Ranking Iranian provinces in terms of the environmental performance of industries with a developed decision-making approach

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ABSTRACT: Nowadays, environmental management with the aim of preserving the environment has become a crucial matter to industries. Rising global concerns about the negative effects of industrial activities have led to a variety of changes in governments' policies and strategies to improve environmental performance. Hence, studying the environmental performance of industries is an important task. This study evaluates and ranks the Iranian provinces in terms of environmental performance of industries, in various dimensions. This research defines a multidimensional set of environmentally friendly manufacturing criteria by examining the various aspects of industrial activities impacts on the environment and also with the assistance of experts' guidance for evaluating the industries at the provincial level. Then, we use a combined approach based on decision-making trial and evaluation laboratory technique and analytic network process (DANP) method to calculate the interactions between the research criteria and sub-criteria along with their influential weights. In the end, we utilize the additive ratio assessment (ARAS) technique to obtain relative utility coefficients (closeness coefficients) and ranking the provinces. Generally, this study concludes that industries in northwestern and southwestern provinces of Iran are more environmentally friendly than other provinces. In this evaluation, Bushehr, North Khorasan and Khuzestan provinces were ranked first to third with their relative utility coefficients of 0.488, 0.412 and 0.401, respectively.

1- Introduction

Industry is an important part of any country's economy. However, its negative aspects have undeniable destructive effects on the environment. Industries are one of the largest consumers of materials, water, and energy in any country and play an important role in the production of environmental pollutants [1]. The environmental effects of manufacturing industries are greater than any other industry in the world. These effects are mainly due to the consumption of materials, water and energy in industrial production systems and are generally divided into four categories, including emissions, production of industrial waste, consumption of valuable resources and emissions of greenhouse gases [2].

Nowadays, manufacturing industries are under increasing pressure from consumers, stakeholders, and governments to reduce the environmental impact of their industrial activities. Recently, green production strategies have been recognized as one of the most popular and effective options for improving the environmental performance of industries [3]. Green production refers to the production of goods using environmentally friendly processes and technologies to reduce the environmental impact of industries [4, 5]. Nowadays, environmental protection has become a

growing concern for every country. Therefore, control of environmental pollutants is a high priority for authorities [6].

Iran's rapid population growth and industrialization have led to neglect of environmental conservation in parts of the industry, which requires prudent oversight by industry and environment officials. Also, despite the great interest and motivation on the subject of sustainable industry and environmentally friendly production, research in this field is lacking. Therefore, this study intends to evaluate and rank the country's provinces in terms of the environmental performance of industries by providing a multidimensional set of comprehensive criteria. For this purpose, an integrated approach of multi-criteria decision-making (MCDM) is presented and used. The proposed approach is a combination of DEMATEL and ANP methods used to derive interactions between criteria and sub-criteria as well as their weight calculation. In the next step, the ARAS technique is used to evaluate and rank the industries of the provinces.

2- Methodology

Numerous researches have been carried out on solving the environmental problems of the Iranian industry by combining different MCDM tools[7]. This study presents a developed MCDM approach for the environmental assessment of industries at the provincial level of the country. Initially,

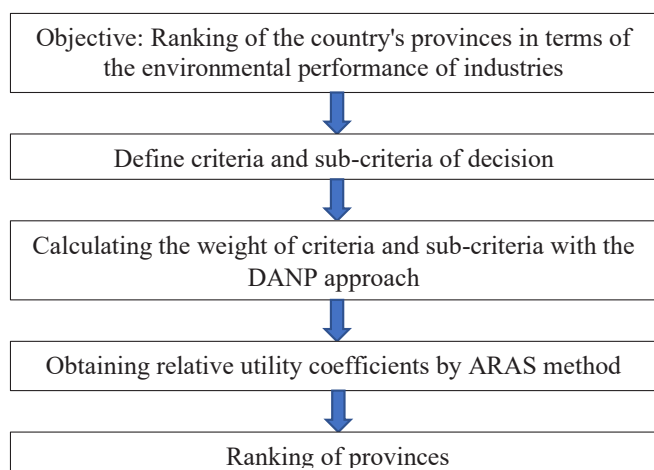*Corresponding author's email: R.Dabbagh@uut.ac.ir

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│ Objective: Ranking of the country's provinces│
│ in terms of the environmental performance of │
│ industries                                    │
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┌─────────────────────────────────────────────┐
│ Define criteria and sub-criteria of decision │
└─────────────────────────────────────────────┘
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┌─────────────────────────────────────────────┐
│ Calculating the weight of criteria and       │
│ sub-criteria with the DANP approach          │
└─────────────────────────────────────────────┘
                      ▼
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│ Obtaining relative utility coefficients by   │
│ ARAS method                                   │
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│ Ranking of provinces                         │
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Fig. 1. Research Methodology Framework

according to the opinions of industry and environmental experts, a multidimensional set of green production and environmentally friendly industry criteria has been defined to evaluate the industries of the provinces. Then, with the help of the DEMATEL technique, the values of interactions between the criteria and sub-criteria were extracted and in the next steps, these values were used to normalize the ANP unweighted super matrix and extract the fair weights of the criteria and sub-criteria. Finally, the evaluation of the industries of the provinces is completed by performing calculations of the ARAS technique and obtaining the relative utility coefficients of each province and their ranking. Figure 1 shows the methodological framework of this research.

3- Results and Discussion

In this research, different dimensions of industrial activities' impact in the provinces of the country on the characteristics of the environment from the industrial workshops of the country between 1392 to 1397 have been considered and the criteria for evaluating them in terms of environmental compatibility have been defined. Based on the literature of environmental characteristics of industrial producers for the main criteria including the number of environmental units and staff of these units, environmental certificates of producers, amount of industrial wastewater produced and recycled, amount of industrial waste produced and disposal methods and the number of factories with air pollution control equipment It has been considered at the provincial level. Thirteen criteria were proposed to evaluate the industries of the provinces in terms of environmental compatibility (green production) with the help of the experiences of experts in the field of industry and environment.

These criteria are classified into four dimensions, including environmental characteristics, air quality control, industrial wastewater management, and industrial waste management. For example, it is clear that the three most important eco-criteria based on more weight include the ratio of the number of industrial workshops with a valid environmental certificate to the total number of workshops (0.185), the ratio

Ilam	Chaharmahal	Ardabil	Kohgiluyeh	Zanjan	Khuzestan	Khorasan-SH.	Bushehr	**Province / Coefficients**
352	357	357	363	382	401	412	488	Total utility coefficient
8	6	7	5	4	3	2	1	Overall rank of the province

Markazi	Kordestan	Esfahan	Alborz	Khorasan-JO	Azarbaijan - E	Kerman	Lorestan	**Province / Coefficients**
227	228	246	278	287	297	306	318	Total utility coefficient
16	15	14	13	12	11	10	9	Overall rank of the province

Fars	Semnan	Golestan	Qazvin	Hamedan	Hormozgan	Azarbaijan- W	Kermanshah	**Province / Coefficients**
189	192	194	195	198	199	205	223	Total utility coefficient
24	23	22	21	20	19	18	17	Overall rank of the province

	Sistan	Mazandaran	Qom	Gilan	Tehran	Khorasan-R	Yazd	**Province / Coefficients**
	83	118	155	165	182	185	187	Total utility coefficient
	31	30	29	28	27	26	25	Overall rank of the province

Table 1. Relative utility coefficients and ranking of provinces

of workshops with air pollution control equipment to the total number of workshops (0.105) And the ratio of the number of workshops with industrial waste to sanitary landfill to the total number of workshops with waste (0.089).

The results of calculating the values of relative utility coefficients for 31 provinces of the country, obtained from the ARAS technique in different dimensions and general conditions (13 criteria), can be seen in the table below. A higher coefficient for a province indicates a better situation for that province compared to other provinces in terms of environmentally friendly industry. In general, Bushehr, North Khorasan, and Khuzestan provinces were in the first to third ranks with coefficients of 0.488, 0.412, and 0.401, respectively. In general, it can be concluded that the northwestern and southwestern provinces are in a better position than in terms of environmental performance; they have industries.

4- Conclusions

Based on thirteen sub-criteria, it has been done in four main criteria to evaluate the industries of the provinces of the country. Based on the DANP approach for the weight of criteria and sub-criteria, it was found that the criterion of environmental characteristics of industrial workshops, and the sub-criterion of the ratio of the number of workshops with valid environmental certification to the total number of workshops (C3) weighing 0.185 were recognized as the most effective criteria and sub-criteria.

The results showed that the industries of the northwestern and southwestern provinces of Iran, compared to other provinces, are more compatible with the environment and green production standards. In this evaluation, Bushehr, North Khorasan, and Khuzestan provinces were ranked first to third with utility coefficients of 0.488, 0.412, and 0.401, respectively. Therefore, each province can identify the strengths and weaknesses of the environmental performance of its industries and apply them in its policies.

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