ORIGINAL PAPER

Planning the decision-making process and strategic management of ROP wastewater treatment system in Abadan Oil Refinery with a combined benefit of SWOT and AHP

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ABSTRACT

The present study aimed to plan the decision-making process and strategic management of ROP system for oil refinery wastewater treatment with the combined benefits of the AHP and SWOT techniques. The research was conducted at Abadan Oil Refinery in Iran during 2019-2020. The AHP approach was used for the pairwise comparison of the factors or criteria to divide their priorities using eigenvalues. We also used statistical analysis, Delphi questionnaires, validity and reliability assessment of the research, and extraction of the influential external and internal factors in the performance of the ROP unit of Abadan Oil Refinery. In addition, the Expert Choice 2000 software was applied to weigh the parameters, and Cronbach's alpha was estimated at 0.932. Based on the SWOT matrix and due to the significant multiplicity and role of the internal weaknesses and external threats affecting the refining performance, the consistent, prioritized strategic planning had defensive strategies from the first- to the third-rank model output. The systemic, maintenance, and efficiency issues of the refinery ROP system necessitate the prioritization of defensive strategic strategies due to the considerable multiplicity and role of the internal weaknesses and external threats affecting the refinery performance. Our findings indicated that currently, the strategic state of the refinery ROP system in entropy conditions is unstable, and the strategic orientation to improve the operational and environmental efficiency of the refinery should be based on the minimization of the external threats and reduction of the internal weaknesses.

Keywords: ROP, Abadan Oil Refinery, AHP, SWOT

Introduction

In their development process, developing and developed countries have been faced with the challenge of wastewater production by oil, gas, petrochemical, and energy industries,[1, 2] which is a major issue in the industrial development process of these countries, as well as an important source of environmental pollution.[3] Currently, significant efforts are made across the world to overcome this issue.[4] Given the industrial development process of countries and increasing use of oil and energy resources,[2, 5] wastewater in the related industries is an inevitable phenomenon, which requires proper management.[6]

Refineries use large quantities of water in Iran and are often located at the center, adjacent to large cities or even within cities. Due to its location at the city center, Abadan Oil Refinery causes noticeable pollution and unpleasant odors in the region, which in turn affect the health of the refinery staff and urban residents. In the current research, we aimed to strategically manage the recovery oil plant

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(ROP) system of Abadan Oil Refinery wastewater treatment plant using the combined model of SWOT and analytic hierarchy process (AHP).[7]

The ROP unit is responsible for the purification of petroleum products at Abadan Oil Refinery. The unit starts with a uniform pool where the unit effluent first enters. In this pool, the flow rate decreases to a large extent, and the flow alleviates, so that the oil materials would be more likely to rise through their lighter weight than water. These materials are found on the surface, and the suspended solids settle in the structure. Following that, the oil that has accumulated on the surface of the water enters the separating ponds with the water.

Several models are used for strategic planning based on the SWOT.[8] The technique was introduced in the 1960s by Albert Humphrey during a research project at Stanford University using the data of 500 companies. The SWOT matrix has been established as an effective tool for strategic environmental management planning among specialists.[9, 10] SWOT is also a systematic analytical tool for the identification of internal and external factors and selection of an appropriate matching strategy to optimally coordinate the factors.[7, 11]

AHP is a common decision-making method,[7-12] which mainly involves the analysis of a hierarchical process.[13, 14] Criterion selection is the first step in the AHP analysis,[15] after which the candidates are assessed based on the identified criteria. The word options or candidates also show the word alternatives or candidates and may be used interchangeably. The reason for the hierarchical reading in the AHP method is that we must first start with the goals and strategies of the organization at the top of the pyramid, and when they are expanded, the criteria could be identified to reach the bottom of the pyramid. However, the operation of the process units is associated with some hidden risks, which may directly impact the environment in the immediate vicinity and around the process industries. The main innovations of the current research were the identification and removal of air pollution from the wastewater treatment system. Notably, this approach is widely used to rank and determine the importance of various factors, while also prioritizing each criterion using pairwise comparisons. The AHP process is aimed at the selection of the most viable options based on various criteria through pairwise comparison.[16] In addition, this technique is used to weigh different criteria. Since increasing the number of the elements in each cluster makes pairwise comparisons difficult, the decision criteria are often divided into sub-criteria.

The present study aimed to plan the decision-making process and strategic management of ROP system for oil refinery wastewater treatment with the combined benefits of the AHP and SWOT techniques.

Materials and Methods

Study area

Khuzestan province is located in the south west of Iran between 23 degrees and 58 minutes to 29 degrees and 58 minutes of north latitude and 47 degrees and 41 minutes to 50 degrees and 39 minutes of east longitude, covering an area of 64.266 square kilometers. It is a relatively large area of the country's geographical border located on plains and has a warm climate due to its proximity to vast deserts, such as the Great Sahara Desert and Iraq. Huge oil and gas industries in this region have caused tremendous heating and pollution (Fig. 1).

Applied techniques

Initially, we studied the technical, design, spatial, and process characteristics of oil refinery treatment systems and evaluated the current status of the environment, with an emphasis on the environmental situation in the operational area of the refinery based on field operations, field observations, and the analysis of technical documents. In addition, the Delphi questionnaire was used to apply the expert opinions, which was modified based on Cochran's formula for limited communities by 40 selected individuals from five target groups, including university professors, consultant specialists of engineering companies, experts in the executive apparatus, managers of oil refineries, and the related officials at the national and regional levels.

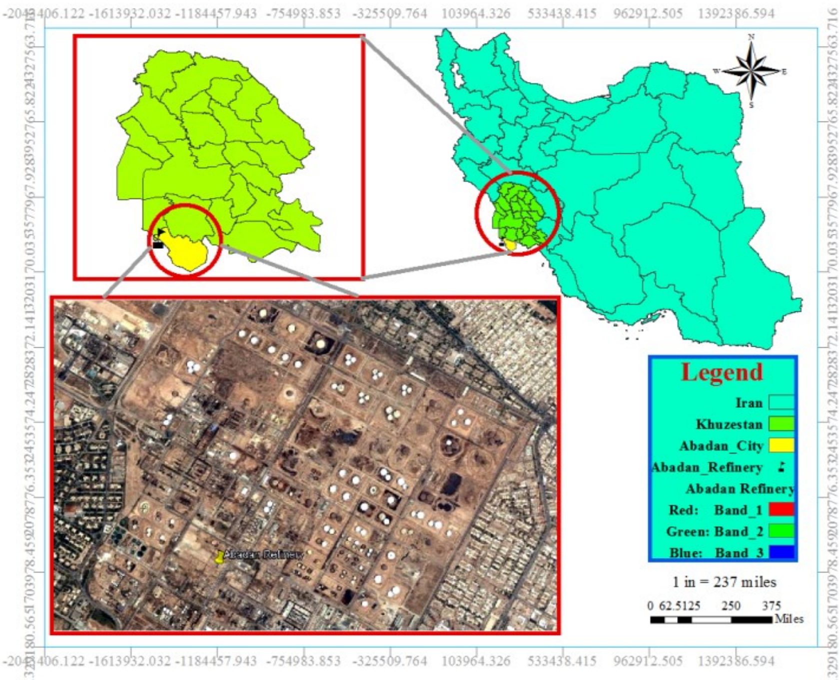

Fig. 1. Geographic location of study area

The statistical analysis of the results was performed based on the pairwise comparisons of 141 identified variables. In order to statistically analyze the completed Delphi questionnaires, each common statistical parametric indicator was calculated, including the arithmetic mean, geometric mean, standard deviation, variance, fashion, range of change, minimum, and maximum in the Excel software and SPSS. In addition, the statistical analysis of the Delphi questionnaires, validity and reliability analysis of the questionnaire, extraction of the external and internal influential factors in the performance of the ROP unit of Abadan Oil Refinery, and weighting and ranking of the results of the strategic parameters affecting the decision-making process were obtained and performed using the Expert Choice 2000 software, and the decision-making and policy-making of various items were presented, including the factors (components), criteria, sub-criteria, and strategic plans (Tables 1-5).

In order to measure the validity of the Delphi questionnaire, it was tested at the plant in the form of a pretest stage. For this purpose, the first 10 items of the initial questionnaire were designed and provided to five selected experts of the mentioned target groups, and the approaches to the pairwise comparison of various levels of the components, criteria, sub-criteria, and programs were explained and clarified. Furthermore, an operational strategic action was envisaged in order to optimize the process of controlling the effective itemsin accordance with the type of the variables considered for the decision-making and strategic environmental policy of the project under study in terms of structuring, as well as the expected technical-scientific content under screening.

Based on the expert review and reflection, the pretest stage was implemented, and the correction-optimization operation was also performed to finalize the Delphi questionnaire. Notably, the Delphi questionnaires were designed for the current research based on the previous studies in this regard and the pretest stage, and their expected validity was also achieved. According to the statistical results, the arithmetic mean data was 4.640, the geometric mean was 2.878, and the standard deviation was 3.171.

The reliability of the Delphi questionnaire shows the similarity of the results in case of the re-measurement of the features using the same questionnaire under similar conditions. On average, the total Cronbach's alpha coefficients of a completed Delphi questionnaire are equal to 0.932, which confirms the reliability of the current research due to exceeding the numerical basis index of 0.7. We also applied the SWOT in combination with the AHP to this end.

Table 1. Strategic components and criteria for component of natural environment around refinery

Row	Component	Row	Criteria	Sub-criteria
1	Component of the natural environment around the refinery	1-1	Climate of the region	Temperatures Rainfall Compass Relative humidity Uncertainties
		1-2	Water resources of the region	Types of water resources How to distribute water resources Uncertainties
		1-3	Vegetation and surrounding green space	Types of plant species Vegetation density Herbal formations Uncertainties

Table 2. Strategic components and criteria for component of natural environment around refinery

Row	Component	Row	Criteria	Sub-criteria
2	Component of the natural environment around the refinery	2-1	Land use	Land use pattern Land use intensity Areas occupied by spaces Uncertainties
		2-2	Demographics of the region	Relative population density Family size Population rate Uncertainties
		2-3	Surrounding development plans	How to distribute development plans Local development programs Uncertainties
		2-4	Surrounding health status	Diseases caused by air pollution Diseases caused by water and soil resources Uncertainties
		2-5	Environmental pollutants	Air pollutants Water pollutants and soil Uncertainties

Table 3. Strategic components and criteria for HSE in refinery

Row	Component	Row	Criteria	Sub-criteria
3	HSE in refinery	3-1	Environmental status of the refinery	Environmental indicators Environmental hazards Uncertainties
		3-2	Health status in the refinery	Health Indicators Health hazards Uncertainties
		3-3	Safety status in the refinery	Safety indicators Safety hazards Uncertainties

Table 4. Strategic components and criteria for component of technical characteristics and conditions of refinery

Row	Component	Row	Criteria	Sub-criteria
4	Component of technical characteristics and conditions of the refinery	4-1	Technical features and refinery design	Types of functional units The way to locating units Uncertainties
		4-2	Process and functional characteristics of the refinery	Types of production processes Refinery production capacity Types of refinery products
		4-3	VOC features in the refinery	VOC generating resources VOC index status VOC control system VOC control system performance Uncertainties
		4-4	Features of ROP system in refinery	How to install ROP system System process in the ROP section ROP system capacity and efficiency Uncertainties
		4-5	Criteria for refinery effluent characteristics	Types of refinery effluents Wastewater quality indicators Wastewater treatment system efficiency Uncertainties

Table 5. Strategic components and criteria for strategic characteristic of refinery

Row	Component	Row	Criteria	Sub-criteria
5	Strategy characteristic of refinery	5-1	Upside documents and legal requirements	Related upside Documents Related legal requirements Uncertainties
		5-2	Refinery Development Programs	Refinery development programs Space Development Programs - Bodybuilding Uncertainties
		5-3	Refinery Strategic Document	The mission of the refinery strategy Refinery Strategic Perspective Uncertainties
		5-4	Strategic goals of the refinery	The strategic goals of the refinery Refinery micro-strategic goals Uncertainties
		5-5	Strategic issues of the refinery	Ecosystem strategic issues

Results and Discussion

AHP enables decision-makers to relatively prioritize each factor through pair comparisons. In order to make decisions and devise strategic environmental policies, the project under study was screened and reviewed by the experts in the present study in terms of the structure and expected technical-scientific content. After the pretest and correction-optimization operations, the Delphi questionnaire was finalized. According to the studies conducted in this regard,[9] we designed the Delphi questionnaire in accordance with the pretest with the expected validity, and the total Cronbach's alpha coefficient of the completed Delphi questionnaire was estimated at 0.932, which also confirmed the reliability of the research as it exceeded the numerical basis of 0.7. Finally, the hierarchical analysis process was performed using the Expert Choice 2000 software, and the incompatibility rate based on the input data was determined to be 0.01 (Fig. 2).

The weight of each of the five main components was calculated using the same software (Fig. 3).

SWOT could be the basis of decision-making and goal setting for managers and professionals. Given the internal and external factors in an industry, SWOT could provide a proper solution for strategy development. Furthermore, SWOT could effectively achieve goals by formulating the necessary policies in accordance with domestic and foreign priorities. The SWOT matrix allows various options and strategies, and the SWOT analysis regularly analyzes the previously identified weaknesses, strengths, opportunities, and threats. When the weakness, strength, opportunity, and threat factors are identified in SWOT, they enter the relevant cells, and the considered strategies for cell intersection are identified in terms of weight priority. Therefore, this matrix perpetually offers four types of strategies, including ST, WT, WO, and SO.

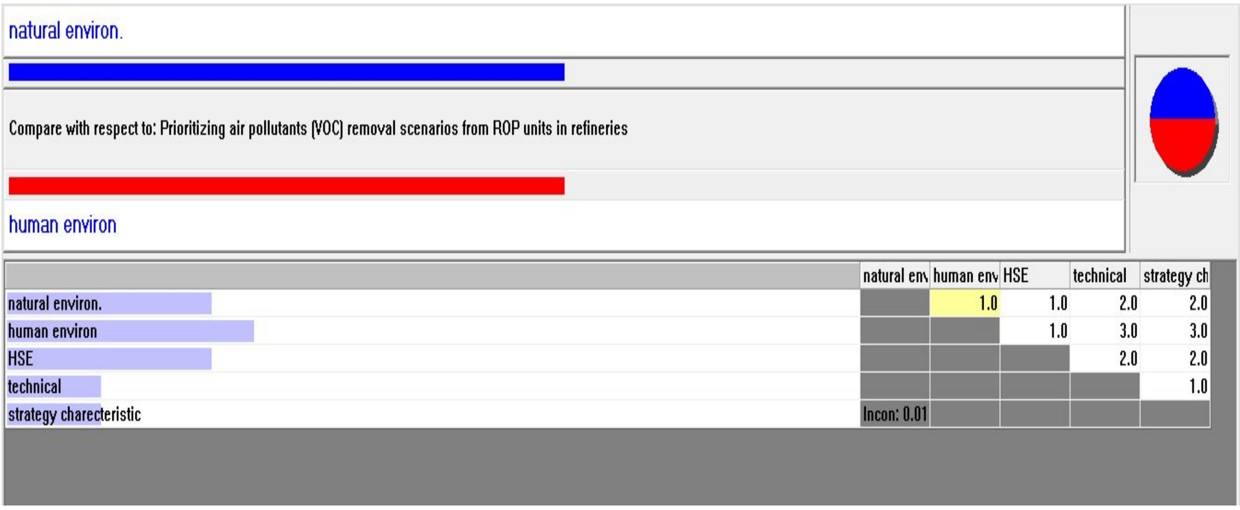

Fig. 2. Schematic image of pairwise comparison of studied components by software

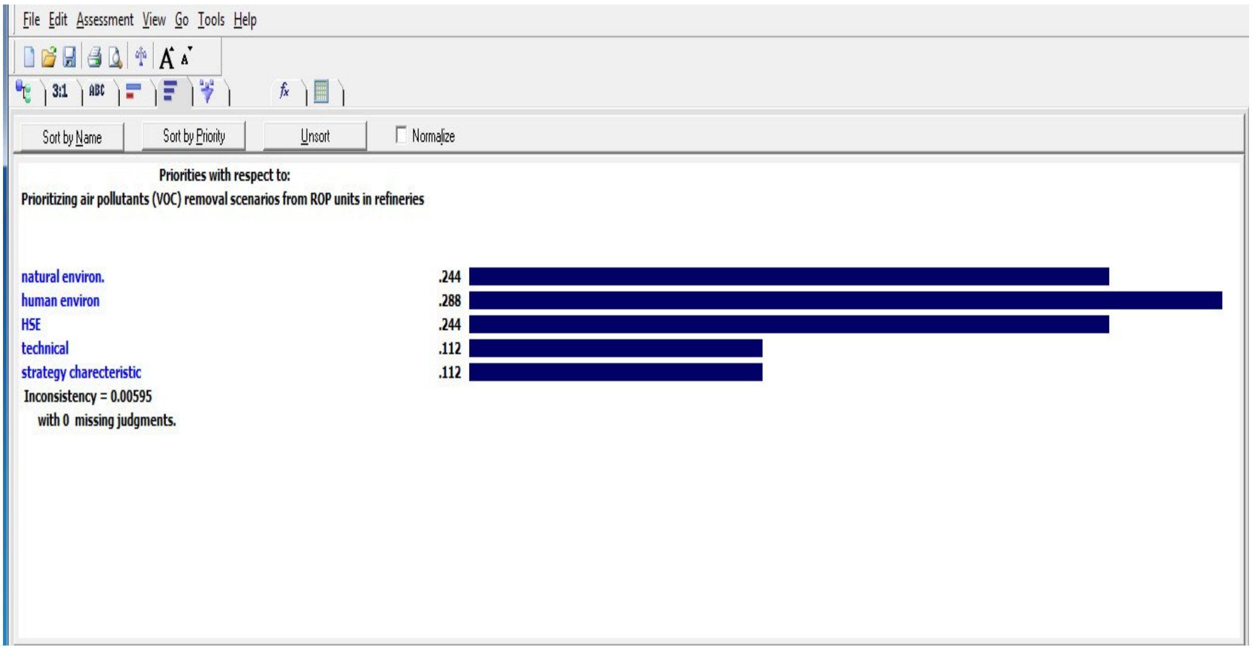

Fig. 3. Pair comparison of studied components

In the current research, we initially used field studies, expert judgment, face-to-face conversations with the experts and stakeholders, and the SWOT matrix and identified the foremost influential issues in external and internal strategies (Table 6).

The SWOT analysis is commonly used to identify the strengths and weaknesses (internal factors) of an industry along with the environmental opportunities and threats (external factors) entering the system.[7, 17] SWOT also provides a fundamental analysis to decision-makers.[17] This stage of the present study was designed based on the determined macro and strategic goals, and the strategic plans for the ROP system of Abadan Oil Refinery were also prepared based on the scenario spectrum, followed by the prioritization of the SWOT factors. Table 7 shows the final priorities in this regard.

Table 6. Raw SWOT matrix of reviewed strategic factors in Abadan Oil Refinery

External Influencing factors	(Threats)	(Opportunities)
	T1 -The refinery is not serious about implementing over-the-counter periodic repair programs T2 -High concentration of oil and oil in the effluent entering the treatment plant T3 -Lack of environmental and climatic limiting factors on the performance of the treatment plant T4 -Existence of human settlements and opposing uses around the refinery T5-Concerns about the release of unpleasant odors due to imperfect performance of the treatment plant T6 Lack of comprehensive and effective plan to reduce environmental pollution (physical, chemical, biological) in the region T7 -The entry of sewage flow in conditions beyond the design load capacity of the treatment system T8 -The hot and dry climate of the region and the pollution of the air and the work environment have caused the absence of skilled workers and reduced efficiency	O1 -Development-oriented attitude of senior refinery managers O2 -The refinery is making serious efforts to conduct environmental self-declaration periodically O3 -Existence of HSE requirements in oil contracts O4 -Private Sector Participates in Waste Transfer and Recycling, Wastewater, Wastewater and Consulting to Reduce Environmental Pollution in the Region
	(Weaknesses)	(Strenghts)
External Influencing factors	W1 -Failure to use the results of environmental assessments in management decisions W2-Transfer particles larger than 5 mm to the treatment plant W3 -Lack of modern technologies in the field of environmental projects W4 -There is a problem with the clogging of pumps and nozzles in the treatment plant W5 -Sewage pH fluctuations in the treatment structure W6 -Failure to use the results of environmental assessments in management decisions W7 -Lack of effective environmental prevention laws W8-Failure to permanently collect materials floating in the treatment plant W9-Reduce refinement efficiency over time W10-Reducing the shock level of the treatment plant due to the tensions caused by the quantity and quality of the incoming effluent in recent years W11-Existence of thick dark floor in ROP system due to poor system performance W12-Existence of problems in the equipment and facilities of electromechanical treatment plant	S1-Proper use of skimmers to collect oil and oil in the treatment system

A study in this regard analyzed the stakeholders' perceptions of the challenges and opportunities offered by the Joint Forest Management (JFM) in Zero Province, located in the south of Burkina Faso.[10, 18] In the mentioned study, the SWOT approach was applied in combination with the AHP,[19] and the results indicated that the subjects responded better to the resources of the stakeholders with a positive perception of the JFM compared to those with negative perceptions. In addition, optimal organizational settings had the highest overall factor score in terms of strength.[20, 21] In terms of better community interactions, the highest overall factor for opportunities was obtained. On the other hand, uncertainty in decision-making at higher levels was observed to be the most significant threat to the JFM in the zero province in southern Burkina Faso. Therefore, the differences in the views toward the existing realities in the mentioned study require the involvement of all the stakeholders in this field, and interventions in this regard are highly recommended.

Table 7. Overall priority of SWOT factors

	Aggressive or ambitious strategies (SO)	Conservative strategies (ST)
Strengths	SO1: Avoid transferring particles larger than 5 mm to the treatment plant to prevent clogging of nozzles and pumps	ST1: Use an input stream balancing tank, as well as perform pre-treatment
	SO2: Permanent collection of floating materials on floating metal tank and initial sedimentation tank	ST2: Using uniform pool
	Reformist strategies (WO)	Defensive or defensive strategies (WT)
Weaknesses	WO1: Increase system stay time for winter through an aeration tank	WT1: Avoid system shock load shock
	WO2: Utilization of financial and support of Khuzestan province in order to physically improve the refinery treatment system	WT2: Minimize effluent produced in the refinery through more effective control of water consumption, optimization of production process, reuse of condensate water, indirect converters and evaporators in production process, leakage control in connections, valves and equipment
		WT3: Identify venues and prevent them from entering the ROP system
		WT4: Permanent pH control and acid-alkaline regulation and pH adjustment in the range of 6.5 to 8.5
		WT5: Remove blockage of nozzles to avoid problems with compressor performance and corrosion of connections and ultimately reduce the efficiency of the treatment plant

Assessment

Regarding the output, a regular and complete review of the characteristics of the oil refinery was obtained in the present study. The applied method reduced the time required to perform the SWOT analysis,[22] which is considered to be a key advantage for senior decision-makers. In addition, the saved time could be allocated to improving the quality of the output and analysis of the results without the need for a consultant for the board meeting. The output is significantly more objective and easier to understand, and acquiring more knowledge from experts in this regard could lead to the higher quality of the analysis. If the number of the experts increases, they will ask more questions for more information; therefore, the number of the questions should be limited. Another advantage of this method is the use of more expert knowledge, while the main limitation is the lack of freedom of action in answering the questions. In any case, it is considered to be a scientific method of decision-making across the world.

The method used in the present study could be used for similar cases. It is more appropriate to use a larger sample sizes for increased heterogeneity in terms of preferences. To collect data from a large sample, a mail letter review could be efficient or a place could be provided to the respondents, so that they would be gathered and asked to devise the factors and agree on a paired comparison.

Conclusion

The present study aimed to plan the decision-making process and strategic management of the ROP wastewater treatment system in Abadan Oil Refinery (Iran) using the combination of SWOT and AHP based on pairwise comparisons by the AHP. According to the results, the human environment component around the refinery weighed 0.288 (highest weight), while the natural environment around the refinery and the HSE refinery had the second weight priority of 0.244 with the technical characteristics and conditions governing the refinery. In addition, the strategic features of the refinery with the weight of 0.112 were ranked third in terms of weight. Several problems were detected in the system, maintenance, and efficiency of the refinery ROP due to the significant multiplicity, internal weaknesses, and external threats affecting the treatment performance, which further necessitate the prioritization of strategic planning. The first-to-third rankings of the modeling output were entirely consistent with the defensive strategies, reflecting the fact that the strategic status of the refinery ROP system is currently in unstable entropy conditions, and the strategic orientation to improve the operational level and environmental efficiency of the refinery should be primarily based on the minimization of the external threats, as well as the minimization of the internal weaknesses.

We used the priorities calculated from the SWOT factors to develop a managerial approach. In addition, our findings could be used to form a set of appropriate strategic options for the related industries. In the further investigations in this regard, the fuzzy logic based on the AHP method could be more effective than classiclogic in case of uncertainty. Multi-criteria decision-making methods could also be employed instead of the AHP for result assessment.

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Conflicts of interest

The author declare that they have no conflict of interest.

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