Original Article: Assessment of Environmental Effects in the Petrochemical Industry

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ABSTRACT

Environmental impact assessment is considered as a tool for environmental planning and management of development projects. There are several methods of environmental impact assessment. To choose the right method for each project, one should pay attention to a set of conditions and characteristics such as method specifications, environment characteristics, and the nature of the project. The purpose of environmental impact assessment is to identify and systematically value the potential effects of projects, programs, plans, policies and laws on the physical, chemical, biological, cultural, economic and social components of the environment. The first goal of environmental impact assessment is to encourage planners and decision makers to look at and pay attention to the environment and ultimately succeed in taking actions that are compatible with the environment. Environmental impact assessment is actually a process that includes detection, prediction, assessment and mitigation of biophysical, social and other similar effects from developments proposed by decision makers and commissions. This process is designed to ensure that the impacts of the developments are well understood and accounted for before they are implemented. This assessment causes all the effects and environmental consequences to be considered by weight or other economic and social effects during the implementation of development plans. If this stage is done well, its profit will be determined in the same planning stage.

Introduction

Considering that development and environment are two inseparable issues, it is necessary to obtain and use environmental management tools to minimize damage to resources and environment in all development programs, but not to pay attention to short-term consequences and in the long

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term, various projects will cause major problems for humans and nature. Evaluation of the environmental effects of development is one of the efficient methods that identify and reduce negative effects by identifying the project activities and the environment of the study area. This method can also be made available to managers, planners and decision makers as a tool for planning, so that the potential environmental effects that appear as a result of the implementation of civil and industrial projects can be identified and presented different options tried to solve it. Environmental impact assessment includes a large amount of quantitative and qualitative information that are together. It seems that the main problem in this process is that the impact assessment methods are not able to categorize the qualitative information of nature [1-3].

Therefore, to solve this problem, qualitative information is relatively converted to a numerical scale. Recently, multi-criteria decision-making methods have been widely used in various scientific fields in order to make appropriate decisions, considering the set of criteria, among which we can mention the importance of environmental effects in the assessment of environmental effects [4].

In fact, the multi-criteria decision-making method has been introduced to express both qualitative and quantitative terms in the decision-making process by presenting a quantitative systematic method in order to reduce the ambiguities and problems of human mental judgments. The application of environmental impact assessment as one of the tools of environmental management emphasizes the necessity of using this approach for large construction projects such as exploration, construction and operation of oil fields and related equipment [5].

Discuss

Based on the studies, 57% of the world's oil reserves and 45% of the gas reserves are located in the Persian Gulf region, and according to the estimates, the oil reserves in this region are 715 billion barrels and the volume of its gas reserves

is 2,462 trillion cubic feet. The Islamic Republic of Iran also has a significant share of these reserves. According to the goals foreseen in the 20-year development vision document, Iran should be ranked second in the gas producing countries in the world. According to the latest official statistics published in the country's hydrocarbon balance sheet in 2004, Iran has 14.86% of the world's natural gas reserves. However, Iran's share of its production is only 3.1%.

With the production of 87 billion cubic meters of gas in 2004, Iran has ranked sixth in the world after Russia, the United States of America, Canada, England and Algeria. The word petrochemical is a combination of the two words petrol and chemistry, and its literal meaning is chemical substances derived from oil. The establishment of petrochemical factories in order to convert part of oil and gas into products with more added value is of great global importance [6].

The construction and management of these projects has a major place in industrial development plans due to the existence of huge oil and gas resources in the country. The national petrochemical Industries company, as one of the four main companies of the Ministry of Petroleum since its establishment in 1963, has been playing an important role in economic development, expansion of non-oil exports, and supply of raw materials for downstream industries.

Therefore, considering the great importance of the industry in the advancement of the country's major goals, and also taking into account the level of pollution and its negative effects on the environment, conducting a new method to evaluate the effects of the development of the said industry can provide a clear horizon in the field of the industry's progress. Petrochemical is considered environmentally friendly.

History of environmental impact assessment

The process of preparing the environmental impact assessment report for the first time in 1969 became official with the enactment of the

national environmental policy act in the United States. Since then, similar procedures have been adopted in more than a hundred developed or developing countries. After the Stockholm conference in 1972, many countries obliged themselves to carry out environmental impact assessment studies before implementing projects. At the end of 1970, initial research studies were conducted in the field of environmental impact assessment in the Netherlands, after which proposals were presented to introduce an official assessment system. In 1979, plans were presented to the Dutch Parliament, and in 1986, the environmental impact assessment law was approved and declared independent of the European economic community. In Iran, despite the fact that the 50th article of the constitution has clearly declared the duty of everyone to protect the environment in the Islamic republic of Iran. The first law on environmental impact assessment in Iran was approved by the council of ministers in 1994. Due to this law, the implementers of 7 different types of projects were required to prepare an environmental impact assessment report. The subsequent approvals of the council of ministers included more projects in this plan, but due to the lack of an approved model, no movement was made in the implementation of the said resolution, until again in 1997, with the approval of the model for preparing an environmental impact assessment report in the said council, moving towards forecasting and compliance with environmental considerations in the construction and operation of development projects was opened. In this way, the executives were required to prepare a project environmental impact assessment report along with the project feasibility and location report. Until now, various definitions of environmental impact assessment have been mentioned. In general, environmental impact assessment is: the process of a formal study that is used to predict the environmental results of a proposed project and leads to yes or no

Types of environmental impact assessment methods in projects and development plans

There are various methods to evaluate and depict the results of project activities. Among the methods used in the evaluation of environmental consequences, we can mention the matrix, network, list or checklist, fuzzy logic, quick matrix of works evaluation and AHP. The important point in using these methods is that each method needs its own sources and related information fields. As a result, it has a special efficiency for certain designs. Therefore, all methods will not be equally effective in evaluating the design or the environment. In the usual evaluation methods in the country, there is no specific methodology for evaluating works based on various environmental criteria. In the past years, several efforts have been made in order to create more advanced and favorable methods for evaluating environmental consequences. The easiest way to predict the works is to use allegorical analogies or make comparisons with the works of existing and experienced projects. In this analogical method, information about similar projects in similar environments is used to achieve the expected results of the project under study. This method is descriptive or quantitative [7].

Introducing DECISION LAB software

DECISION LAB is a comprehensive software for Prometheus method and Gaia design. This software was developed by a Canadian company working on visual decision making, in collaboration with the author. This software replaced the PROMCALC software that was previously developed by the author. The present software has Windows that uses a special type of spreadsheet to manage the data of a multi-criteria problem.

Figure 1. View of DECISION LAB software

All data related to Prometheus such as evaluations, preference functions, weights, etc. can be entered by the evaluator as input. In addition, this software provides other additional information for the user, such as the qualitative definition of criteria, the correction of missing values in the multi-criteria table, or the definition of percentage thresholds in preference functions. Classification of options and criteria can also be defined for better identification of subgroups related to sectors and easier analysis of the problem to be decided. All the computations caused by Prometheus and Gaia can be done in real time and any data entered into it will quickly appear in the output window. Prometheus ratings, active profiles and Gaia plans are displayed in different windows and can be compared with each other [8-10].
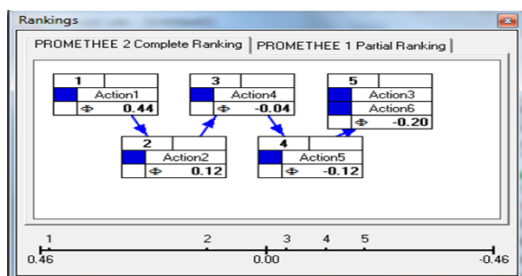

Figure 2. Software outputs

Several active tools and displays are available to facilitate the development of sensitive and powerful analyses. It is possible to calculate stable intervals of weights for individual criteria or a group of criteria. Display of weights can be used as an active definition of weights in the criteria and its effect can be seen quickly in the Prometheus ranking in the decision-making center of the Gaia plan. This case can be especially useful in cases where the decision maker does not have a definite theoretical criterion regarding weighting and wants to increase his freedom in this regard. The Prometheus GDSS process is also integrated into DECISION LAB by defining multiple scenarios for the same decision problem. These scenarios have similar lists of options and criteria, but can include different preference functions, different sets of weights, and even different evaluations for some criteria. Each of these scenarios can be analyzed separately using Prometheus and Gaia,

but it is also possible to combine all scenarios and produce a group ranking of Prometheus or Gaia. Conflicts between decision makers can be easily detected and analyzed. At the end of an analysis, the DECISION LAB report generator can produce tailor-made reports including tables and graphics required by the user. The generated reports are in html format and for this reason they can be easily edited by word or printed in an article and placed on the web. DECISION LAB can also be easily connected with other applications such as databases. Also, this connection can be updated as needed. The next stage of the Prometheus software is web implementation, which is developed under the name of Q-E-D.

Background research

In a study conducted by Hatami Marbini et al. in 2013 regarding the use of the Electra method in assessing the safety and health of hazardous waste recycling equipment, they concluded that the method proposed in the recent study made it easier to recycle waste materials. It becomes dangerous [11]. This method evaluates both quantitative data and qualitative data. Also, the organized and systematic framework presented in this study helps to evaluate and rank the facilities available in hazardous waste materials.

Nasiri et al. (2013) used the combined method of Prometheus and AHP to evaluate suitability in a watershed in Iran, and their results show the effectiveness of this method in environmental studies [12].

Khodabakhshi and Jafari in 2009 evaluated the environmental effects of Ardabil dam and drainage irrigation network using the multi-criteria decision-making method of Electra TRI. In this research, the weight of the criteria was determined and after the environmental impact assessment, the result was compared with one of the global environmental impact assessment methods [13].

In 2009, Melmasi et al investigated the environmental effects of petrochemical industries producing PET-PTA. In this research, the hierarchical analysis method was used to

investigate the adverse effects caused by the studied petrochemical industry [14]. Based on the results of periodic measurements and the nature of the studied petrochemical industry activities, 9 types of major pollutants including heavy metals, petroleum compounds, TDS, COD, SO, NOX, CO, H2S and suspended particles were valued and compared. The results of this study showed that water pollution is the most important environmental pollutant caused by the discharge of effluents from the treatment systems of industrial complexes into the surrounding estuaries, especially Zangi estuary.

Salehi Moid and Karimi evaluated the environmental effects of Hamadan to Bijar gas transmission line in 2016, emphasizing the use of RS and GIS. This research was done with two methods: descriptive checklist and Leopold's matrix. The results showed that despite the damage caused to the environment caused by excavation, embankment and explosion that will be done in some specific places. Carrying out this project, especially in the exploitation phase, will have high local, regional and national benefits due to its social and economic benefits [15].

In 2012, Tavakli and Tavet Behveh carried out the project to assess the effects of the development of the Anzali Bypass Road. This impact assessment was done using a simple matrix method and the result was that the mentioned plan is rejected due to the 16 km road passing through the protection area of the wetland as well as the results obtained from the matrix method and the continuation of the plan is only if there is economic justification for the modification. It will be possible to provide options and improvement plans [16].

In a study in 2001, Safaiyan et al. evaluated the environmental effects of development in the north of Iran with the destruction model. They found that the assessment of the effects of development on Iran's environment. Nakarood and sardab rood, is worrying. The cause of this destruction can be attributed to excessive and unprincipled exploitation of forests, conversion of forests and pastures to agricultural lands, industrial units and change of use in general [17].

In 2001, Hamid Reza Jafari evaluated the effects of development on the watershed of Letyan Dam with the destruction model. The results of this research show that 510 networks, i.e., 68% of the total 748 networks studied, are undevelopable due to the unfavorable natural conditions governing them, and also 149 networks, i.e., 20% of the total networks studied, are due to destruction caused by They have lost the quality of development to a large extent due to human activities and the consequent increase in the destruction rate, and have been given the third and fourth priority [18].

In 2014, Sami, in a study using the hierarchical analytical process and the Prometheus method, chose suitable places to replace power plants in Bangladesh to reduce the effect of electromagnetic waves emitted from these power plants on the surrounding environment. Due to the type of project selected and quantitative and qualitative data and also because this research has some uncertainty. Fuzzy methods can be considered as useful methods for it. On the other hand, the selected methods, especially the Prometheus method, have excellent display power due to their association with the Gaia graphic method and can show the contrasts between different options well. Also, these methods have good flexibility and can cover all quantitative and qualitative data and analyze them [19].

In 2013, Salvador Corente and colleagues developed a multi-criteria hierarchical process using Electra and Prometheus methods. Robust ordinal regression (ROR) supports the multi-criteria decision-making process by considering all sets of parameters assumed as preferred models. This preferred information is usually adopted by decision makers. As a result, in the ROR process, it is necessary to identify the preferred relationship between the set of options. In this study, the researchers expanded the Electra and Prometheus methods on hierarchical criteria. Therefore, a hierarchical version of ROR was prepared using the mentioned methods [20].

In 2013, Xing Ming et al investigated a suitable method for choosing alternative materials for

older materials in an environmentally friendly way. This replacement was done with the aim of cost reduction, higher efficiency and lower material weight using neural network methods and Prometheus method. As a result, it was found that the Prometheus method has higher efficiency and better results than the other method. Also, this method effectively reduces compensatory effects [21].

Of course, this feature is also seen in another type of multi-criteria method called Electra. With the difference that the Prometheus method is easier to understand and has simpler mathematical formulas than the Electra method. In addition, this method has more accurate calculations and more details and is easy to use. As a result, it can be said that in the recent study, the Prometheus decision-making method is preferred over other methods.

In another study in 2013, Roca and Herva investigated integrated multicriteria methods for environmental assessments. In this research, it was concluded that the simpler and smoother the multi-criteria method is, the more effective it will be in environmental decision-making and environmental assessment. It was also stated that in this regard, in a simple and smooth method, it is possible to select the criteria and determine the weights with the desired and suitable method. One of the easiest methods investigated in this research was the Prometheus method, which has been investigated in the research. In this article, it was used more than other methods for environmental decisions. In the studied articles, the most common method after Prometheus was the Electra method [22].

In 2012, Radolfo Veschera and Adele Tixeria de Almedia investigated the decisions made in portfolios through the Prometheus method. In this study, various options were proposed using a new formula of Prometheus. The results of these tests showed that this method shows relatively good results in almost all options. While this method requires little calculations even for very complex problems [23]. For easier problems, the method used is used in almost all

cases and produces a relatively complete ranking [24].

S. Wynod and R. In 2012, Jia Girobha used Vicor's method, which is one of the multi-criteria decision-making methods, to find a suitable replacement material for the panel used in electric machines and to evaluate this process in evaluating the effects of four different materials. The results of this research showed that polypropylene can be used as a suitable alternative material [25].

In 2011, Ling Hsu Chen et al used the Prometheus method to make decisions in IS outsourcing. This technology is one of the common methods in information technology and many companies and organizations have focused on it to reduce costs and increase their competitive power. Therefore, choosing a suitable outsourcing model is an important goal for these organizations. In this study, using the fuzzy Prometheus method, four potential sources have been used to use seven criteria and four decision makers. The resulting classification results produced a reference that helped decision makers and organizations to improve their efficiency during the outsourcing process [26].

In 2011, Hatami Marbini studied the multi-criteria Electra method under fuzzy conditions. In this research, he compared the mentioned method with several other multi-criteria methods and found that this method has advantages over the other investigated methods. One of these advantages can be considered as providing useful information. Also, the Electra method creates an incomparable situation between the investigated options in necessary cases [27].

In 2011, Achilas and his colleagues conducted research titled "Desirable strategies for creating an optimal and environmentally friendly urban environment with the help of the ideas of local people and officials and using a multi-criteria method." In this study, which used the Electra method, it was stated that the Electra method has the ability to collect and analyze a large number of evaluation criteria and can also

include the opinions of many decision makers in the decision-making process. This method also has the ability to deal with the uncertainty and low accuracy of the input data, which can sometimes confuse the decision maker [28].

In 2011, Kaya and Kahrman carried out a kind of industrial planning in Electra AHP fuzzy integrated method to evaluate the environmental effects. In this paper, criteria weights were determined by the fuzzy AHP process. The fuzzy electret method was also evaluated as a pre-ranking method for six industrial sectors near the city of Istanbul, and finally these six areas were ranked from the most effective to the least effective [29].

In 2010, Li Wei Giang organized a study to expand the Prometheus method based on generating fuzzy numbers. In this research, the necessary condition to obtain the weight of all the criteria and the appropriate options for each criterion is that the decision data and the linguistic variables used are all defined as fuzzy numbers [30].

Patch and Rodriguez in 2010 tested the development impact assessment process with a fuzzy logic approach. According to them, this method will facilitate the evaluation of development effects. The characteristics selected to evaluate the effects of development included intensity (P1), extent (P2) and sustainability (P3). The main actions are marked with A and the factors that potentially affect the environment are marked with F. Each investigated effect is estimated by double A-F evaluation as well as three features P1, P2, P3 by triangular fuzzy numbers. Each effect is simultaneously described by its own confidence limits and membership function. Since the membership functions of all the works were very close to triangular fuzzy numbers, the triangular method (TA) has been used to describe all the works. As a result, it was shown that the method of evaluating the effects of development was able to integrate many heterogeneous effects that affect the environment in very diverse conditions and in various ways. This issue can lead to the formation of global indicators [11].

In a study conducted by Blanco et al. in 2009, an attempt was made to produce software to evaluate the effects of development. According to this group, most of the changes created in the environment as a result of development activities are negative changes. They evaluated the qualitative and quantitative environmental effects during the following three stages:

1- Determining the type of activities that can harm the environment.

2- Determining the environmental factors and also determining the degree of importance of each factor in such a way that the maximum importance has a score of 1000.

3- Determining the importance of the effect, which is measured based on the degree of the effect or its intensity. Then these data are taken into the matrix and weighted in terms of fuzziness. Fuzzy matrix is mostly used for data quantification. In this method, the desired model, namely the AIEIA model, was used. C^{++} program was used in this process. As a result, this software produces reliable results and is an easy-to-use tool. Also, due to the administrative structure rich in information that this software has, it can be used in offices and in various projects.

In 2009, Jia Hong and Kevin worked on a decision support system for environmental impact assessment with the integrated approach of fuzzy logic and fuzzy analysis network process. This project was implemented with the aim of using the fuzzy logic method to create a combined decision support framework and show the right path to the decision makers. With this method, it is possible to evaluate facts, values and important acceptable transformations. Also, with this method, a combination of standards and the opinion of decision makers can be implemented. In this regard, the Fuzzy Analysis Network Process (FANP) was presented for the management of environmental factors. Then the process studied in this article was tested on a highway in Taiwan and the results of using the combined method of decision support and fuzzy analysis network were evaluated positively [32].

In this research, Patch and Rodrigues in 2009, during the process of evaluating the effects of development with fuzzy logic, first the characteristics of the existing effects are determined and then two examples of dimensionless characteristics of these effects include Pi (to evaluate the value of each characteristic) and Vi (to evaluate the combination Each environmental impact) was valued from zero to one hundred. Then the characteristics of each work are described using fuzzy numbers and created confidence limits. Then the process was developed based on mathematical calculations and the use of formulas. Finally, the fuzzy value of each environmental effect was obtained and using it, the total positive and negative environmental values were estimated. At this stage, the de-fuzzification operation was performed and finally it was concluded that the use of fuzzy logic in this method has made the evaluation work fast and the calculations easy.

In 2009, Nikolic et al. studied the classification of copper concentration based on its quality using multi-criteria decision-making methods. In this article, it was stated that many factors are involved in environmental issues, the Prometheus method is considered a suitable method for evaluation.

R. She. Parireras and J. Oh you. Vasconcillos in 2007 investigated the best solution for multi-criteria problems using Prometheus. During this research, the researchers achieved interesting results and were able to find a new version of Prometheus, which was called multiple Prometheus. This method provided better results than the original method and had the capacity to solve all kinds of sequential and discontinuous problems [2].

In a study conducted by Bocklin et al. in 2006 on the topic of decision support method for environmental impact assessment using fuzzy logic. The results of the mentioned method were analyzed to evaluate the development effects. This method was developed in such a way that it can predict the expected changes in physical, biological and socio-economic systems during various projects and activities. In this study, a solution was presented by using fuzzy logic, which can be used to communicate between different factors and their fuzzy form. It is worth noting that this method focused more on several highways located in Brazil.

The best results obtained in this study were obtained from methods such as hierarchical approximation and random programming, especially Electra, Prometheus, AHP, and MAUT methods. In another part of the same study, the definition of membership functions was discussed using linguistic variables in the examined highways and the principles of fuzzy logic were implemented on them. After finishing the article between the two options of creating a highway or not creating it, it was concluded that this project can be done by supporting local communities and reducing environmental impacts.

Also, the ecotourism protection operation of the region should be carried out by the EPA of Hatomirim region. Another alternative method is to create Park-highway, which can be the best possible solution from the economic, social and ecological point of view [13].

In 2005, Amir al-Badavi and his colleagues studied the decision-making process in commodity trading using the Prometheus method. The purpose of this study was to develop a suitable decision model for selecting the highest share in the stock market process and also to create a model to arrange the structure of this model. The structure of this research was based on two pillars of industry evaluation and company evaluation. Prometheus method was used to solve this problem [4].

The results of this research were analyzed in the Tehran stock market, and a number of experts decided to determine the effective criteria on the evaluation of the industry and the evaluation of the company.

In a study conducted in 2005 by Cavallaro and Sirallo to evaluate the wind power plants of the Italian islands using multi-criteria methods, it was found that the Prometheus method is the

ideal method for the evaluation of energy power plants. It was also stated that these power plants have qualitative data and their evaluation is not an easy task.

Gonzalez et al. in 2002 evaluated the environmental impacts of life cycle (LCA) with the help of fuzzy method. Life cycle assessment is a method that evaluates the environmental effects of a product, but it is a costly and time-consuming method and requires a lot of data. For this reason, in this article, LCA is made easier by using the fuzzy method. After that, membership functions constructed by PROD method were deduced. The next step is the combination, that is, according to the inferred cases, a single rule should be obtained for all the membership functions, and then the fuzzified functions should be de-fuzzified again. The results of the study have shown that the LCA method using fuzzy logic has many advantages, including the speed and ease of work in dealing with qualitative data, and in relation to medium-sized industries, it can be the answer to many environmental problems [5].

In 2000, Salemi and Anna studied the evaluation of development effects with fuzzy logic. In this research, environmental factors were defined by fuzzy numbers. Considering the quality of global components as a derivative of primary environmental components, these qualitative environmental components should be transformed into fuzzy physical factors.

In fact, the fuzzy method can establish a proper relationship between environmental components and their importance. Therefore, the total environmental effects (TEI) were calculated using the matrix method, and the effectiveness percentage of each component of the environment was obtained in a fuzzy form. In fact, in this study, a criterion was presented to compare the environmental effects of the entire phase for different regions [3].

This criterion was based on the rating method, which could take into account the degree of caution required in decision-making and the acceptable risk.

Silvert in 1996 discussed the classification of ecological effects using fuzzy sets. He stated that the reason for using fuzzy methods is to improve existing shortcomings such as ambiguity and uncertainty in natural processes. The study was conducted in three stages:

✓ Grading any type of existing effect such as the release of pollutants in the environment. The scores range from zero to 100%. These effects show what part of the acceptable effects each member has assigned.

✓ Each component is integrated with each other for different types of effects. The most appropriate way is to consider the least amount of these effects and therefore many unacceptable effects will be removed in this way.

✓ The total scores obtained or their average are de-fuzzified and presented to the decision makers. As a result, if the score of the adopted decisions is lower or higher than the acceptable threshold, the desired decision will be rejected.

In 1996, Al-Rashdan and his colleagues performed the following steps by examining the assessment of environmental effects and ranking environmental projects:

✓ Determining environmental problems and related goals.

✓ Selecting and testing fundamental goals.

✓ Criteria and their weighting.

✓ Development of environmental projects.

In this process, the geometric representation of problems shows that the use of multi-criteria decision-making method in this study is an effective method for analysis systems and is considered a suitable solution in evaluating problems. Also, aspects of the problem that could not be easily measured in numerical terms and were investigated were investigated. This process increased the speed of the learning cycle

to understand and even change the viewpoint of decision makers.

Louis C. Dias et al. in 1996 studied the implementation of a parallel method of Prometheus. In this study, the use of parallel processes has been discussed.

This means that the computational dimension of the computational method should be done in the construction phase of a decision support system. In this regard, several parallel programs were made and compared in 16 processor computers. In this study, the aim was to get an idea of how parallel methods can be used in different situations and to conclude which part of this method is more suitable for the given situation. So, the result was that in some situations, the reduction of the computer's response time meant that the parallel method in question is very desirable and can be used as a decision support tool.

Goikocha et al. in 1992 examined environmental assessment on four multi-criteria methods. This evaluation was done for water resource planning by two different groups. One group consisted of agricultural planners with experience in the military, and the other group consisted of graduate students. Based on a set of non-parametric statistical methods, the results were obtained and then one of the methods was preferred by both groups over the other method. This preference was attributed to the ease of use and comprehensibility of this method.

In 1992, Hobbs et al. expanded his research conducted in 1979 and 1986 and reached two important results.

✓ More experienced planners prefer simple and transparent methods.

✓ The classification of options can be more sensitive to the type of multicriteria method chosen than to the use of individuals.

In another study, Tekol in 1992 evaluated 15 multi-rank methods and found the most

appropriate method for watershed resources. The evaluation was based on four types of criteria: related to the problem, related to the decision maker, related to the method and related to the solution. It was concluded that the classification of multi-criteria methods can be different according to the type of problem.

Another comprehensive study to evaluate three different multi-criteria methods was again conducted by Hobbs in 1986 in relation to a nuclear power plant. In this study, suitability, ease of use, validity and sensitivity of the results were mentioned as influential factors. The most important conclusions included the following:

✓ Decisions can depend on selection methods, even on factors such as question interpretation that are theoretically unrelated.

✓ Users should exercise more than one method out of caution.

✓ In order to be able to explain, predict and control factors that are theoretically unrelated, researchers must expand their theoretical understanding in relation to the decision problem.

In 1982, Dusketin et al. reviewed various multi-criteria methods for the Taxon River basin. As a result, he found that the choice of the desired method depends on such things as the type of data to be compared, the nature of the options that must be examined, the stability of the results of these methods, the power of the results due to the possibility of changes in the value of the parameters, the ease of calculations. It depends on the amount of interaction between the decision maker and the system analyst.

Hobbs in 1979 compared different multi-criteria methods in relation to power plants. In the end, he stated four factors that can be effective factors in choosing the type of multi-criteria method. In his research, factors such as reliability, flexibility, comparability of the results of this method with other methods, ease of using the method and its comprehensibility by

the decision maker are considered as effective factors in choosing the type of method. He stated that choosing a suitable method for decision-making alone can be a separate problem in this process. He also stated that choosing the type of decision-making method depends a lot on the type of problem to be solved.

Introducing effective factors in research evaluation

Weather and climate: The weather regime of the study area is uniform and its atmospheric changes are not very noticeable in different areas. This region is one of the dry temperate regions with relatively hot and dry summers and winters with freezing and snowfall. According to de Marten's classification, Qadhemgah area has a semi-arid and cold climate and Shazand has a cold Mediterranean climate. According to Ghosen's classification, its regime is considered to be a cold steppe climate. In the classification of Amberjeh, Gadhamgah region is cold and semi-arid with the climate of upper altitudes. According to Silyanif's classification, Qadegah has a medium semi-arid climate and Shazand has a severe semi-arid climate. The climate characteristics of the study area based on the ten-year statistics from 1979 to 1989 are as follows.

Temperature: In the two stations of Gadhamgah and Shazand, the investigation of the temperature situation shows that the average annual temperature in these two areas is 1.2 and 1.9 degrees Celsius, respectively. The average absolute maximum temperature is 42 degrees Celsius in Gadgah and 38 degrees Celsius in Shazand. The absolute minimum temperature in these stations was recorded as 2 and 20 degrees Celsius below zero respectively. The average maximum temperature is 9.18 degrees Celsius in Gadgah and 8.16 degrees Celsius in Shazand. The average minimum temperature in these stations is 5 and 9.2 degrees Celsius, respectively. In other words, Shazand has a lower temperature than Qadhemgah. In this region, on average, 115 days of freezing have been recorded, the maximum of which is from December to February.

Rainfall: The average annual rainfall in Shazand station is 4.453 millimeters, which is more than Gadgah, which is 3.377 millimeters. The highest rainfall in this region also happened in March. The investigation of the average seasonal rainfall in both stations of the study area shows that the highest rainfall occurs in the winter season, and after that, autumn and spring are the rainy seasons, and in the summer, the amount of rainfall in both stations is more than 4.1% annually. It is not the highest recorded rainfall in 11 years was 877 mm in Qadhemgah and 7.671 mm in Shazand. The minimum rainfall in the two mentioned areas is 8.70 and 4.277 millimeters, respectively.

Relative humidity: In the study area, relative humidity has been recorded with an average of 59% and a minimum and maximum of 49 and 38% during 11 statistical years. The highest amount of relative humidity is in January and the lowest in June to September with 19%.

Wind: The examination of the wind situation shows that in January, the prevailing direction of the winds was from the north, west and northeast respectively.

In Bahman, the prevailing winds blew from the west and at the next stage from the southwest and north. In the month of March, the prevailing winds blow from the west and south-west, so that in the winter season, the prevailing direction of the winds was from the west in the later stages, north and south-west. In this season, winds with a speed of more than 21 knots blew from the southwest and southeast, and winds of more than 16 knots blew from the west, southwest, and southeast. In the mentioned season, the amount of air stillness has not been recorded. The predominant direction of the winds in April was from the southwest in more than 35 percent of the time, and in the next phase from the west. In Khorhad, the prevailing wind direction was northwest in more than 40 to 45 percent of the time, southwest about 27 percent of the time, and west about 22 percent of the time. In general, in the spring season, the prevailing wind direction was from the southwest and in the later stages

from the northwest and west. The amount of air stillness in this season is insignificant [37].

Selection of criteria: The criteria on which the options are evaluated were selected. In fact, to compare the options and finally evaluate and categorize them, a series of criteria are needed, and these criteria can be both quantitative and qualitative. In the case of impact assessment, the determination of these criteria can be based on the decision maker's personal opinion or the experience of similar projects can be used. In the current study, the selection of these criteria was based on previous projects and the opinion of experts. Based on this, 8 of the criteria that were most used in past researches were selected.

Selection of scale and quantification of criteria

In order for the value of all criteria to enter the model equally and quantitatively, it is necessary to choose a suitable scale to quantify the criteria. For this, it is necessary to determine the scoring range of the criteria, in other words, it should be determined in which range of points the criteria are placed. In the work of impact assessment, it is possible to use contractual points in projects such as a scale (1 to 3) to score the criteria. Therefore, in this regard, a questionnaire was designed based on the desired options and criteria and was placed in the hands of various experts and experts who had information related to petrochemicals, and they chose different options based on the desired criteria from 1 They rated up to 3. In addition, experts' valuation of the designed questionnaire was hierarchical. In this way, the preliminary designed questionnaire was given to the Arak petrochemical environmental expert and due to the lack of information of the researcher about the studied area, he was asked to correct the mentioned questionnaire in addition to valuing the criteria if needed. As a result, after completing and correcting the questionnaire, its final version was provided to other experts and evaluated. After receiving the questionnaires by the researcher, the geometric mean was taken from them and thus the supplementary questionnaires were combined with each other.

Control the coordination of values

According to the determined criteria and the considered numerical scale, due to ensuring the coordination of the judgments of different experts, the coordination of the values given to the criteria was controlled, which was controlled by calculating the standard deviation of the presented values. Thus, if the standard deviation of the values presented for each criterion is smaller than one, there is harmony between the presented numbers. Therefore, the geometric mean of scores is considered as the standard value in that option, and if the standard deviation is one and greater than one, it is necessary to revise the presented values, which was followed by the entropy method to control the coordination of the values.

Weighting criteria

The criteria are weighted to determine the relative importance of each of them, and the sum of their weights should be equal to one, for which the entropy method was used. For this purpose, first, the data in the geometric mean table was normalized (unscaled). This action is done to remove the impact of the qualitative effect of the criteria and to make different measurement scales comparable. In the current research, this de-scaling was done using the de-scaling method using the total normalized method, and the following formula was used for the de-scaling process:

$$n_{ij} = \frac{r_{ij}}{\sum_{i=1}^{m} r_{ij}}$$

Evaluate weights for (W_j) for criteria

In most multi-criteria problems, especially multi-criteria problems, we need to know the relative importance of the criteria. So that their sum is equal to the unit (normalized) and this relative importance measures the degree of preference of each criterion (objective) over the others for the desired decision. Below are four methods in evaluating the weights for the existing criteria in a decision:

✓ Entropy method.

✓ Linmap method.

✓ weighted least squares method.

✓ Special vector method.

Since in cases where we have a decision matrix, the entropy and Linmap methods are mostly used, and because of the emphasis of many experts on the entropy method, the entropy method was also used in this study. Entropy is a major concept in physical sciences, social sciences and information theory, as it indicates the amount of uncertainty of the expected information content of a message.   In another sense, entropy is a measure in information theory, for the amount of uncertainty and if the distribution is spread, it is more than if the frequency distribution is sharper. This uncertainty is explained as follows. In this regard, we first calculate a value with the symbol E.

$$E = \sum_{i=1}^{n} [P_i . \ln P_i]$$

✓ So that in order to ensure $0 \leq E \leq 1$, the value of K is positive.

✓ m= options

✓ n= criteria

$$\kappa = \frac{1}{\ln m}$$

$$d_j = 1 - E_j \; ; \; \forall_j$$

$$W_j = \frac{d_j}{\sum_{j=1}^{n} d_j} \; ; \; \forall_j$$

Determining environmental impact classes

Classes are determined based on experiences or contracts that exist in different projects.

Determining the value range of each class and the corresponding border of each class

The scope and range of each category must be determined, so that it is clear in which range of these categories the options fall. For this, it is necessary to have the profile or border of each floor. For this purpose, we use the range of criteria points as follows.

$$X = \frac{A}{n}$$

A: Score range of the criteria

n: the number of desired floors

X: Distance between floors

The range of the first floor = x + minimum score (criterion) and...

Ranking the effect of activities based on Prometheus

Pairwise comparison of all options according to each criterion

The basis of the Prometheus method is to make a pairwise comparison between options in different criteria. This pairwise comparison is done through dj (a,b)= gj (a)-gj (b), where dj (a,b) represents the amount of difference between the two options according to the jm criterion.

Calculate the degree of preference

In this step, a utility function is used to convert the difference between two options into a degree of preference. Basically, the decision maker gives relative superiority to the option that is at a higher level in terms of the desired criterion. In cases where the difference between the options is negligible from the point of view of the decision maker, none of the two options is preferred over the other.

The greater the difference, the higher the percentage of superiority. In this case, it can be said that these priorities are real numbers that vary from zero to one.   This means that the decision maker has a function in mind for each criterion:

$$P_j(a_i, a_k) = F_j\{d_j(a_j, a_k)\} \quad \forall a_i, a_k \in A$$

$$0 \leq P_j(a,b) \leq 1$$

In other words, the preference intensity of one option over another option is done by converting the difference between two options to a scale of zero to one. In the case where a criterion is at the maximum level, based on the observed difference between the two alternatives, a is preferred over state b based on the evaluations made in the criterion g_j (0).

$$P_j(a,b) > 0 \rightarrow P_j(a,b) = 0$$

If a criterion reaches its minimum value, its preference function will be as follows:

$$P_j(a,b) = F_j\{-d_j(a,b)\}$$

In these cases, we call the expression $\{g_j$ (0), P_j (a,b)$\}$ the general criterion related to the criterion g_j (0). This general criterion is defined for each criterion.   Six preference functions are used in the Prometheus method, and these functions are listed below. Among these functions, the V-shaped preference function is most often used for quantitative measures.

Results

Choosing appropriate scales to quantify criteria: Since it is necessary to convert the value of all criteria into a quantitative form, based on the existing methods, a scale of 1 to 3 was defined to score the criteria. Due to the negative nature of the selected effects, all these criteria are placed in the reduction category.

Control the coordination of values

In order to ensure the coordination of judgments about environmental effects and related criteria, the control of the coordination of the value given to the criteria was done by calculating the deviation of the values presented to each criterion.

Scaling

This method was done to quantify the effect of all data.

Determining the weight of the criteria

One of the requirements of working with the Prometheus model is determining the weight of the criteria. Since there is no specific weight for the criteria, in this research, the entropy weighting method, which is described in detail in the third chapter, was used to determine the weight of the criteria.

Determining environmental impact classes

Since the Prometheus method is a classification method, therefore, determining the classes and also the border between the classes is one of the requirements of working with this method.

Table 1. Classes of environmental effects in the construction phase

A lot of negative effect	Major negative effect	Moderate negative effect	Low negative effect	Negligible negative effect
-0/148 0/161	-0/135 0/148	-0/122 0/135	-0/109 0/122	**-0/096 0/109**

A= 0/065   n=5   X=0/013

Table 2. Classes of environmental effects in the operation phase

A lot of negative effect	Major negative effect	Moderate negative effect	Low negative effect	Negligible negative effect
-0/267 0/329	-0/204 0/267	0-/142 0/204	-0/080 0/142	**-0/017 0/080**

Classification of effects based on the Prometheus model

All the data obtained in the above seven paragraphs, as described in detail in the third chapter, were entered into the Prometheus model and the following steps were performed on it.

Pairwise comparison between options

At this stage, a matrix with the number of rows and columns equal to the number of options of the corresponding phase was formed and each option was compared with each other for each criterion. In this part, a 17x17 matrix for the construction phase and an 8x8 matrix for the operation phase were formed for each criterion.

Calculate the degree of preference

At this stage, as mentioned in chapter three, based on the selected functions for each criterion and also based on the degree of deviation of each option compared to other options, the degree of dominance of each option is measured and placed in the desirability tables.

Calculation of positive and negative superordinate currents and total superordinate current

In this step, the degree of predominance of one option over other options and the degree of predominance of other options over the desired option were calculated and the results are shown in tables (3) and (4).

Table 3. Total positive and negative currents in the construction phase

	φ^+	φ^-	φ
A1	0/351	0/080	0/270
A2	0/248	0/143	0/104
A3	0/291	0/141	0/149
A4	0/315	0/161	0/153
A5	0/126	0/251	-0/124

Table 4. Positive, negative and total super-rate flows in the exploitation phase

	φ^+	φ^-	φ
A1	0/374	0/025	0/349
A2	0/022	0/283	-0/260
A3	0/135	0/087	0/048
A4	0/023	0/279	-0/256
A5	0/292	0/043	-0/249

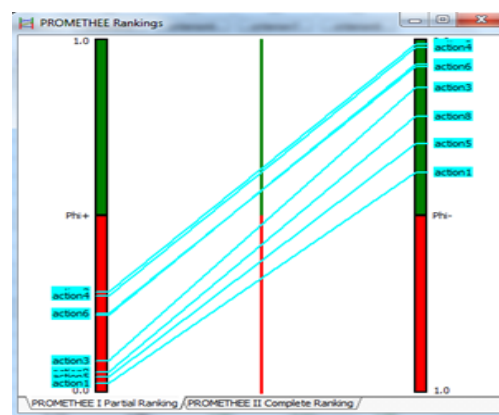Rating of construction and operation phase in Decision Lab software

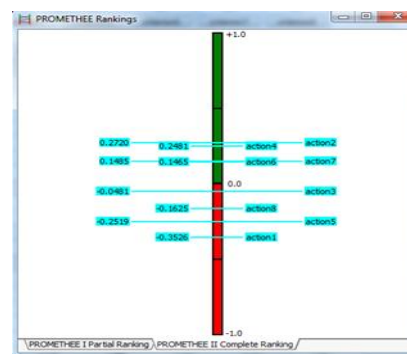**Figure 3.** Partial ranking of options in the operation phase

Figure 4. Complete ranking for the operation phase

Conclusion

Various methods are used to evaluate environmental effects in Iran, each of which has its own advantages and disadvantages. Some of these methods are traditional and others have been recognized in recent years as suitable methods for environmental impact assessment. The method used in the recent study (Prometheus method) is one of the multi-criteria methods that have been used in various fields. In the current study, the researcher used this method to evaluate the environmental effects of the petrochemical industry and achieved results. One of the most important problems in the implementation of the mentioned project is the lack and in some cases the absence of information about the study area and arak petrochemical in scientific documents and also in related offices in arak city. One of the advantages of the Prometheus method compared to the traditional method implemented in this study is that it requires less information about the location and condition of the study area. Another feature of a suitable evaluation method is that it is flexible and can consider various qualitative and quantitative criteria simultaneously. Also, high speed is another feature of a good method.

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