Desert

Desert
Online at http://desert.ut.ac.ir

Desert 19-2 (2014) 111-119

Solar desalination plant site suitability through composing decision-making systems and fuzzy logic in Iran (using the desert areas approach)

H. Paktinat[a*], H.A. Faraji[a], A. Rahimi Kian[b]

[a] *Faculty of Geography, University of Tehran ,Tehran, Iran*
[b] *Faculty of Electrical & Computer Engineering, University of Tehran, Tehran, Iran*

Received: 5 November 2013; Received in revised form: 24 August 2014; Accepted: 30 September 2014

Abstract

Freshwater resources represent around 3% of all water on Earth, and less than 1% of that is available. Considering current conditions, as well as future predictions of need, freshwater resources cannot meet human needs. Thus, sweetening of the brackish water can be performed to provide freshwater for human use. Solar energy, because of Iran's climatic conditions, may be used for sweetening the brackish water. The objective of this study was to survey the lands using groundwater resources for the installation of solar desalinations. According to the goal, criteria and indicators were identified by the analyses of previous studies' data, Delphi method and the internal structure of measurements and indicators determined using the DEMATEL technique. Then, indicators were weighted using the analytic network process (ANP) method, and indicators' suitable membership functions were defined using fuzzy logic. Indicators have been combined by the means of minimum function. Eventually, the areas were classified into four classes. The results showed that among 250 scope studies, 20 scopes have been put in class one, and these are located in five provinces. The results also indicated that among the provinces of Iran, Yazd is located in an area with the highest percentage of class one, and is ranked first. Comparisons of the obtained results with the climatic conditions of Iran confirmed the results.

Keywords: Solar desalination; ANP; Fuzzy logic; DEMATEL; Delphi

1. Introduction

More than two thirds of the Earth's surface is covered by water. Oceans contain about 97% of the Earth's water, and only about 3% of all water on the Earth is freshwater; less than one percent of that is available for human uses. Generally, the human need for water is doubled every 20 years and, currently, most of the water resources have been consumed in the countries of the Middle East. It is estimated that the population will be increased by 50% in Africa, 25% in Asia and 14% in America in the next 20 years (FAOSTAT, 2000). It is clear that the population in developing countries such as Iran has increased more than the average level of Asia (World Bank, 1990-2010). Therefore, considering current conditions as well as future predictions, current freshwater resources are limited for future use.

Furthermore, in many areas, due to climatic and geological conditions, freshwater may not be available. Humans should therefore supply the missing portion of water by sweetening brackish water. Desalination refers to a process that separates salt from brackish water (salty water). Desalination is performed for different purposes including drinking water (freshwater), agriculture, industry, and the military worldwide. Water obtained by the means of desalination can be an important water resource for many countries of the Middle East, Persian Gulf and northern Africa.

Water and energy are two human needs that are always going to be together, and with the

* Corresponding author. Tel.: +98 913 9527062,
Fax: +98 21 66404366.
E-mail address: paktinat.hadi@gmail.com

increase in population their correlations are increased (Gude *et al.*, 2011). The solar desalination process is energy consuming (Rodriguez, 2003). Therefore, the increased use of desalination plants causes one main problem for energy consumption. Energy may be supplied from the electrical, mechanical and heating resources. The benefits and efficiency of water desalination strongly depend on the costs of energy consumption (Sagie, 2001). Energy is the biggest variable for the cost of a water desalination system, while more than one-third and even more than half of the cost of water production belongs to it (Chealhry, 2003).

Factors that have more of an influence on the cost of water sweetening are the quality of input water (level of salinity), quality of produced water, costs of energy, and scale (Alatigi *et al*., 1999; Dore, 2005). Economic factors are the most important factor determining final success and the development of water desalination systems. Worldwide, 77% of fuels are supplied by fossil resources, and they produce pollutant gases and greenhouse gases in the conversion process, which damages ozone layer, is dangerous for the environment, produces heat, and causes an increase in the temperature of the Earth (Rashidi & Gharib, 2011). Furthermore, resources of fossil fuels are reducing whilst their prices are increasing, so the use of fossil fuels for a water desalination system cannot be an economical process. Solar energy has the largest correlation with the need for water as compared to the other renewable energies because it is the main factor for water reduction (Gastli *et al*., 2010).

Solar energy is a natural energy and is cheaper than fossil fuels, but primary investments for the collection and conversion of solar energy into a usable form are high (Sagie, 2001). Solar energy is one of the best renewable energies, and Iran has good climatic conditions for its development. The amount of sun radiation in Iran is almost 5kwh/m^2/year, and Iran has sun radiation 300 days per year in more than 90% of its areas (Saghafi, 2009). The data used in this study were obtained from NASA[1]. These data extend the temporal coverage of the solar data from approximately 11 years to 22 or more years (e.g., July 1983 through June 2005) and related to the (SSE[2]) NASA project.

The objective of this study was to survey the lands for the installation of solar desalination using knowledge-based systems (Delphi method and questionnaires), the DEMATEL technique, multi-criteria decision-making systems and fuzzy logic. Effective site selection for the installation of solar desalinations depends on several factors, including morphology, hydrology and sun radiation.

Geographical information system (GIS) with a multi-criteria decision-making process (MCDM), a spatial decision support system and fuzzy logic can be used for the selection of optimum areas for the installation of solar desalinations.

Many investigations have been performed using an analytic network process, but multi-criteria decision-making systems, structure making systems and incorporated knowledge systems are not used frequently. Only one investigation has been done with the help of multi-criteria decision-making systems and geographical information systems to determine suitable areas for the installation of solar desalinations using groundwater. Salim grouped Egypt into several classes (Salim, 2012). Rujula (2009) presented the best energy resource in Mauritania using multi-criteria analysis, and has found that the best resources for energy in Mauritania for water desalination are wind and solar energy, respectively (Rujula & Dia, 2010).

The objective of this study was to survey the lands using groundwater resources for the installation of solar desalinations with the help of geographical information systems and multi-criteria decision-making systems.

2. Material and methods

The area of this study is located in Iran, because all of the areas in Iran do not need the water desalination and considering two indicators including precipitation rate and salinity level of groundwater, some areas of Iran with precipitation rates higher than threshold of dry areas and those with non-salty water were removed from this investigation. According to the new definition of desert, with the exception of a narrow strip in the north of Iran, other parts of the country encounter the problem of desertification (Shakerian *et al*., 2011). Some climatologists used the annual mean precipitation indicator to obtain different values for the separation of dry areas from non-dry ones. Based on Fink's findings, areas with an annual mean precipitation less than 500 mm are dry, and those with an annual mean precipitation less than 250 mm are deserts (Jazirei, 1991). Gansen noted that the areas with an annual mean precipitation less than 350 mm are located in dry areas, and if this value is less than 125 mm, these areas are deserts (Hossein Zadeh, 1998).

[1] http://eosweb.larc.nasa.gov
[2] Surface meteorology and solar energy

Another drought indicator is the reconnaissance drought index (RDI). This index is based both on precipitation (P) and potential evapotranspiration (Dastorani *et al*., 2011).

Considering Iran's climatic conditions, the areas studied with an annual mean precipitation more than 300mm were removed. Isohyet line (Iran Water Resources Management Company) was used to identify these areas. On the other hand, according to the World Health Organization (WHO), the allowable limit for the salinity of freshwater (drinking water) is 500 ppm, and for specific cases this value is 1000 ppm (Eltawil *et al*., 2009). Thus, groundwater with a salinity of less than 1000 ppm was removed from the study. Eventually, because of data availability limitations, the areas without sufficient data were removed, and finally 250 areas out of 609 in Iran concerning the Water Resources Management Company were selected. Figure 1 shows these areas.

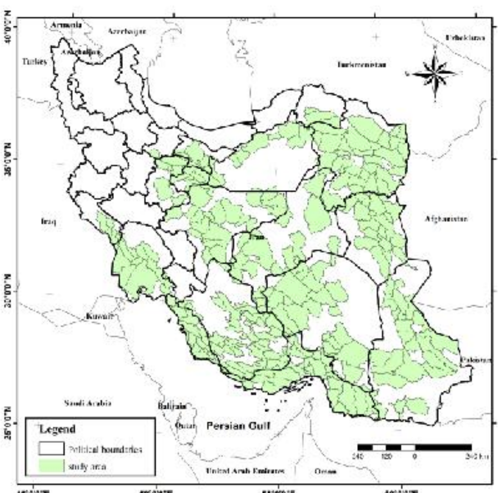

Fig. 1. Case study boundary

Determination of the appropriate place for the installation of solar desalination depends on full and correct knowledge of effective factors and means of selection in the current study. Previous investigations and the Delphi method were used to identify the effective factors on the classification of water desalination systems. Meriam Salim (2012) used sun radiation, depth of groundwater, salinity of groundwater and distances from the Nile Delta and valley to determine suitable places for the installation of solar desalination using groundwater.

In this study, regarding the distance from the Nile valley, two indicators, including the distance from communication lines (roads) and residential centres were obtained and. as has been mentioned by Salim (2012), this is due to the reduction of population compression, residential places, and communication lines because of an increasing distance from the Nile valley (according to Egypt's conditions). Charbi (2011) used a slope indicator for surveying the suitability of places (areas) for water desalination systems (Charbi & Gastli, 2011). By considering Iran's conditions and national effective factors in this study in addition to the use of resources, the Delphi method was used to incorporate the experts' viewpoints and identify new factors.

The Delphi method is a structured process for the collection and classification of existing data with respect to some groups of experts, while distributing a questionnaire to them and taking control feedback from the received answers. The Delphi method is used to discover creative and reliable ideas or supply suitable information for making decisions (Jafari & Montazer, 2007).

Thus, unlike scanning investigations, the reliability of the Delphi method does not depend on the number of participants in the investigation, but its reliability depends on the scientific reliability of specialists that participate in the investigation. In the current investigation, three specialists in the Delphi method attended and their viewpoints were taken and collected using questionnaires. Using the Delphi method, slope, dam and precipitation were added to the effective factors in this study.

After the identification of criteria and indicators at the next step, it should be clear that these criteria and indicators independently affect each other, or work together. Therefore, if they work together, what are their communication structures? In the current study, because of the correlations between indicators, the DEMATEL technique was used to identify the communication structures for the desired criteria and indicators. There are many multi-criteria decision-making methods with regard to the assumption of existing independence between the elements of system, but for all the cases this independence does not exist (Buyokozkan & Cifci, 2012). The DEMATEL technique was presented in 1993 as a method for structural modelling concerning a problem (Fontela & Gabus, 1976).

This method specifies knowledge of specialists for determining the communication structures between criteria and drawing the network map. The DEMATEL technique is one of the pairing comparison-based decision-making methods that use experts' views to determine the elements of a system and their systemic structures using the graphic theory of principal structures of existing elements in the system, while influencing and interacting with each other to obtain the elements. Experts' jurisdictions in pairing comparisons are simple, and specialists do not need to know about the DEMATEL process, but the quality of their viewpoints and extent of their insights into different sides of the problem have strong influences on the results given by DEMATEL (Aghaebrahimi, 2008).

Thus, the DEMATEL questionnaire has been provided and given to the specialists, and they were asked to complete the questionnaires. After this, the DEMATEL technique was implemented using the obtained questionnaires according to the following steps.

Step 1: Find the initial average matrix and the average matrix obtained based on pairing matrices completed by specialists.

Step 2: Calculate the primary matrix of normal and direct relationships.

Step 3: Calculate the final relationship matrix (T).

Step 4: Define a threshold value to achieve a final effect map.

In the final step, threshold limits are determined by calculating the average of the elements' matrix. Because the matrix provides information on interactions between two factors, decision makers should determine a threshold limit for filtering the insignificant effects. Final results for this procedure are shown in Table 1. Zero (0) in Table 1 means that there is no interaction between the elements in the rows and columns, while number 1 indicates the effects of elements in the rows on those in the columns.

Table 1. Final results of DEMATEL techniques

Criteria	Distance from Dam	EC	Slope	Radiation	Precipitation	Distance from roads	Distance from Residential Centers	Groundwater Depth
Distance from Dam	0	0	0	0	0	0	0	0
EC	0	0	0	0	0	0	0	0
Slope	0	0	0	1	0	0	0	0
Radiation	0	0	0	0	0	0	0	0
Precipitation	1	1	0	0	0	0	0	1
Distance from roads	0	0	0	0	0	0	1	0
Distance from Residential Centers	0	0	0	0	0	1	0	0
Groundwater Depth	0	0	0	0	0	0	0	0

For solving the problems of site selection, because a set of purposes should be optimized at the same time, a multi-criteria decision-making process is used (Forghani *et al*., 2007). As has been mentioned before, there are many multi-criteria decision-making methods that assume the elements of the system as independent ones, but for all cases this independence does not exist (Wu, 2008). For solving this problem, the analytic network process is a relatively new method that was presented in 1996 by Saaty (Saaty, 1996). Saaty has presented the ANP method for solving the problems of correlations between choices or criteria (Najafi, 2010; Dorri & Hamzei, 2010).

The analytic network process is one of the multi-criteria decision-making techniques, and is considered as one of the compensatory models (Faraji-Sabokbar *et al*., 2008). In fact, the analytic network process is one of the multi-criteria decision-making techniques that can remove the limitations of the analytic hierarchy process (Kiani *et al*., 2010). The analytic network process can be used as an effective tool for cases in which the interactions between the elements of a system are formed as a network structure (Saaty, 1996).

Developing an ANP model requires identification of the problems, definition of the related criteria and sub-criteria, and determination of their relationships and interactions. As mentioned before, unlike the analytic hierarchy process, in which the relationships between elements of a system are unidirectional, in the analytic network process, one element of a model influences the other elements, and may even be affected by the other elements so that when using a method the internal relationship between elements should be specified in the analytic network model. In the current study, the DEMATEL technique was used to find internal relationships between the elements of a system for the analytic network model (Fig. 2), which has been described in full above (Saeidi & Najafi, 2010).

The modelling process in the ANP technique includes the following steps:

1. Pairing comparisons matrix and estimation of relative weighting:

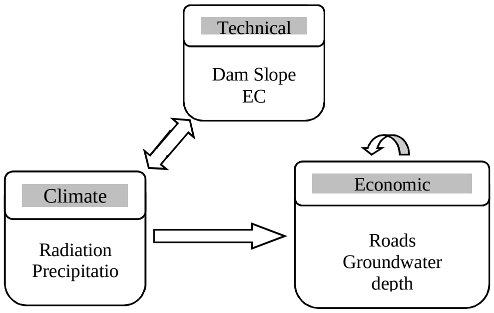

Fig. 2. General structure of model

After developing the network model, pairing comparisons between criteria and sub-criteria were performed using the relative significance scale. Pairing comparisons and element-pairing matrices in each level are performed according to relative significance rather than control criteria, which may be similar to the AHP method. Experts' viewpoints were used to obtain the pairing matrices. To avoid specific problems in the decision-making process, we try to select participants with the same levels of specialists and sufficient knowledge on the related issues.

2. Formation of primary supermatrix

ANP elements have specific interactions. These elements can include decision maker unit, criteria, results and choices. Relative weight of each matrix has been calculated based on pairing comparisons similar to AHP method. Obtained weights entered to supper matrix showing the interactions between elements of system.

3. Calculation of general weight vector

In order to implement analytic network technique in current study, Super Decisions software, version 2008, was applied. Thus, at first step, internal structures of indicators and criterion network models were simulated using the results reported by the DEMATEL technique (Table 1). Then, in order to collect the experts' viewpoints, a questionnaire was designed and given to the specialists, and, afterwards, the obtained results were collected. At the final step, using questionnaires, pairing comparisons were made between criteria and indicators. Weights obtained from the analytic network technique are shown in Table 2.

4. Combination of layers:

After identifying the criteria and indicators using previous studies and the Delphi method, relationships between these criteria and indicators were identified and then weighted by the analytic network process. Afterwards, these indicators needed to be combined. In order to do this, fuzzy logic was used in the current investigation.

Table 2. Criteria and indicators used in the model and weights obtained from ANP

Criteria	Indicators	Weight
Technical	Distance from Dam	0.051
	EC	0.1821
	Slope	0.099
Economic	Distance from Roads	0.0459
	Groundwater Depth	0.2144
	Distance from Population Centers	0.1458
Climate	Radiation	0.1368
	Precipitation	0.125

Fuzzy theory was first presented by an Iranian scientist named Asqar Lotfizadeh, professor of the University of America working on non-reliable conditions (Kahraman *et al*., 2006). Considering fuzzy logic, the degree of membership of an element within a set is defined by a value in the interval between zero (uncompleted membership) to one (completed membership) (Pour Ahmad, 2007). Degrees of membership are usually defined by the membership function by which they can be linear, non-linear, continuous or non-continuous (Bonham & Carter, 1991).

Considering the fuzzy model, for each pixel in each map, the value of zero to one (0-1) is given to indicate suitable places for the pixels with respect to the related criteria for the objectives of this study. On the other hand, concerning fuzzy logic, each area according to the value adapted with the criteria has a membership value indicating the amount of area suitability. To achieve success, the use of fuzzy mathematics for different applications is strongly dependent on the proper membership function (Sui, 1992). In the current investigation regarding different factors, three kinds of fuzzy function were used (Table 3).

In the current study, the first kinds of functions were used to model the indicator of distance from a road, distance from residential centres, distance from a dam, precipitation and radiation. Generally, elements related to distances and continuous issues such as radiation can be modelled by these functions. In order to model the slope and salinity indicators, because of non-linear variations for these two indicators, a sinusoidal function was used for this case. Boundary values and membership functions have been defined for the indicator map related to six factors shown in Table 3.

Table 3. Membership functions and domains defined for the indicators

Indicators	Membership Function	Domains
Distance from Roads		
Distance from Residential Centers	U=	min ≤ x ≥ max
Precipitation		
Radiation	U=	min ≤ x ≥ max
Distance from Dam		
Slope	U=	c ≤ x ≥ d
	U=	a ≤ x ≥ 1500
EC	U=1	X=1500
	U=	1500 < x ≤ d

Regarding the natural depth of groundwater and existing data, it was not possible to survey gradual changes for the suitability of different areas in a specific map, so for this indicator, the membership function was utilized. However, all the points with the same depth have a same degree of membership. Different classes for the mentioned factors and the given fuzzy values for them are shown in Table 4. After applying the fuzzy functions and creating fuzzy layers, all the layers were multiplied by the weights obtained from the analytic network process (Fig. 3); then, they were combined using minimum function (Fig. 4).

Table 4. Different classes of groundwater depth and degree of fuzzy membership in each class

Membership Value	Class	Indicator
1	0-25	
0.8	25-50	
0.6	50-75	Groundwater Depth
0.4	75-100	
0.2	100-125	

Using minimum function instead of the simple additive weighting method (SAW) has a main advantage. Minimum function is a non-compensation function, while the SAW method is a compensation one. On the other hand, in minimum function, unlike the SAW method, the effects of an indicator cannot be removed by the impacts of the other indicators.

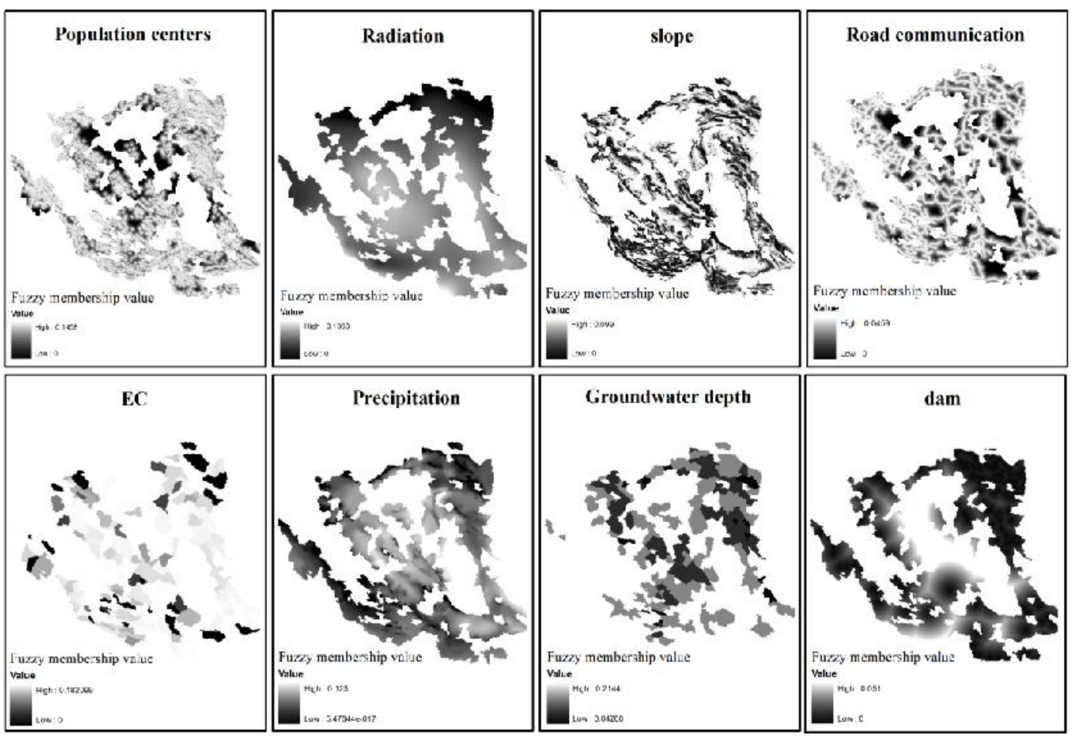

Fig. 3. Weighted fuzzy maps of indicators used in the study

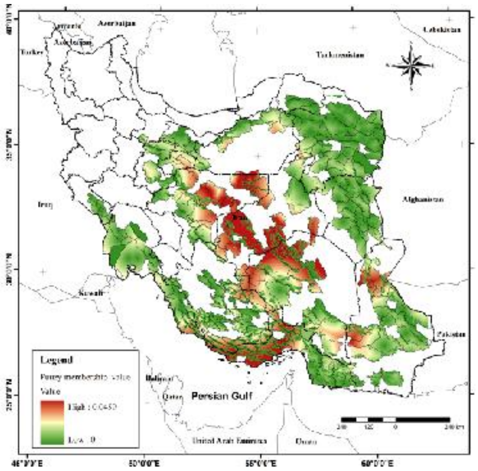

Fig. 4. Final phase map obtained by minimum function

3. Results

Regarding the results obtained from this study, technical, economical and climatic criteria and eight indicators (Table 2) were selected as the most important factors in the survey for selecting the suitable lands for the installation of water desalination systems.

The analytic network process indicated the depth of groundwater and level of salinity to have the largest weights. After combining the layers by the minimum function and preparing a final fuzzy map for the study, the fuzzy map was classified by the interval of 0.015 and all limitations were classified as four classes in a manner where classes one and four refer to the most and least suitable lands for the installation of water desalination systems, respectively (Fig. 5). The results have shown that class one is located in five provinces of Yazd, Isfahan, Kerman, Hormozgan and Semnan. Yazd province is located in the area with the highest percentage of class one and is ranked first. Kerman, Isfahan, Hormozgan and Semnan provinces have occupied the other positions, respectively.

The results showed that among 250 scope studies, 20 were put in class one. Largest area is located in Yazd-Ardakan plain in Yazd province with the average EC of 8538 ppm and the average piezometric level of 50 to 75m according to the inspections, field studies and investigation information on these areas. The results obtained from this investigation are fully logical and practical.

On the other hand, a good agreement can be found between the current investigation and climatic conditions in Iran confirming these results. Generally, class one determines the most suitable areas. In central areas in Iran, with hot and dry weather conditions, groundwater is often salty and the precipitation rate is very low. It should be noted that the defined classes are conventional and the final fuzzy map can be classified in different classes with different intervals.

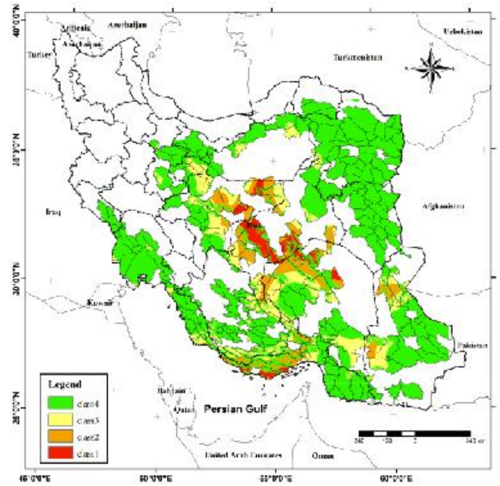

Fig. 5. Final classification map of study area

4. Discussion and Conclusion

Because of hot weather and a low rate of precipitation, and the increased use of groundwater, water levels in desert areas in Iran are to be decreased and the salinity of water increased. Desalination of brackish water is the only solution when there are no water resources. One of the most important factors influencing the development and final success related to a water sweetening system is the economic factor: desalination is a very energy-consuming process. The highest varying cost is spent for energy regarding the desalination process, so that more than one third and even sometimes more than half of the costs of water desalination may belong to it (Chaudhry, 2003).

Solar energy is a natural form of energy, and is cheaper than fossil fuels. Iran is located on the worldwide solar belt and is a country that has good access to solar energy, with susceptible areas for using this energy. According to different developed technologies related to desalination using solar energy, we can now use both parts of solar energy including photon and heating for the desalination process. One of the unique advantages for using solar energy in Iran is the applicability of it in all of the areas, even those with a low solar heating rate. The results obtained from the current study have shown that central areas including Yazd, Isfahan, Kerman, Hormozgan and Semnan provinces are more susceptible for the installation of water desalination systems. Solar desalinations require low costs for operation and maintenance processes, but need high primary investments for the installation. Otherwise, this technology could be the best solution for areas where population centres and water resources are reducing. The results obtained from the current investigation have shown that suitable selections for the installation of water desalination can be performed using multi-criteria decision-making and geographic information systems (GIS).

References

AghaEbrahimiSamani, B., A. Makoi, M.H. SadrLahijani, 2008. Challenges of Iranian companies in oil and gas projects to DEMATEL. Sharif Journal (Industrial Engineering & Management), 45; 121-129.

Alatiqi, I., H. Ettouney, H. El-Dessouky, H., 1999. Process control in water desalination industry: an overview. Desalination, 126; 15–32.

Bayod Rujula, A.A., N. Khalidou Dia, 2010. Application of a multi-criteria analysis for the selection of the most suitable energy source and water desalination system in Mauritania. Energy Policy, 38; 99–115.

Beheshtifar, S., M.S. Mesgari, M.J. Voldan-Zoj, M. Karimi, 2010. The use of fuzzy logic in GIS to locate gas stations. Journal of Civil and Surveying Engineering, 44; 583-595.

Bonham-Carter, G.F., 1991. Geographic Information System for Geoscie ntists: Modeling with GIS. Pergamon, Ontario, 291-300.

Buyokozkan, G., G. Cifci, 2012. A novel hybrid MCDM approach based on fuzzy DEMATEL, fuzzy ANP and fuzzy TOPSIS to evaluate green suppliers. Expert Systems with Application, 39; 3000-3011.

Chaibi, M.T., 2000. An overview of solar desalination for domestic and agriculture water needs in remote arid areas. Desalination, 127; 119-133.

Charabi, Y., A. Gastli, 2011. PV site suitability analysis using GIS-based spatial fuzzy multi-criteria evaluation. Renewable Energy, 36; 2554-61.

Chaudhry, S., 2003. Unit cost of desalination. California Desalination Task Force, California Energy Commission. Sacramento, California.

Dari, B., E. Hamzehee, 2010. Determine risk response strategies using ANP technique, (Case Study: North Azadegan oil field development project). Journal of Technology Management, 4; 92-75.

Dastorani, M.T., A.R. Massah Bavani, S. Poormohammadi, M.H. Rahimian, 2011. Assessment of potential climate change impacts on drought indicators (Case study: Yazd station, Central Iran). Desert, 16; 159-167.

Dore, MHI., 2005. Forecasting the economic costs of desalination technology. Desalination, 172; 207–14.

Eltawil, M.A., Z. Zhengming, L. Yuan, 2009. A review of renewable energy technologies integrated with desalination systems. Renewable and Sustainable Energy Reviews, 13; 2245–2262.

Faraji-Sabokbar, H.A., M. Salmani, F. Ferydooni, H. Karimzadeh, H. Rahimi, 2010. Rural Waste Landfill location using network analysis process (ANP): A case study rural areas of Ghoochan city. Modares Journal, 14; 137-149.

Forghani, A., N. Yazdan-shenas, A. Akhoondi, 2007. Provide a framework for locating industrial centers nationally with a case study. Journal of Knowledge Management, 77; 81-104.

Garcia-Rodriguez, L., 2003. Renewable energy applications in desalination: state of the art. Solar Energy, 75; 381–93.

Gastli, A., Y. Charabi, S. Zekri, 2010. GIS-based assessment of combined CSP electric power and seawater desalination plant for Duqum-Oman. Renewable and Sustainable Energy Reviews, 14; 821–827.

Gude, V.G., N. Nirmalakhandan, S. Deng, 2011. Desalination using solar energy: Towards sustainability. Energy, 36; 78-85.

HosiynZadeh, S.R., 1999. Tabas territory based on detailed studies of the role of geomorphic and external dynamics processes in resonance the desert phenomena and desertification. PhD thesis, Faculty of Literature and Humanities, Tehran University.

Jazirehee, M.H., 1992. Drought phenomenon. Journal of Forest and Range, 13; 23-34.

Kahraman, C., T. Ertay, G. Buyukozkan, 2006. A fuzzy optimization model for QFD planning process using analytic network approach. European Journal of Operational Research, 171; 390–411.

Kiyani, A., A. Khanjari, Q. Fazelniya, 2010. The usage ANP model for proposed ICT patterns to optimize the relationship between urban and rural in city of Alashtar. Agricultural Modares Journal, 14; 267-249.

Montazer, G.A., N. Jafari, 2008. Fuzzy-Delphi Method to determine the financial policies, Humanities and Cultural Studies. Journal of Sustainable Development, 8; 1-10.

Najafi, A., 2010. Applying the analytic network process (ANP) in the analysis of structural challenges and the Executive environmental in the implementation of project management. International Journal of Industrial Engineering and Production Management, 21; 63-76.

Poorahmad, A. Q. Habibi, S. Mohammad-zahrayi, S. Nazari-Adli, 2007. Fuzzy algorithms and GIS for locating urban facilities. Environmental Studies, 42; 42-31.

Rashidi, M., H. Qarib, 2011. The use of Solar Energy; Strategy for Sustainable Development Renewable Energy. First International Conference on Emerging Trends in Energy Conservation, Tehran, Iran.

Saeedi, H.R., A. Najafi, 2010. Using analytic network process (ANP) to determine the movement priorities of animals from forest, and organization of immigrants Forest, Case Study: Bababkvh Gilan district. Journal of Forestry, 4; 309-321.

Saghafi, M., 2009. Renewable energy. Tehran University Press, Tehran.

Sagie, D., E. Feinerman, E. Aharoni, E., 2001. Potential of solar desalination in Israel and in its close vicinity. Desalination, 139; 21-33.

Shakerian, N., Gh.R. Zehtabian, H. Azarnivand, H. Khosravi, 2011. Evaluation of desertification intensity based on soil and water criteria in Jarghooyeh region. Desert, 16; 23-32.

Sui, D.Z., 1992. A Fuzzy GIS Modeling Approach for Urban Land Evaluation. Journal of Computers, Environment and Urban Systems, 16; 101-115.

The FAOSTAT database, Food and Agriculture Organization of the United Nations. 2000. Population: annual time series. Rome: Food and Agriculture Organization of the United Nations.

Wu, W.W., 2008. Choosing knowledge management strategies by using a combined ANP and DEMATEL approach. Expert Systems with Applications, 35; 828–835.