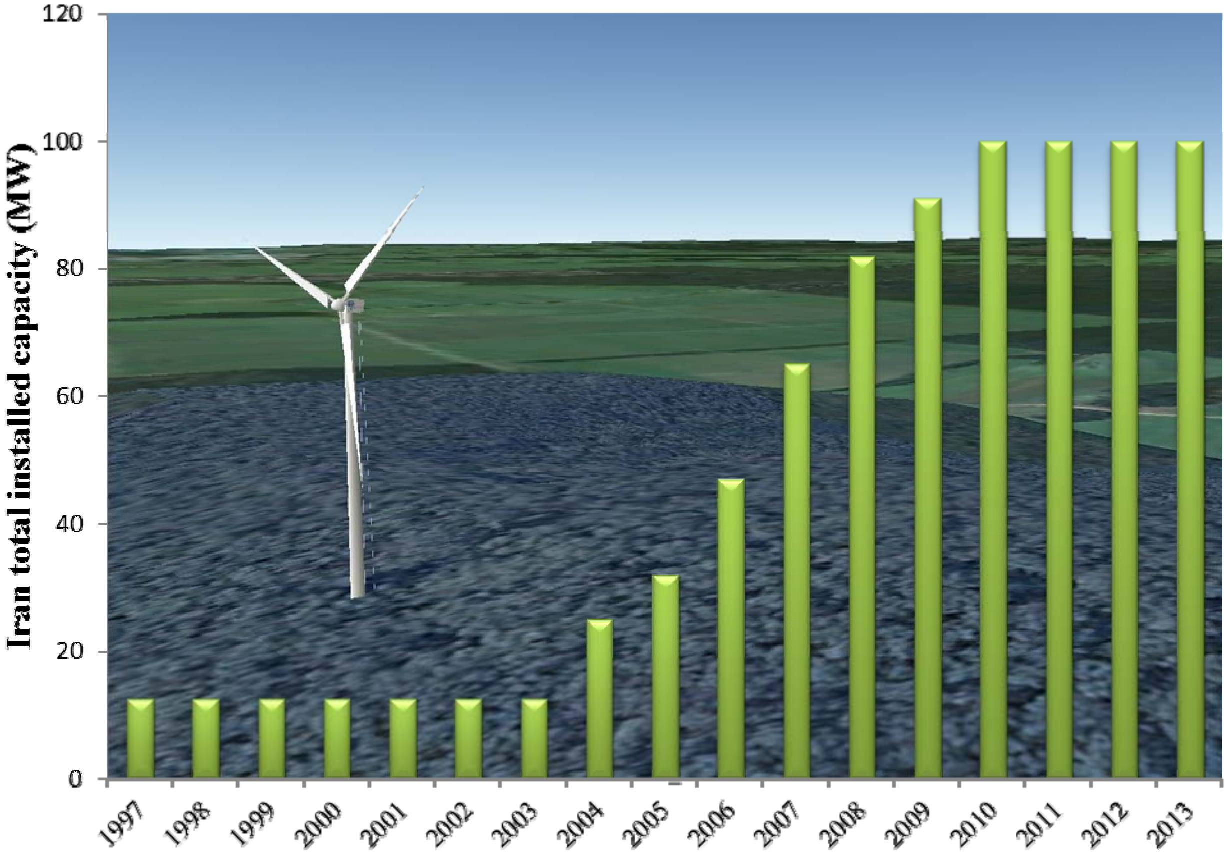
In 2013, by adding 35 GW of wind power the capacity reached to 318 GW. In contrast with the last years on which Europe and the America were the jumpers, in 2014, Asia has taken the lead. Moreover, this phenomenon has spread in new regions such Latin America which allocated a considerable portion of new establishments. In addition, offshore wind broke the record by adding more than 1.6 GW. To have a better illustration, figure 2 shows the world total energy of wind farms [5].

Figure 2. The world total energy of wind farms.



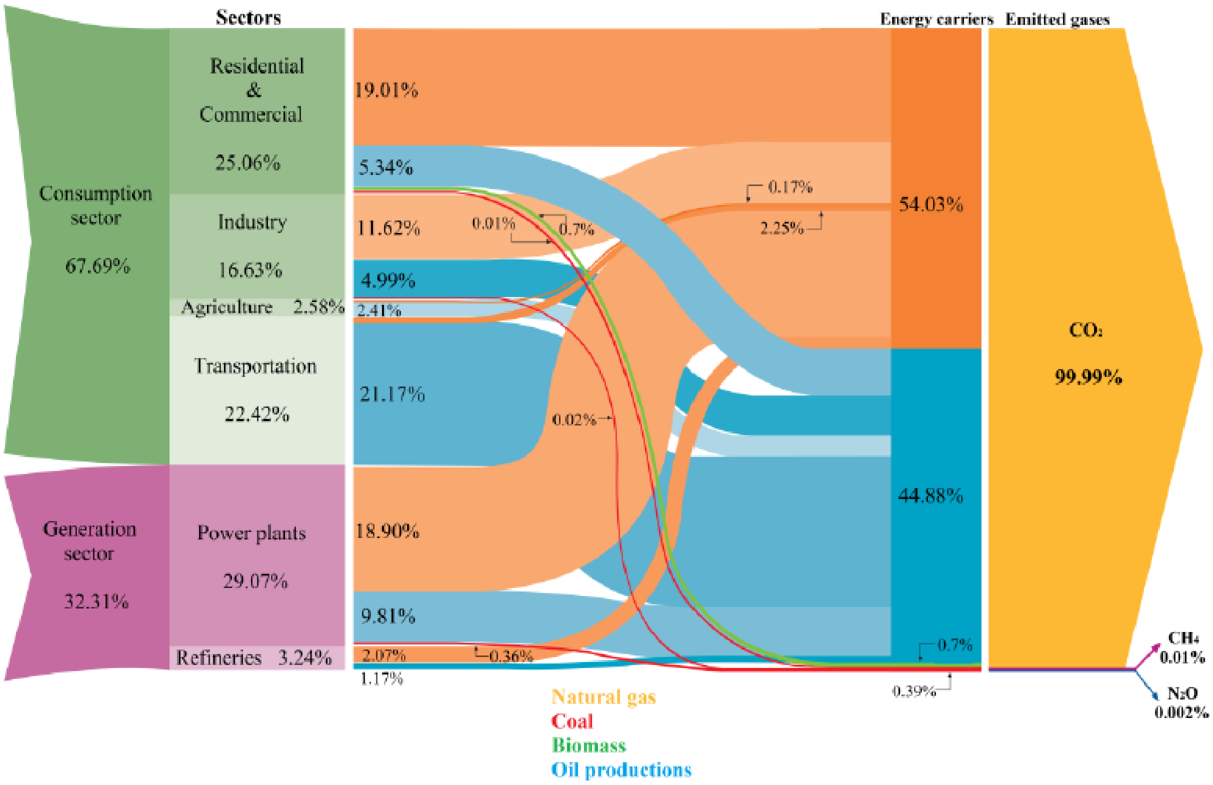
Because Iran is a developing country and its population, industry and agricultural sectors improves, the electricity consumption is growing more and more. Moreover, because of air pollution and global warming most of the countries look forward to shifting from fossil fuel to renewable energy. However, due to lack of financial supporters and availability of fossil fuels, improvement of renewable energy is slow in Iran [6]. The growth of utilizing wind energy and installed capacity is shown in figure 3 [7]:

Figure 3. The total installed capacity of Iran.



Even though Iran is one of the biggest producers of oil and gas, these resources do not last forever and cause global warming and detrimental effects. For example the amount of NO_2, CH_4 and CO_2 in Iran are 11.9, 52.2 and 532323.8 thousand tones. To have a better illustration the figure 4 shows the amount of the greenhouse gas emission as follows [8].

Figure 4. Greenhouses gases from varied energy sectors.

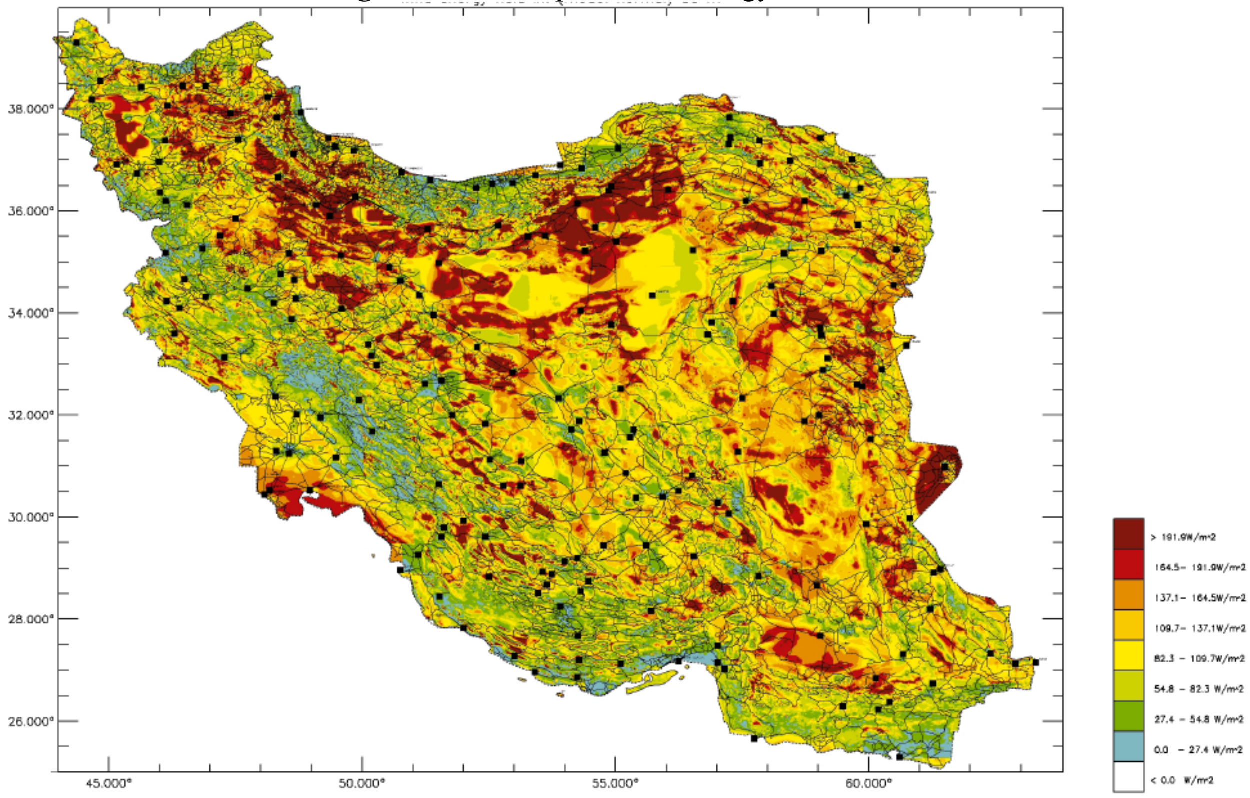


In addition, primary consumption is 9.108 quadrillion Btu and net consumption is 182.70 billion kWh. These gases cause air pollution which result in a lot of diseases such as lung cancer [9] which its rate has increased in recent years. Along the same lines, the Iranian parliament has made the rules which underwrite and support the renewable energy infrastructure and in 2014 they approved that the electricity organization will buy every kWh of renewable energy twice as expensive as it used to buy. It means that these supportive subsidies, clean energy and the profitable industry, interest rate and so forth related to renewable energy [10] lead investors to invest in these areas. As a result, replacing fossil fuels is a viable task and in long term is considered one of the most attractive types of projects in Iran.

Researches and investigations for potential of wind in Iran depict that the viable wind farms project in Iran can generate 18000 Megawatt and the total capacity can be obtained from wind farms is 100000 Megawatt [11].

The geographical situation of Iran including low air pressure creates a suitable wind flows in summer and winter compared to north and northwestern. Because of the difference in air pressure among Central Asia, the Atlantic Ocean and Iran, cold winds, humid and Mediterranean blow from the north, Atlantic and west, respectively. Figure 5 shows the comprehensive map of wind energy of Iran 80 m above ground [11].

Figure 5. The map of wind energy in Iran.



Based on high initial investment, risk factors, wild competitive market and for establishing wind farms, and being a complex and delicate issue, this problem is deemed a multi criteria decision making (MCDM). In recent years, many researchers have paid attention to this issue and utilized these methods for varied sections in energy such as energy policy, photovoltaic power plants site selection, energy planning and so forth [12].

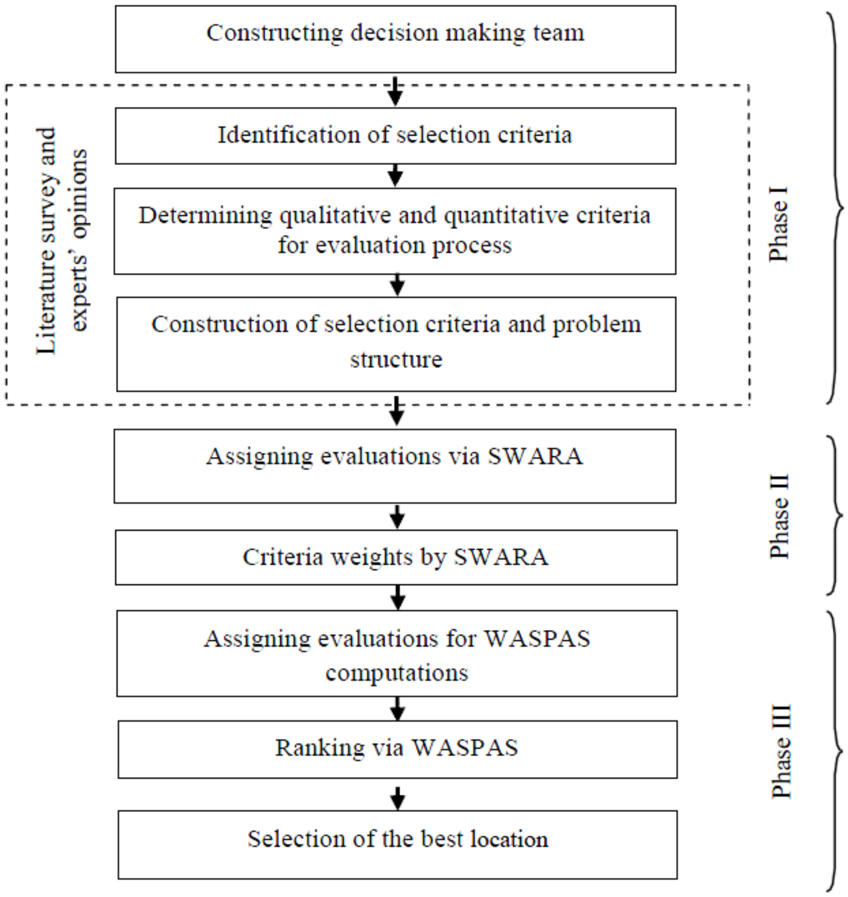
To have a better illustration, some studies worked on this delicate issue and suggested their methods are discussed. Haaren and Fthenakis [13] used spatial multi criteria analysis for New York State and the results are compared with the current sites. Gorsevski et al. [14] employed spatial decision support system in Northwest Ohio and their framework create a hierarchy by economic and environmental criteria for wind farm which uses weighted linear combination and geographical information system. Kim et al. [15] investigated a feasible study around Korean Peninsula for offshore wind farms based on benefit to cost ratio, the potential for installment and grid accessibility. Lozano et al. [16] investigated the combination of Geographic Information Systems (GIS) with Multi criteria Decision Making Methods for ranking the places having the potential for an onshore wind farm in Murcia and employed ELECTRE-TRI methodology to compare the methods which have been employed. Yahyai et al. [17] applied a hybrid Analytical Hierarchy Process and Ordered Weigh Averaging (AHP-OWA) for Oman and the lands classified the data based on GIS . Mekonnen and Gorsevski [18] demonstrated a web-based Participatory Geographic Information System (PGIS) to investigate the suitability of offshore wind farm for Lake Erie in Ohio. Aydin et al. [19] generated a decision support system and fuzzy objectives by using GIS for Usak, Aydin, Denizli, Mugla, and Burdur provinces in western Turkey. In another study, Yeh and huang [20] applied GQM, fuzzy DEMATEL, and ANP to determine the most significant contributory factors of wind farm locations. The results show that safety and quality criteria and environment and ecology criteria are paramount of importance. Azadeh et al. [21] applied Data Envelopment Analysis for wind farms in Iran and used Principal Component Analysis (PCA) and Numerical Taxonomy (NT) to validate the data. Bagocius et al. [22] applied permutation method for specifying the construction of offshore wind farms, moreover, some studies applied MCDM methods for selecting the best wind turbines. Martin et al.[3] employed TOPSIS method to evaluate the primitive designing of offshore wind turbines. Bagocius et al.[23] utilized WASPAS method for selection of best location for offshore wind farms and selecting the best wind turbine in the Baltic Sea.

2. Methodology

2.1. SWARA-WASPAS:

The matter which is a MCDM can be considered as a quantitative and qualitative problem. SWARA and WASPAS are suggested in 2010 and 2012, respectively. This research has applied a SWARA-WASPAS method [24] for ranking and weighting each criteria and the related alternative. The most important reason why this paper applied this method is to consider and deal with the problem based on different criteria and manifold aspects. To have a better illustration, figure 6 shows the phases in order and with details:

Figure 6. The procedure of the applied method.



Phase 1: Based on the expert's area, the team is made for specifying the criteria affecting the problem. After that, with regard to the related literature the experts formed the decision tree which is

shown in figure 7. This figure illustrates the structure and table 1 considers the criteria which are relevant to previous studies.

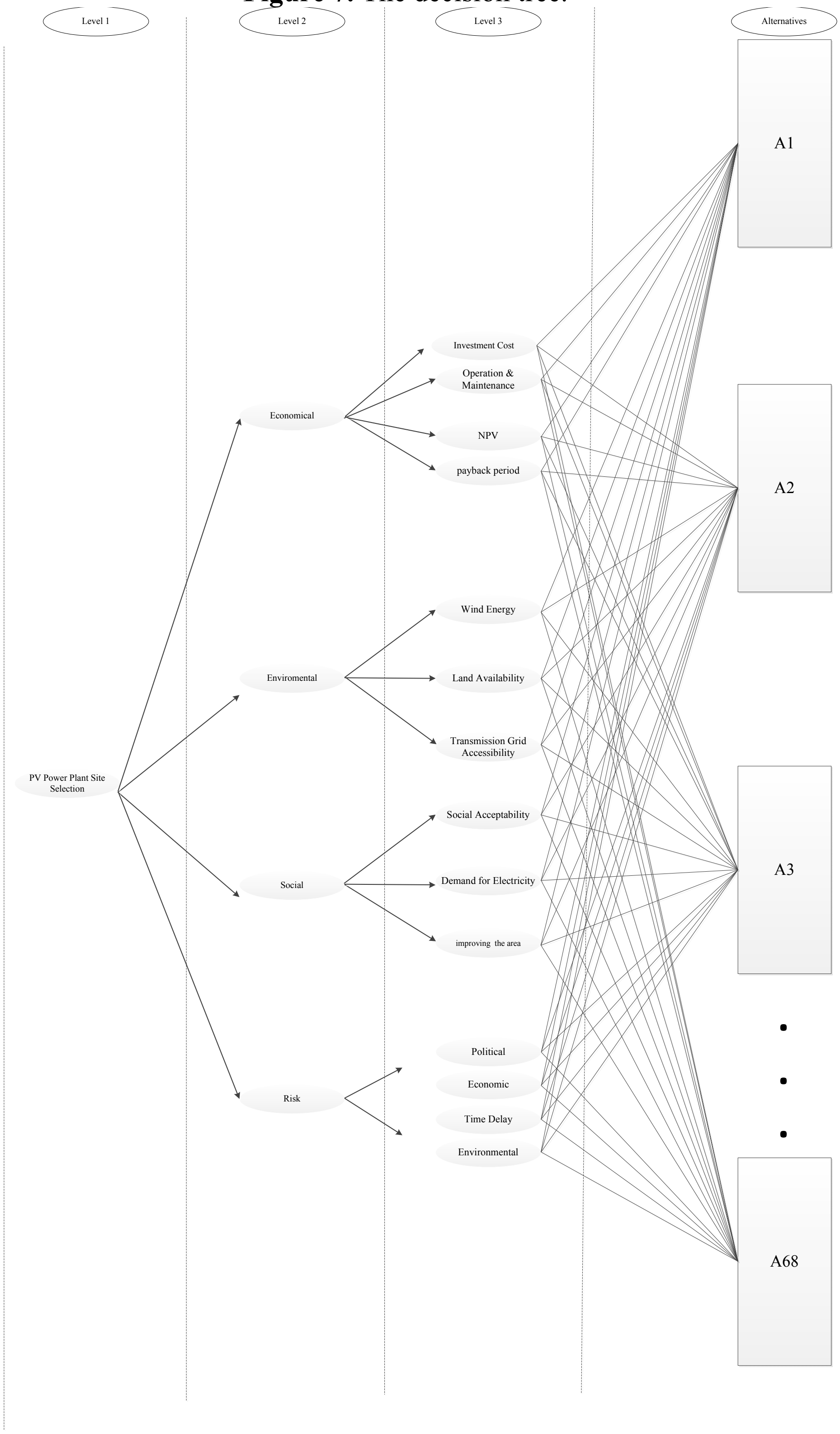
Phase 2: Having utilized SWARA with consideration of expert's assessment, the criteria are weighted by the experts.

Phase 3: In this phase, alternatives are evaluated for utilizing for WASPAS method.

Table 1. The criteria and sub-criteria introduced in the previous studies.

Evaluation Criteria	Sub-Criteria	Preferred	References
Economical (C1)	C1-1: investment cost	Min	[25-50]
	C1-2: operation & maintenance cost	Min	
	C1-3: NPV	Max	
	C_{1-4}: payback	Max	
Environmental(C2)	C2-1: Wind energy	Max	[51-58]
	C2-2: land availability	Max	
	C2-3: transmission grid accessibility	Max	
Social (C3)	C3-1: social acceptability	Max	[56, 59-62]
	C_{3-2}: demand	Max	
	C3-3: effect on progress of surrounding region	Max	
Risk (C4)	C4-1: political risk	Min	[63-66]
	C4-2: economic risk	Min	
	C4-3: time delay risk	Min	
	C4-4: environmental risk	Min	

Figure 7. The decision tree.

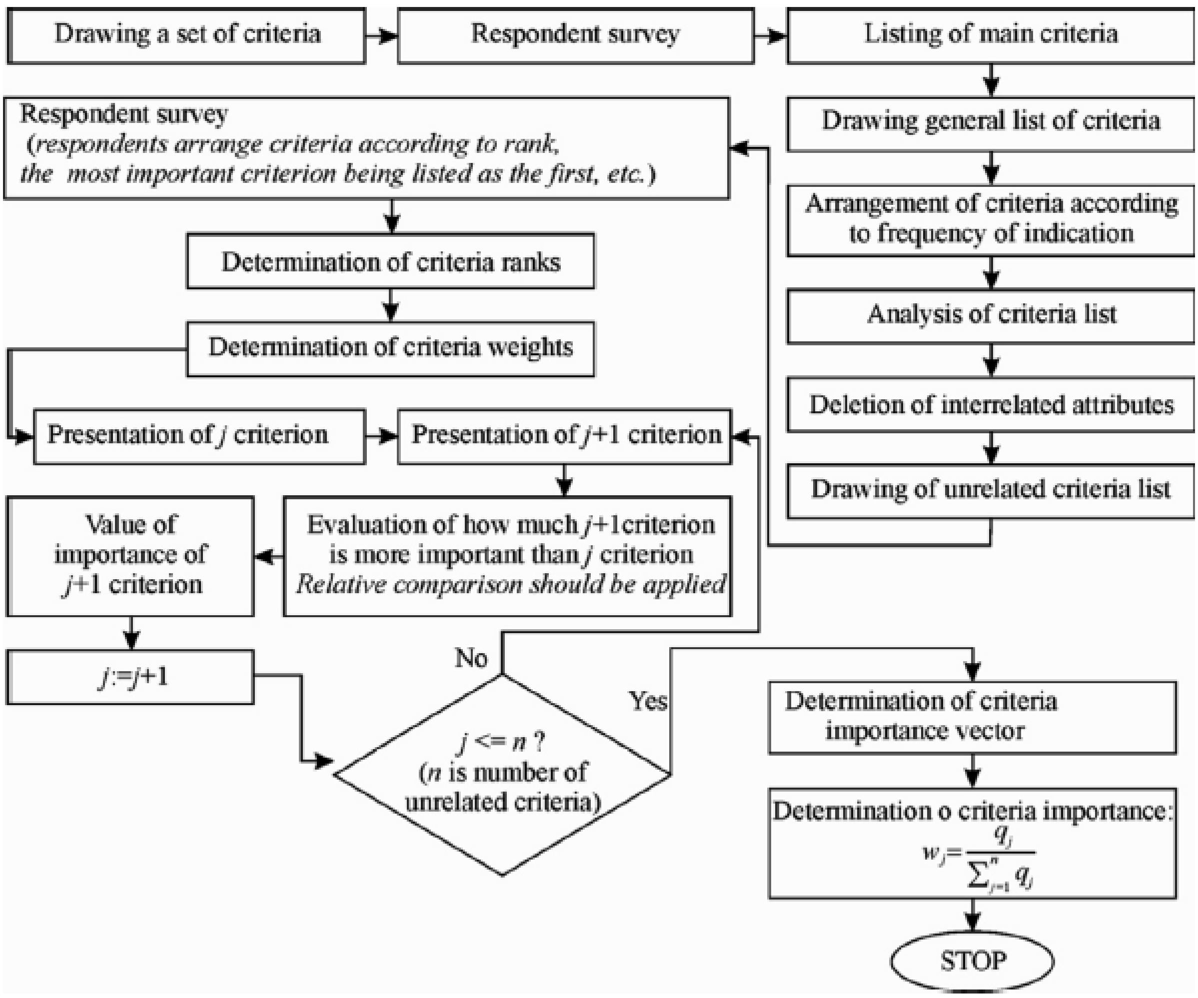


2.2. SWARA

For evaluation of the criteria and the weights, experts play an important role, so for determining the significance of them is done individually. After that, the criteria are ranked from the most to least with regard to total outcome. The expert's implicit knowledge and the related experience are the items helping them with decision making process. Based on SWARA the highest rank and the lowest are allocated to the most and least important respectively. The total ranks are determined with regard to the mean value of ranks [67].

The robustness of SWARA method is to assess expert's comments related to accuracy of the weight in the process of its procedure [68]. Moreover, it is able to assess the ranks with regard to the policies of governments. Therefore, it is straight forward that prioritization of the criteria can be done without being weighted first. The structure of SWARA is varied from other methods such as AHP, ANP and FARE SWARA provides a condition in which decision makers take a decision considering the goals and strategies. Based on aforementioned capabilities of SWARA method, it can be used by high ranked policy makers [68]. In other words, the capability of SWARA method is varied for many applications, to support this theory some researches done in different areas based on SWARA method are: Ruzgys et al. [69] applied a SWARA-TODIM method for evaluation of external wall insulation in residential buildings. Zolfani et al. [70] applied this method for selecting mechanical longitudinal ventilation when car accidents happen. Zolfani and Saparauskas [71] employed it for ranking sustainability evaluation factors of energy. To clarify better, based on the criteria weight applied in this paper, Figure 8 Shows the process of decision making for SWARA method [72].

Figure 8. identifing the critera.



2.3. WASPAS

WASPAS method was suggested in 2012 by Zavadskas et al. [73]. They combined Weighted Product Model and Weighted Sum Model to create WASPAS and proved that the robustness and accuracy of this model is considerable in comparison with WPM and WSM. Even though WASPAS introduced in 2012, due to its robustness it has been applied in some studies, Staniunas et al. [74] utilized it for ecological–economical assessing of multi-dwelling houses, Bagočius et al. [75] applied WASPAS for prioritizing a deep-water port, Vafaeipour et al. [76] prioritized the placement of solar power plants in Iran. Zavadkas et al. [77] developed the WASPAS method and created a new method called WASPAS-IVF and applied for prioritization of derelict buildings' redevelopment.

The procedure of WASPAS is as follows [24]:

The decision matrix is normalized

If the optimum value is maximum:

$$\bar{x}_{ij} = \frac{x_{ij}}{\underset{i}{opt}\, x_{ij}}, \text{where } i = \overline{1,m};\ j = \overline{1,n} \tag{1}$$

else:

$$\bar{x}_{ij} = \frac{\underset{i}{opt}\, x_{ij}}{x_{ij}}, \text{where } i = \overline{1,m};\ j = \overline{1,n} \tag{2}$$

Calculating the weights and summing up for summation section:

$$\bar{\bar{x}}_{ij,sum} = \bar{x}_{ij} q_j, \text{where } i = \overline{1,m};\ j = \overline{1,n} \tag{3}$$

Calculating WASPAS weights for multiplication section:

$$\bar{\bar{x}}_{ij,mult} = \bar{x}_{ij}^{\,q_j}, \text{where } i = \overline{1,m};\ j = \overline{1,n} \tag{4}$$

Final computation for evaluation and ranking alternatives:

$$WPS_i = 0.5\sum_{j=1}^{n} \bar{\bar{x}}_{ij} + 0.5\prod_{j=1}^{n} \bar{\bar{x}}_{ij}, \text{ where } i = \overline{1,m};\ j = \overline{1,n} \tag{5}$$

(4)

3. Discussion and results

3.1. SWARA Results

This section focuses on the outputs calculated by SWARA and table 2 depicts the results of criteria. The sub criteria are calculated in the same way and the results are shown in table 3. The criteria are ranked and depicted in the first column then the final weights of sub criteria is calculated via multiplying the weight of criteria by the related sub criteria. First the experts determined the weight of each criteria and sub-criteria, and after that the weights are ranked based on the mean values. S_j is determined based on the experts' ideas by Dephi method.

Table 2. The result obtaind from SWARA for assessed criteria.

Criterion	**Comparative importance of average value** s_j	**Coefficient** $k_j = s_j + 1$	**Recalculated weight** $w_j = \frac{x_{j-1}}{k_j}$	**Weight** $q_j = \frac{w_j}{\sum w_j}$
Environmental (C2)		1.00	1.00	0.35
Economical (C1)	0.29	1.29	0.78	0.27
Risk (C4)	0.29	1.29	0.60	0.21
Social (C3)	0.24	1.24	0.49	0.17

The following table shows the weights for all the sub-criteria briefly.

Table 3. The weights of sub-criteria.

Sub-Criteria	Weights	Sub-Criteria	Weights
C_{1-1}: investment cost	0.09	C_{3-1}: social acceptability	0.06
C_{1-2}: maintenance	0.05	C_{3-2}: demand	0.07
C_{1-3}: Net Present Value	0.06	C_{3-3}: improving the area	0.05
C_{1-4}: payback	0.07	C_{4-1}: Political risk	0.05
C_{2-1}: wind energy	0.11	C_{4-2}: economic risk	0.07
C_{2-2}: availability of land	0.10	C_{4-3}: delay risk	0.04
C_{2-3}: transmission grid accessibility	0.14	C_{4-4}: environmental risk	0.05

3.2. WASPAS Results

Having calculated the SWARA results, this study prioritizes the cities by WASPAS described in the WASPAS section. The 68 cities considered alternatives for selection of wind farm project. The Delphi method is used for reaching a compromise between experts and the input weights are shown in table 4.

Table 4. The WASPAS inputs.

	C_{2-1}	C_{1-1}	C_{1-4}	C_{1-3}	C_{4-2}	C_{2-3}	C_{1-2}	C_{3-2}	C_{4-4}	C_{4-1}	C_{4-3}	C_{3-1}	C_{3-3}	C_{2-2}
Preferred	Max	Min	Max	Max	Min	Max	Min	Max	Min	Min	Min	Max	Max	Max
Q	0.11	0.09	0.07	0.06	0.07	0.14	0.05	0.07	0.05	0.05	0.04	0.06	0.05	0.10
Meshkin Shahr	3	6	7	7	3	6	7	8	7	4	6	7	6	5
Namin	3	6	6	7	3	6	8	6	7	4	7	6	7	3
Oscoo	2	7	7	7	2	6	8	7	7	3	6	6	7	5
Ahar	7	5	6	7	3	6	7	7	7	5	6	7	6	4
Bonab	1	6	5	7	4	6	6	6	7	5	5	6	8	5

Mayan	2	7	4	7	5	6	6	6	7	6	7	5	8	6
Chaldoran	2	8	8	7	1	6	9	8	7	6	6	5	8	4
Brojen	1	6	6	8	3	9	6	7	8	3	5	7	6	6
Moghar	1	6	5	8	4	9	7	7	8	3	4	6	7	6
Morchekhort	2	5	3	8	6	9	5	8	8	2	4	7	6	8
Varzaneh	2	4	2	8	7	9	6	6	8	3	5	6	5	7
Eshtehard	3	9	8	7	1	9	5	9	9	2	2	9	4	8
Kahrizak	1	8	8	7	1	9	4	8	9	3	2	8	4	9
Latman	2	9	9	7	1	9	5	9	9	1	1	9	3	6
Khomeyn	1	6	5	3	4	6	5	7	7	5	5	6	7	7
Nahavand	1	4	6	5	3	7	6	6	6	5	6	5	7	7
Rasul Abad	2	5	7	7	2	7	5	5	6	6	6	6	7	6
Kabodarahang	2	6	5	7	4	7	6	6	6	6	7	5	7	6
Delvar	1	4	4	6	5	9	5	7	5	4	5	7	8	7
Bardkhoon	3	5	5	6	4	9	7	6	5	3	6	6	8	8
Esfarayen	1	4	6	7	3	7	6	7	9	4	5	5	6	8
Bojnurd	2	7	8	7	1	7	5	9	9	3	4	5	5	8
Davarzan	2	6	3	7	6	7	4	7	9	3	6	5	7	7
Sarakhs	2	3	7	7	2	7	7	9	9	4	6	7	8	9
Ghadamgah	3	5	6	7	3	7	7	6	9	5	7	6	7	7
Khaf	9	5	5	7	4	7	6	5	9	5	6	5	6	8
Jangal	1	4	6	7	3	7	6	5	9	4	5	4	6	7
Rudab	3	5	5	7	4	7	6	6	9	3	6	5	7	7
Afriz	2	4	4	7	5	7	5	7	9	4	7	6	6	6
Fadashk	3	3	6	7	3	7	7	5	9	6	7	5	8	7
Nehbandan	4	5	5	7	4	7	5	6	9	6	5	6	7	6
Mahi Dasht	1	4	6	7	3	8	6	8	6	7	6	6	7	7
Divandare	1	6	5	6	4	8	7	7	5	8	6	4	8	5
Ghorve	2	5	6	6	3	8	8	8	5	7	7	3	6	5
Abadan	2	8	4	7	5	9	5	9	6	4	3	8	5	5
Shushtar	1	6	5	7	4	9	6	8	6	4	4	8	6	7
Mahshahr	3	5	7	7	2	9	4	9	6	5	2	9	6	5
Hoseynie	2	5	4	7	6	9	6	5	6	5	7	6	7	6
Javim	1	5	4	6	5	8	7	6	7	4	6	5	6	8
Marvdasht	1	6	5	6	4	8	6	5	7	5	5	6	5	8
Abade	2	4	4	6	5	8	6	6	7	5	7	4	7	7
Eghlid	2	3	4	6	5	8	8	7	7	4	6	5	8	7
Arzooye	1	3	3	7	6	8	6	5	4	5	7	6	6	9
Rafsanjan	2	5	4	7	5	8	6	6	4	3	6	6	6	8
Shahre Babak	1	5	3	7	6	8	7	5	4	4	6	5	8	8
Agh Ghala	1	4	6	5	3	6	4	7	5	3	5	7	8	7

Marave Tappe	1	5	5	5	4	6	5	7	5	4	6	6	6	6
Jask	1	3	8	6	1	9	4	8	5	4	3	6	7	6
Kish	2	6	9	6	1	9	3	9	5	6	2	8	7	4
Behabad	2	5	5	8	4	9	6	5	6	4	5	7	6	8
Halvan	2	4	3	8	6	9	7	6	6	5	6	6	7	8
Korit	1	5	3	8	6	9	7	5	6	5	7	5	8	7
Abarkuh	1	3	2	8	7	9	6	4	6	4	6	6	8	8
Ardakan	2	6	3	8	6	9	5	6	6	4	5	7	7	9
Delgan	2	2	6	6	3	8	7	6	2	7	7	5	6	8
Dehak	2	3	5	6	4	8	6	5	2	7	6	4	7	8
Nosratabad	2	3	6	6	3	8	7	6	2	8	8	3	8	7
Lutak	5	4	6	6	3	8	8	5	2	7	7	4	8	8
Khash	2	4	7	6	2	8	7	5	2	6	7	5	7	9
Chabahar	2	3	9	6	1	8	3	9	2	6	3	7	7	6
Langrood	1	5	5	2	4	4	6	8	7	4	4	7	7	6
Haddadeh	3	4	6	5	3	8	4	6	6	4	5	7	8	8
Kahak	2	4	5	5	4	8	5	7	6	3	6	6	6	9
Moalleman	4	3	5	5	4	8	5	5	6	4	6	7	7	9
Senar	1	4	6	3	3	6	6	8	7	4	7	7	8	8
Shurje	5	5	7	5	2	5	4	8	8	3	4	7	7	8
Jarandagh	4	4	7	5	2	5	7	5	5	6	7	3	8	5
Soltanye	3	3	3	6	3	8	5	7	7	5	4	7	5	7

The result shows the options for all the cities in Iran and the rank from 1 to 68 shows the best choices from the best to the worst and the results based on the procedure of WASPAS are depicted in table 5.

Table 5. The results of WASPAS.

Alternatives	$0.5\sum_{j=1}^{n}\bar{\bar{x}}_{ij}$	$0.5\prod_{j=1}^{n}\bar{\bar{x}}_{ij}$	WSP_i	Rank	Alternatives	$0.5\sum_{j=1}^{n}\bar{\bar{x}}_{ij}$	$0.5\prod_{j=1}^{n}\bar{\bar{x}}_{ij}$	WSP_i	Rank
Meshkin Shahr	0.2491	0.2304	0.4794	35	Abadan	0.2438	0.2252	0.4689	44
Namin	0.2514	0.2297	0.4811	33	Shushtar	0.2359	0.2069	0.4428	60
Oscoo	0.2549	0.2277	0.4825	31	Mahshahr	0.2136	0.2027	0.4163	65
Ahar	0.2652	0.2454	0.5106	15	Hoseynie	0.2559	0.2316	0.4875	27
Bonab	0.2551	0.2202	0.4753	39	Javim	0.2651	0.2290	0.4941	26
Mayan	0.2812	0.2503	0.5315	5	Marvdasht	0.2554	0.2214	0.4768	38
Chaldoran	0.2510	0.2083	0.4594	49	Abade	0.2638	0.2380	0.5018	21
Brojen	0.2320	0.2030	0.4350	62	Eghlid	0.2623	0.2353	0.4976	22
Moghar	0.2484	0.2169	0.4653	46	Arzooye	0.2575	0.2152	0.4727	41
Morchekhort	0.2715	0.2470	0.5185	10	Rafsanjan	0.2577	0.2370	0.4947	25
Varzaneh	0.2784	0.2485	0.5269	7	Shahre Babak	0.2757	0.2342	0.5099	16

Eshtehard	0.2564	0.2238	0.4802	34	Agh Ghala	0.2399	0.2101	0.4500	55
Kahrizak	0.2404	0.1954	0.4358	61	Marave Tappe	0.2426	0.2147	0.4573	51
Latman	0.2576	0.2164	0.4740	40	Jask	0.1967	0.1708	0.3675	67
Khomeyn	0.2693	0.2334	0.5027	20	Kish	0.1991	0.1788	0.3779	66
Nahavand	0.2420	0.2099	0.4519	54	Behabad	0.2496	0.2280	0.4776	37
Rasul Abad	0.2342	0.2110	0.4452	58	Halvan	0.2667	0.2367	0.5034	18
Kabodarahang	0.2552	0.2308	0.4859	29	Korit	0.2690	0.2262	0.4952	24
Delvar	0.2389	0.2086	0.4475	56	Abarkuh	0.2822	0.2310	0.5132	12
Bardkhoon	0.2647	0.2466	0.5112	14	Ardakan	0.2765	0.2465	0.5230	8
Esfarayen	0.2489	0.2128	0.4617	48	Delgan	0.2232	0.1936	0.4169	64
Bojnurd	0.2511	0.2164	0.4676	45	Dehak	0.2442	0.2144	0.4586	50
Davarzan	0.2851	0.2575	0.5427	2	Nosratabad	0.2401	0.2048	0.4449	59
Sarakhs	0.2490	0.2128	0.4618	47	Lutak	0.2684	0.2390	0.5074	17
Ghadamgah	0.2635	0.2395	0.5030	19	Khash	0.2392	0.2063	0.4454	57
Khaf	0.3140	0.2872	0.6011	1	Chabahar	0.1889	0.1685	0.3574	68
Jangal	0.2536	0.2179	0.4715	42	Langrood	0.2932	0.2477	0.5409	4
Rudab	0.2749	0.2563	0.5311	6	Haddadeh	0.2491	0.2320	0.4812	32
Afriz	0.2528	0.2301	0.4829	30	Kahak	0.2536	0.2326	0.4862	28
Fadashk	0.2621	0.2336	0.4958	23	Moalleman	0.2654	0.2465	0.5119	13
Nehbandan	0.2661	0.2484	0.5146	11	Senar	0.2596	0.2195	0.4791	36
Mahi Dasht	0.2250	0.1925	0.4174	63	Shurje	0.2821	0.2600	0.5421	3
Divandare	0.2446	0.2079	0.4525	53	Jarandagh	0.2757	0.2464	0.5221	9
Ghorve	0.2406	0.2137	0.4543	52	Soltanye	0.2418	0.2276	0.4694	43

4. Conclusions

In this study, all the important factors are involved for selection of wind farms in Iran based on expert' comments and criteria are weighted via SWARA. Then, the weights of criteria which are resulted from SWARA are applied to WASPAS method. Regarding the results, Khaf is the best city to install wind farms among 68 cities in Iran. Moreover, other cities are priorotized in order by SWARA-WASPAS method. The results can be helpful for policy makers and determing energy strategy in Iran. In addition, the method can be used for placement of other power plants such as compressed air energy storage, solar towers as well as geothermal. In addition, this method can be used for the selection of wind turbines, PV and so forth. Although this paper used important factors, the other factors can be added for having more accurate results. Moreover, other hybrid algorithms such as SWARA-VIKOR, ANFIS-SWARA, AHP-WASPAS can be applied and the results are compared with this study.

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