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Sustainable Environmental Management using Life Cycle Sustainability Assessment Model in Petrochemical Industry

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ABSTRACT: This study aims to present a sustainable environmental model using the life cycle sustainability assessment (LCSA) method in Shazand Petrochemical Company. To determine the evaluation indices, two Delphi and DEMATEL-FTOPSIS questionnaires were distributed among 27 and 8 experts in the field of sustainable environmental management. The environmental, social, economic, environmental-economic, socio-environmental and socio-economic factors were selected as the main criteria based on the previous studies. Data analysis was performed using the DEMATEL-FTOPSIS approach. The values of the determined indices were specified by this study, and the management of the company was prepared. The indicated that the BOD/COD output from the company with the value of 2.181 has the highest effectiveness. Moreover, the index of having short - and long-term planning for local sustainable development with the value of 2.416 had the highest influence. Identification of powerful, strategic and high-quality contractors to enter a long-term contract with them in order to get the competitive advantage in the value chain of the company with the value of 0.569 was found to be the best strategy. Eventually, the sustainable management model for petrochemical industry was presented based on the output results. In this model, indices, prioritizing improvement plans and assessing life cycle sustainability were identified as the most important factors among others.

Keywords: Environmental Management model, Petrochemical industry, BOD/COD Effectiveness- LCSA-DEMATEL-FTOPSIS

INTRODUCTION

Environment is of high significance for all human beings as it guarantees the human survival, material development and all types of other necessary conditions. It is impossible for human beings to survive with unsuitable environmental conditions. However, the current economic and social developments have not only posed damage to the environment but also endangered the sustainable development. Extensive development and changes in the environment may significantly affect the survival and development of the human beings. Employing the principles of sustainable development and environmental economics is the main method for changing the attitudes

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about environmental quality with the aim of controlling the main stream of industrial structure modification for supplying the resources. Preventing the high rate of energy loss in the industrial sector provides a great opportunity to control the use of energy carriers and finally reduces greenhouse gas (GHG) emissions. Despite having less than 1% of the world population, Iran has a share of 1.58% of the total GHG emissions in the world with GHG production rate of more than 716 million tons, and is ranked the 13th in the world (Energy Balance Sheet, 2015).The concept of sustainable development is different in public and private organizations, since implementation of the sustainable development method in these organizations requires specific guidelines. To perform the lifecycle sustainability assessment based on the United Nations Environment Program (UNEP) guidelines, specific indices should be defined and the responsibility score of each index should be determined to achieve the sustainability score (RaulAmbrus et al., 2017). Today, lifecycle assessment methods are applied worldwide as sustainability assessment approaches. All the direct or indirect environmental impacts of products, processes and activities are investigated using this method (Shahmohammadi et al., 2017).To assess the sustainability of an industry, an accurate evaluation should be made based on the sustainability indices. the overall goals should be defined in line with the goals of sustainable development introduced by the UNEP in order to achieve significant indices. Some researchers have found that there is a significant difference between the goal-based assessment and the index-based assessment (Wulf et al., 2018).Index development in the life cycle assessment method is a two-way process. A specific set of indices required for defining the strategic goals can help to determine the strategy itself. Socio-economic and environmental indices, environmental pressures and social activities can be used to evaluate the sustainable development strategies. Social development concept is closely related to the lifestyle of individuals in a society (Baumgartner et al., 2017). Azapagic et al.,(2016)) studied sustainable production and consumption used novel Decision-Support Framework Integrating Economic, Environmental and Social Sustainability method.

Considering the sensitivity of sustainable development indices, the political, economic, social, technological, environmental and legal assessment method (PESTEL) can be used. In such methods, it would be possible to approximate the parameters and indices from different aspects by including all stakeholders (Iacovidou et al., 2018).According to the World Commission on Environment and Development, sustainable development is a type of development which can meet the needs of the present generation without hindering the future generations to be able to meet their needs(Sneddona et al., 2006). Environmental factors signify the defined environmental policies, environmental objectives, long-term planning, assigned environmental responsibilities, developed training programs and special environmental practices implemented by the organization (Passetti & Tenucci, 2016).

Azarkamandet al.,(2013) studied the green supply chain of Shazand Petrochemical Company, this study can be completed by establishing a sustainable management model for this chain. Asadollahfardi et al., (2017) studied the Life cycle assessment of construction phase of monorail project in Qom, Iran with determined factors in construction phase for measuring sustainability during the project.

A formulated environmental planning can affect the measurement and assessment techniques for the environmental performance (Walls et al., 2013).The studies on sustainability over the lifetime of a refinery project, emphasize the necessity of a specific and accurate framework with determined factors and parameters in different phases for measuring sustainability during the project. In this study, five environmental, five economic and five social indices were selected for assessment Gholipour et al.,(2018). Development of a sustainable environmental model in petrochemical industries using the LCSA method was investigated in the literature. Ahmad et al.(2018) studied the Socio-Economic Factors on Human Health: Empirical Evidence in China. Lotfi et al. (2015) showed that Districts 1 and 3 of Tehran are in a more favorable situation in terms of environmental sustainability. Sharmin Akhtar et al., (2014) developed the LCSA to select the materials of sewer pipe. In their study, Steckel et al., (2013) evaluated the future energy consumption scenarios in developing countries. Salema et al., (2012) examined the use of petrochemical polymer materials in energy production in Great London. Schau et al., (2012) evaluated the LCSA to produce two types of electric alternators.

The present paper was conducted to provide a sustainable environmental model for Shazand Petrochemical Company in Arak, Iran. Necessary factors for presenting a sustainable environmental model for the mentioned petrochemical company using the LCSA were included. In the proposed model, the most relevant indices for sustainable environmental and social economics were identified and measured using the LCSA and represented as a sustainability dashboard. Afterwards, the modification and improvement of strategies were investigated and prioritized. In this study, the different sustainability indices in petrochemical industry were determined, the internal relations among the indices were specified, the indices were measured, and the suitable solutions for improving product stability were identified using Delphi and DEMATEL-FTOPSIS methods.

MATERIALS AND METHODS

121 primary indices were determined by reviewing the scientific studies, relevant sustainable development models and field studies. Subsequently, 42 indices were determined as the final indices according to the experts' opinions and based on screening the 121 indices in two Delphi rounds. Moreover, the interrelations among the indices and the influences of them were investigated by the DEMATEL technique, and the management board measurement indices were presented. Finally, the FTOPSIS technique was used to prioritize the solutions to improve the sustainable development of the mentioned industry. Documentary and library studies were performed to determine the indices in the model (ISO 14040, 2006).

In this study, four Delphi (2 rounds), DEMATEL, and TOPSIS questionnaires were used, and the sub-indices were identified as a set of items for the sustainable environmental modelling according to the literature and interviews with the experts and directors working in Shazand Petrochemical Company Table 1. All the sub-indices were then surveyed by 27 selected experts who were familiar with all the indices.

The final sub-indices were selected using the Delphi method which was performed in two rounds. The indices with the score of 7 and higher were selected for final analysis, and other criteria were omitted. Forty five of the 121 primary indices were considered in 6 main criteria as presented in Table 3 In the next step, a questionnaire was prepared to be distributed among the experts in Shazand Petrochemical Company. In this questionnaire, which is based on pairwise comparison of all elements, the probability of disregarding a variable is zero. Since all the criteria are considered in the questionnaires prepared based on pairwise comparison and the designer cannot bias the design of questions, they are inherently valid. On the other hand, since the questionnaire compares and measures all the criteria in pairs, the maximum number of questions is asked in a desired structure, and there would be no need to assess their liability of the Sustainable Development scale questionnaire (Biasutti et al.,2017). Moreover, the questionnaires were distributed among 8 petrochemical experts to make a pairwise comparison and to determine the interrelationships of the indices. Finally, the fuzzy multi-variable decision-making techniques were used to analyze the data obtained from the questionnaires and to determine the interrelations and influence of the indices. LCSA was calculated using Eq. 1 which shows that the product is considered both economically and socially. At this stage, a certain acceptable criterion was determined for each index. Then, the actual rate of the index was measured in the process.

$$LCSA = LCA + LCC + SLCA \qquad (1)$$

where, LCSA is Life cycle sustainability assessment, LCA is environmental life cycle assessment, LCC is environmental life cycle costing, and SLCA is social life cycle assessment. The technical documents and scientific papers were thoroughly studied to specify the acceptance criteria. Since manufacturing technology, manufacturing methods, laws, and regulatory requirements vary from country to country, in the petrochemical industry each company has a different license designer. Hence, the technical design documents can be considered as a suitable reference for the acceptance criteria. Knowing that the acceptance criterion is a function of the above-mentioned factors in the petrochemical industry, first the criterion acceptance of the organizational goals of Shazand Petrochemical Company was extracted. The comparison was made after determining these criteria and determining the number of indices. FTOPSIS technique is used to prioritize the projects. The solutions recommended in this study are presented in Table 7. The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) was first proposed by Hwang and Yoon in 1981 as one of the best methods for making multi-variable decisions to select the best solution. In the TOPSIS technique, the selected alternative should have the shortest distance from the ideal solution and the farthest distance from the anti-ideal solution. The TOPSIS method introduces two reference points of ideal and anti-ideal.

The research steps are represented in Table 1.

Interrelations between the criteria based on the fuzzy DEMATEL technique

In the group DEMATEL technique, when a multi-expert approach is used, the simple arithmetic mean of the opinions is used where the direct- or M-matrix is formed. In this study, first the views of each expert were fuzzified, and then the direct- or M-matrix was calculated by the fuzzy mean of the experts' opinions. Fuzzy spectrum and DEMETL technique represented in Table 2.

Table 1. Research steps

Step 1	Identification of environmental indices using LCSA method in the petrochemical industries based on the literature, investigation of the LCSA cycle and experts' opinions
Step 2	Screening the research indices by the Delphi technique
Step 3	Identification of causes and effects of the research indices by the DEMATEL technique
Step 4	Prioritization of the effectiveness of research indices using the DEMATEL technique
Step 5	Prioritization of the solutions using the FTOPSIS technique

Table 2. Fuzzy spectrum and DEMETL technique(Habibi *et al.*, 2014).

Linguistic variable	Quantitative variable	Fuzzy quantitative equivalent		
No effect	0	0.0	No effect	0
Small effect	1	0.1	Small effect	1
Effective	2	0.3	Effective	2
Highly effective	3	0.5	Highly effective	3
Very high effect	4	0.7	Very high effect	4

Calculation of the normalized direct-relation matrix: N = k*M

$\sum u_{ij}$ Should be calculated for every row to normalize the values. By dividing the matrix elements $\tilde{X}$ by the peak of $\sum u_{ij}$ values, the normalized matrix of $\tilde{N}$ will be obtained using Eq. 2.

$$k = max\left(\sum_{j=1}^{n} u_{ij}\right) = 3.240 \quad \tilde{N} = \frac{1}{3.240} \qquad (2)$$

Calculation of the total relation matrix

To calculate the total relation matrix, the $N \times (I - N)^{-1}$ relation is used. In the DEMATEL technique, normal fuzzy matrix is divided into three definite matricesbased on Eq. 3.

$$N_l = \begin{bmatrix} 0 & l_{12} & \cdots & l_{1n} \\ l_{21} & 0 & \cdots & l_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ l_{n1} & l_{n2} & \cdots & 0 \end{bmatrix} \quad N_m = \begin{bmatrix} 0 & m_{12} & \cdots & m_{1n} \\ m_{21} & 0 & \cdots & m_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ m_{n1} & m_{n2} & \cdots & 0 \end{bmatrix} \quad N_u = \begin{bmatrix} 0 & u_{12} & \cdots & u_{1n} \\ u_{21} & 0 & \cdots & u_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ u_{n1} & u_{n2} & \cdots & 0 \end{bmatrix} \qquad (3)$$

Then, the identity matrix of I_{n*n} is formed and the following items were calculated by Eqs. 4-7.

$$T_l = N_l \times (I - N_l)^{-1} \qquad (4)$$

$$T_m = N_m \times (I - N_m)^{-1} \qquad (5)$$

$$T_u = N_u \times (I - N_u)^{-1} \qquad (6)$$

$$\tilde{t}_{ij} = \left(t_{ij}^{l}, t_{ij}^{m}, t_{ij}^{u}\right) \qquad (7)$$

In Table 3, reference is made to the indices and the outputs of the Delphi second-order questionnaire.

Table 3. The criteria and symbols used for Shazand Petrochemical Company

Criterion	Index	Symbol	Index reference
Environmental	Percentage of environmental aspects under control	EN01	GRI 307: Environmental Compliance 2016
	Air pollutants in Shazand Petrochemical Company	EN03	GRI 305:EMISSIONS2016
	Total volume of the water extracted from resources	EN08	GRI 303: Water and Effluents 2018
	Percentage or total volume of the water recycled and reused	EN10	GRI 303: Water and Effluents 2018
	Total weight of the wastes in terms of type (planned and unplanned) and disposal method	EN13	GRI 301:M AT ER I A L S2016
	Amount of CO_2 emission	EN16	GRI 305:EMISSIONS2016
	Amount of air pollutant emission	EN18	GRI 305:EMISSIONS2016
	Amount of emission of volatile organic compounds	EN19	GRI 305:EMISSIONS2016
	Amount of renewable energy use	EN24	GRI 302:ENERGY2016
	Amount of BOD_5/COD output	EN26	GRI 306: EFFLUENTS AND WASTE2016
Social	Percentage of periodic experiments Coverage	SO01	GRI 403:OCCUPATIONAL HEALTH AND SAFETY 2018
	Value of indices and per capita education	SO02	GRI 403:OCCUPATIONAL HEALTH AND SAFETY 2018
	Satisfaction of local stakeholders with the implementation of social projects	SO04	GRI 415: Public Policy 2016
	Satisfaction of employees with HSE status at workplace	SO06	GRI 403:OCCUPATIONAL HEALTH AND SAFETY 2018
	Ratio of the standard payment at the entry level in terms of gender to the minimum statutory payment in major operations locations	SO07	GRI 405:DIVERSITY AND EQUALOPPORTUNITY 2016

Table 3. The criteria and symbols used for Shazand Petrochemical Company

	Number of people hired from the local community up to 75 km radius of the petrochemical company	SO08	GRI 405:DIVERSITY AND EQUALOPPORTUNITY 2016
	Petrochemical knowledge management	SO24	GRI 402: Labor/Management Relations 2016
	Complaint rates of people, organizations, personnel	SO15	GRI 307: Environmental Compliance 2016
	Percentage of literate/expert staff	SO16	GRI 402: Labor/Management Relations 2016
	Hiring the local experts as staff	SO17	GRI 403:OCCUPATIONAL HEALTH AND SAFETY 2018
Economic	Satisfaction of customer with the quality of manufactured materials	EC01	GRI 417: Marketing and Labeling 2016
	Delivery time of the product to the external customer	EC02	GRI 417: Marketing and Labeling 2016
	Productivity of manufacturing electric products	EC03	GRI 302: ENERGY2016
	Coverage of organizational commitment to banks and investors	EC04	GRI 203: INDIRECT CONOMIC IMPACTS 2016
	Management of customer complaints	EC05	GRI 419: Socioeconomic Compliance 2016
	Method of delivering the final product to customers	EC07	GRI 417: Marketing and Labeling 2016
	Profitability	EC09	GRI 201: ECONOMIC ERFORMANCE 2016
Environmental economics	Total gas fuel consumption in the whole company	ENEC03	GRI 302: ENERGY2016
	Consumption of Corrosion Inhibitor	ENEC06	GRI 301:M AT ER I A L S2016
	Amount of energy stored due to optimization and saving	ENEC09	GRI 302: ENERGY2016
	Costs of reduction of air pollution	ENEC16	GRI 305: EMISSIONS2016
	Energy consumption	ENEC23	GRI 302: ENERGY2016
	Compliance of raw materials with qualitative indices	ENEC24	GRI 301:M AT ER I A L S2016
Socio-environmental	Total direct and indirect emissions of GHG in terms of weight	ENSO04	GRI 305: EMISSIONS2016
	Total reduction in GHG emissions as a result of innovative projects for reducing their sources	ENSO06	GRI 305: EMISSIONS2016
	Weight of hazardous wastes carried, transported, imported, exported, or improved according to the provisions of the Basel Convention	ENSO08	GRI 306: Effluents and Waste 2016
	Index of Financial costs of environmental protection per year (against annual income)	ENSO12	GRI 103: Management Approach 2016
	Short- and long-term planning for local sustainable development	ENSO14	GRI 415: Public Policy 2016
	Access to healthy drinking water	ENSO18	GRI 303: Water and Effluents 2018
	Total direct and indirect emissions of GHG in terms of weight	ENSO04	GRI 305: EMISSIONS2016
Socioeconomic	Prevalence/incidence of work-related diseases	SOEC05	GRI 403: OCCUPATIONAL HEALTH AND SAFETY 2018
	Incidence repetition coefficient	SOEC06	GRI 403: OCCUPATIONAL HEALTH AND SAFETY 2018
	Incidence severity coefficient	SOEC07	GRI 403: OCCUPATIONAL HEALTH AND SAFETY 2018
	Share of value-added products of the company in the gross domestic product	SOEC08	GRI 203: INDIRECT CONOMIC IMPACTS 2016
	Direct economic value, and economic values of production and distribution including income, operating costs, employee rewards, grants and other social investments, accumulated profit and payments to shareholders and investors of the private and public sectors	SOEC13	GRI 201: Economic Performance 2016
	Amount of exports and currency import related to the products of Shazand Petrochemical Company	SOEC15	GRI 203: INDIRECT CONOMIC IMPACTS 2016

Shazand Petrochemical Company is one of the important projects in Iran practiced in line with the general policies of petrochemical development for supplying domestic and export needs. The project was implemented in 1984 and its first phase was operated after the design, engineering and installation phases in 1993. From 2000, at the same time with the completion

of various units, the development project was approved to increase the capacity of the units, the first and second phases of which were completed in October 2005 and the summer of 2007, respectively. Shazand Petrochemical Company, with an area of 523 ha, is located near Shazand Power Plant and Refinery, 22 km away from Arak-Boroujerd road. The company consists of 17 production units and the associated subordinate service units

RESULTS AND DISCUSSION

Indices should be measured to draw the management board. For this purpose, reports of the pollutants measurement, HSE management system, customers, sales department, production and purchase process, financial statements of management board, Iran's petrochemical industry, etc., were investigated. After reviewing the sources, data were finalized and the appropriate management board was drawn (Table 4). Gauge Charts were also plotted by Excel software to test the compliance of the sustainability indices with the goals and criteria determined for the company (Fig. 1).

Table 4. Measurement of sustainable development indices at Shazand Petrochemical Company

Index	Symbol	Measurement period	Measurement unit	Equation or measurement method	Target period	Amount measured in the period	% of compliance with the index
Percentage of environmental dimensions under control	EN01	Annual	%	Classified forms	100	75	75
Amount of air pollutants in the entire company	EN03	Annual	mg/nm	According to the method 1503	26	24	92
Total volume of water extracted from resources	EN08	Annual	10^6 m^3/yr	Meter	20	22	90
Percentage or total volume of water recycled and reused	EN10	Annual	m^3/yr	Flow meter	90	70	77

According to the information obtained from the amount of indices, as shown in Fig. 1Chart 1, the status of the environmental indices in Shazand Petrochemical Company is in alert level which can be improved through robust and correct planning. As shown in Fig. 1 Chart 3, measurement of the economic indices and conditions to achieve them indicates that Shazand Petrochemical Company has taken valuable steps to achieve these indices. Therefore, maintaining this index in the current state can ensure the stability of Shazand petrochemical industry.

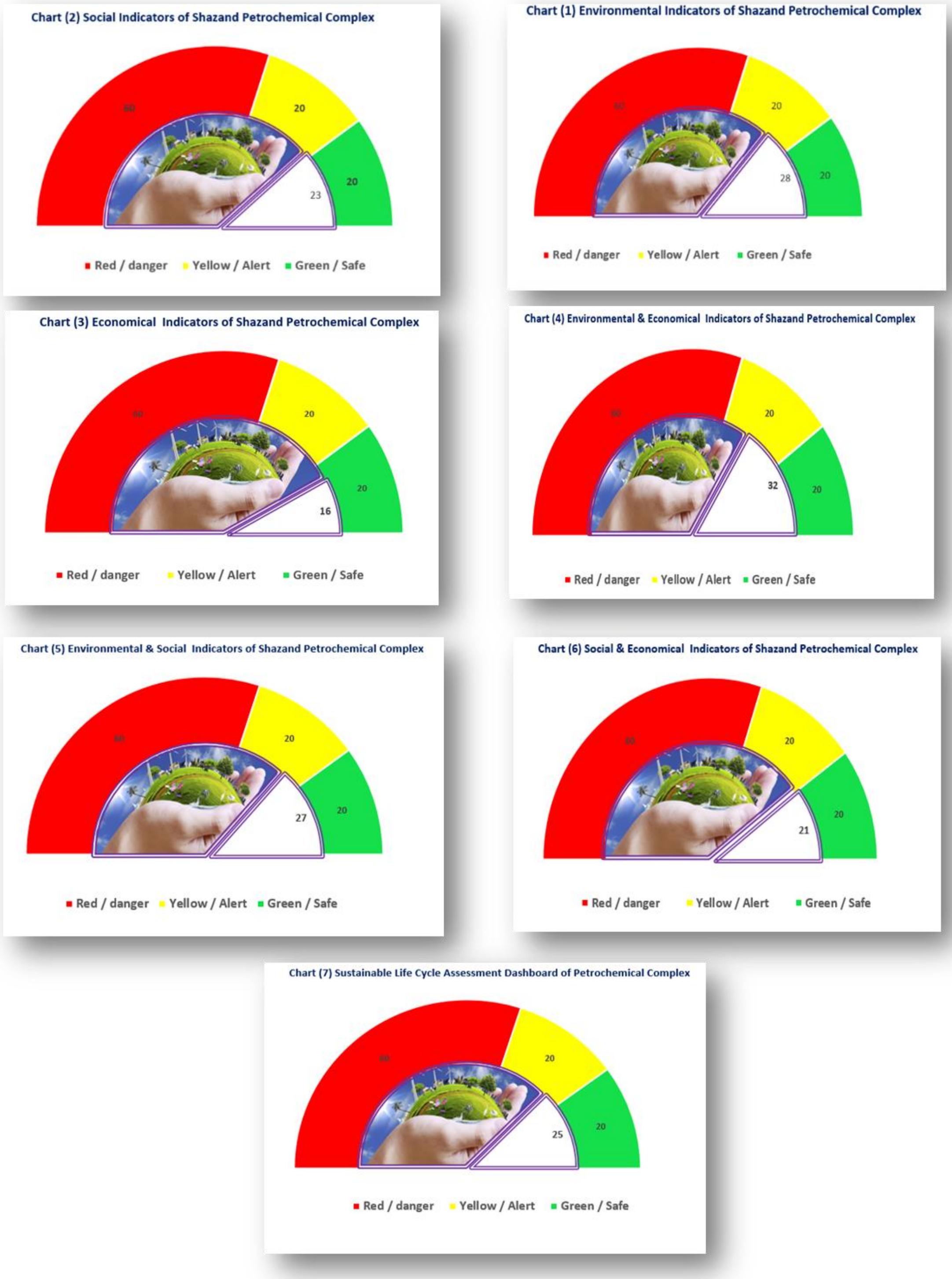

Fig. 1. Measurement of output and compliance with the source measurement criteria

As already mentioned, the DEMATEL-FTOPSIS techniques were used to analyze the data in this study. Moreover, the DEMATEL technique was employed to investigate the interrelationships among the criteria. Finally, the Fuzzy TOPSIS technique was applied to improve the ranking of the projects.

To determine the network relationship map (NRM), the threshold value should be calculated. Using this method, partial relations can be disregarded and the network of significant relationships can be drawn. Only the relationships with the values larger than the threshold in matrix T will be represented in the NRM. To calculate the value of the threshold of relationships, it is only needed to calculate the mean values of matrix T. Once the intensity of threshold is determined, all values of T-matrix which are smaller than the threshold become zero, showing that the relationships not considered to be causative. In this study, the threshold value was found to be0.032. The model for significant relationships of the sub-criteria is presented in Table 5.

Table 5. The model for significant relationships of the sub-criteria

SOEC15	...	EC05	EC04	EC03	Symbol
	...				EN01
	...				EN03
0.04	...	0.034		0.049	EN08
0.047	...	0.05	-		EN10
0.043	...	0.047			EN13
...	...	...	...	...	EN16
	...	-	0.024		SOEC15

The gray cells represent the cells that are not semantically related, and the starred cells indicate no relationship with the results obtained in this study. Table 6 indicates the model for causative relationships of the studied indices.

Table 6. The model for causative relationships of the studied indices

D-R	D+R	R	D	Symbol	D-R	D+R	R	D	Symbol
0.853	1.532	0.34	1.192	EC04	-0.337	1.063	2.2	1.863	EN01
0.483	2.305	0.911	1.394	EC05	-0.211	3.956	2.083	1.873	EN03
0.842	3.322	1.24	2.082	EC07	1.052	3.201	1.074	2.217	EN08
0.588	3.415	1.414	2.001	EC09	0.58	3.1	1.26	1.84	EN10
-1.111	3.188	2.15	1.039	ENEC03	0.1	3.092	1.496	1.596	EN13
0.70	2.422	0.861	1.561	ENEC06	-0.608	3.455	2.031	1.423	EN16
-1.367	2643	2.005	0.638	ENEC09	-1.153	3.085	2.119	0.966	EN18
-0.244	3.086	1.665	1.421	ENEC16	-0.260	3.2	1.73	1.47	EN19
-0.777	3.597	2.187	1.41	ENEC23	-0.439	3.342	1.89	1.452	EN24
-0.374	1.94	1.157	0.783	ENEC24	1.072	3.289	1.108	1.181	EN26
0.597	3.306	1.951	1.354	ENSO04	0.862	1.953	0.546	1.407	SO01
-0.723	2.885	1.804	1.081	ENSO06	0.098	3.083	1.493	1.591	SO02
0.132	2.243	1.056	1.188	ENSO08	0.067	2.024	0.979	1.046	SO04
-0.499	3.098	1.799	1.299	ENSO12	0.552	2.54	0.994	1.546	SO06
-0.457	4.374	2.416	1.959	ENSO14	0.189	2.396	1.104	1.292	SO07
-.0328	0.963	0.646	0.317	ENSO18	0.895	2.575	0.84	1.735	SO08
0.258	2.003	0.872	1.131	SOEC05	-0.575	3.658	2.117	1.542	SO24
-0.495	1.813	1.154	0.659	SOEC06	0.307	3.983	1.838	2.145	SO15
0.331	2.493	1.081	1.412	SOEC07	-0.606	2.873	1.74	1.134	SO16
0.342	2.855	1.257	1.598	SOEC08	1.001	3.006	1.002	2.004	SO17
-0.661	2.353	1.507	0.846	SOEC13	0.638	2.789	1.075	1.714	EC01
-0.201	1.357	0.779	0.577	SOEC15	0.909	3.056	1.073	1.983	EC02
					-0.830	2.706	1.768	0.938	EC03

Referring to Table 6, the sum of elements in each row (D) indicates the effect of each criterion on other criteria of the model. It can be seen that the BOD/COD index in the company has the highest impact. On the other hand, the index of access to safe and healthy drinking water showed the minimum impact on other elements. The sum of elements in column (R) for each factor represents the degree of its affectability by other factors in the system. Accordingly, the index of having a short- and long-term planning for local sustainable development showed a high-level affectability. The index of coverage of organizational commitment to banks and investors also had the minimum effect ability. The horizontal vector (D+R) shows the effect and affectability of the intended factor in the system. In other words, the greater the value of D+R of a factor, the higher the interactions of that factor with other factors in the system. Therefore, the long- and short-term planning index for local sustainable development showed the highest interaction with other criteria, while the index of access to the safe and healthy drinking water revealed the minimum interaction with other variables. The vertical vector (D-R) represents the effectiveness of each factor. Generally, if D-R is positive, the variable is considered to be a cause, and if it is negative, it is considered to be an effect.

According to the status of indices, field reports process studies, 20 solutions were presented for improving the indices. The list of solutions and symbols is presented in Table 7.

Table 7. Strategies for prioritization

Solution	Symbol	Solution	Symbol
Continuous monitoring of performance and effectiveness of all processes in the company to achieve the organizational excellence based on environmental indices of sustainable development defined in the management model	R1	Creating a system to record and manage the reduction of environmental pollution due to GHG and carbon footprints in the processes	R11
Continuous monitoring of performance and effectiveness of all processes of company to achieve the organizational excellence based on economic indices of sustainable development defined in the management model	R2	Creating and updating the industrial and healthcare waste disposal methods in the company in order to prevent the discharge of harmful substances into the environment	R12
Continuous monitoring of performance and effectiveness of all processes of company to achieve the organizational excellence based on social indices of sustainable development defined in the management model	R3	Establishing an educational management system based on the ISO10015 standard to enhance the efficiency of the petrochemical management expertise and knowledge	R13
Increasing the motivation and satisfaction of employees by improving HR processes and developing the HSE system	R4	Establishing a smart health system to monitor and protect the healthiness of the employees in order to check its compliance with the national and regional legal requirements	R14
Designing a system for cost management and organizational productivity performance management in the global market to increase value added and market share and to identify the potential markets	R5	Increasing exports and active presence in regional markets and neighboring countries, including Turkey, Afghanistan and the countries on the verge of the Caspian Sea and Europe	R15
Production of high-quality products based on the standards to meet the market demand and to stabilize and strengthen the brand in a competitive condition	R6	Establishing an HSE system for the management of credit, human, environmental risks and equipment	R16
Necessity of updating the production methods and technologies for optimal management of water consumption and wastewater evaporation considering the serious water scarcity in the region and the necessity of protecting the natural resources	R7	Establishing a risk management and integrated capital system to manage the assets and equipment	R17
Establishing a social responsibility management standard based on ISO26001 in order to satisfy the stakeholders and promote the brand position in the company	R8	Establishing energy management system based on ISO 51000 to optimize energy consumption and use of renewable energy	R18
Identification of powerful, strategic and high-level contractors and entering long-term contracts with them to gain the competitive advantage in the company's value chain	R9	Classifying the customers to fulfill the CRM customer orientation values and improve the product quality, packaging, prices, sales method, and services provided to enhance customer satisfaction	R19
Running a project for CO_2 recycling and purification and converting it to peripheral products in the framework of Clean Development Mechanism (CDM)	R10	Making agile and reducing the size of company and outsourcing the tasks to the local contractors and suppliers to strengthen the company	R20

The following steps were taken to prioritize the presented solutions:

Preparing the decision matrix and scoring the options based on each criterion of seven-degree scale

A. Unscaling the decision matrix
B. Preparing the unscaled fuzzy harmonic matrix
C. Calculating the positive and negative ideals
D. Calculating the distance from the positive and negative ideals
E. Calculating the ideal solution

The decision matrix has been shown in Table 8.

The output of the FTOPSIS algorithm for prioritization of the solutions has been given in Table 9.

Table 8. The fuzzified direct relation matrix (M)

	SOEC15			EN10			EN08			EN03			EN01		M
4	5.25	6.25	R1	4.5	5.5	4	5.25	6.25	R1	4.5	5.5	4	5.25	6.25	R1
0	0	0	R2	0	0	0	0	0	R2	0	0	0	0	0	R2
...	...	...	R3	...	...	...	...	...	R3	...	...	...	...	...	R3
٠	٠	٠	R20	٠	٠	٠	٠	٠	R20	٠	٠	٠	٠	٠	R20

Table 9. The calculated CL values

Final rank	CL	-D	+D	Symbol	Final rank	CL	-D	+D	Symbol
17	0.446	8.636	10.724	R11	20	0.401	7.734	11.561	R1
19	0.422	7.942	10.869	R12	10	0.528	9.698	8.683	R2
6	0.549	10.642	8.755	R13	4	0.556	10.160	8.121	R3
15	0.491	9.248	9.587	R14	7	0.546	10.117	8.410	R4
13	0.512	10.027	9.569	R15	2	0.565	10.828	8.338	R5
12	0.513	9.429	8.940	R16	5	0.555	10.621	8.520	R6
14	0.500	9.422	9.415	R17	16	0.469	8.872	10.033	R7
11	0.514	9.516	8.998	R18	3	0.559	10.779	8.512	R8
8	0.542	10.651	8.995	R19	1	0.569	10.483	7.939	R9
9	0.529	10.083	8.986	R20	18	0.436	8.378	10.833	R10

Considering the calculated values presented in Table9, it can be concluded that among the presented solutions, identification of powerful, strategic and quality contractors to make long-term contracts in order to gain competitive advantage in the company's value chain ranks the first. Designing a system for cost-cutting and organizational performance management to make the products competitive in the global market in order to enhance the value added and market share ranked the second. Finally, the third rank belonged to establishing a social responsibility management standard based on ISO26001 for stakeholders and promotion of the company’s brand. The environmental management model for Shazand Petrochemical Company is presented in Fig 23. This model is based on the latest steps taken in this study. Although this model is exclusively presented for Shazand Petrochemical Company, it can be applied as a general guideline in other petrochemical companies.

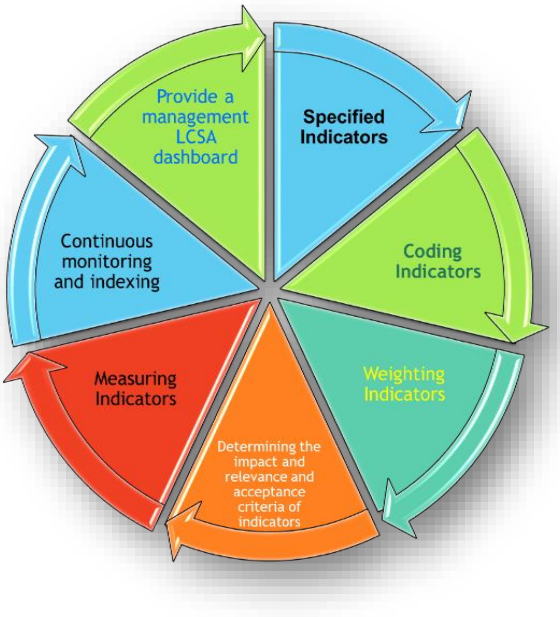

Fig. 2. Sustainable management model for petrochemical industries

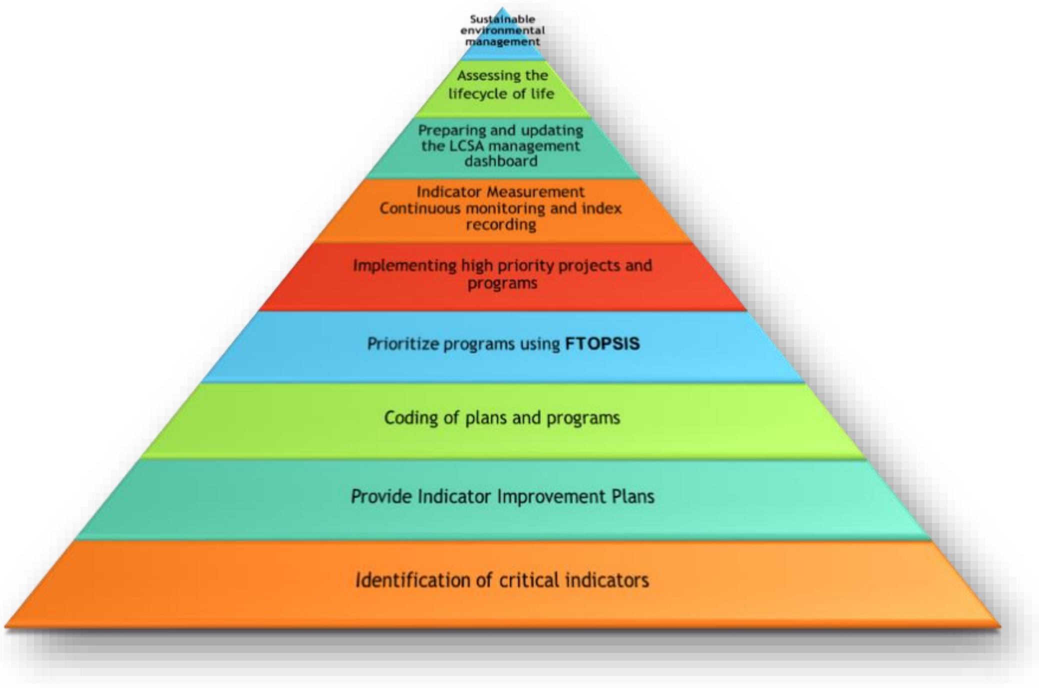

Fig. 3. Sustainable management model for petrochemical industries

According to this model, the preparation of a management dashboard of indices is performed in five steps, the dashboard of sustainable development after determining the indices is obtained in 7 steps and presentation of a successful model for sustainable development includes 9 steps which should be carefully observed by the managers.

CONCLUSION

The principal aim of this study was to provide a sustainable environmental model for Shazand Petrochemical Industries using the life cycle sustainability assessment (LCSA) method. Based on the obtained results, the environmental-economic indices in Shazand Petrochemical Company with a value of 68% is in an alarming condition and may be deteriorated if no appropriate environmental budget is allocated and environmental pollution and energy consumption are not controlled in it. Moreover, the social-environmental and socio-economic indices with values of 73% and 79%, respectively, imply the necessity of improving and updating the common indices by the board of directors in this company. The presented LCSA model revealed that the environmental indices in the mentioned company, with a compliance rate of 72%, are in an alarming condition. Hence, the plans for improving these indices are included in the recommendation. Developing and updating the methods and technologies for treatment of industrial wastewater and recycling of waste products in the company are among the recommendations to prevent the release of hazardous material into the environment. The directors of the company can improve the condition of this index by implementing environmental plans. Moreover, it is recommended to put the identified indices under precise targeting which complies with the International standards. The social and economic indices in the company comply about 77% and 84%, respectively, with the determined goals and criteria. This shows that the company can have a prosperous future if more comprehensive LCSA is performed. Having in mind the water crisis in the country and region, this study suggests that the sustainable development of the company requires a comprehensive water management and recycling plan (the first-ranked result of FTOPSIS with a CL value of 0.569). The accurate indices for water treatment and water consumption reduction should be observed in such plans in order to increase the satisfaction of the beneficiaries. Designing a cost-cutting management system and increasing the organizational productivity should be put on the agenda of the company to increase the value added and market share, identify the potential markets, and improve the competitiveness of products in the global market (the second-ranked result of FTOPSIS with a CL value of 0.565).On the other hand, one of the important strategies for sustainable management of the company is establishing a social responsibility management system based on ISO26001 (the third-ranked result of FTOPSIS with a CL value of 0.559). Higher level of satisfaction in stakeholders and brand development can reduce the rate of complaints from the public/organization/personnel, which were ranked in the second-priority of effectiveness, and substantially help in sustainable management of the company. On the other hand, by identifying the powerful, strategic, and high-quality local contractors and entering the long-term contracts with them, it would be possible to make local development and more interactions, provide a good competitive advantage in the supply chain of the company, and improve the employment in the region and among the local people. Although the index of long-term and short-term planning for a sustainable management system, with a value of 4.37, has the highest affectability, the company can increase its organizational productivity by deploying a sustainable management model and implementing a cost-cutting and performance management system and also sell its products in the global market and provide the country with a high value added by creating a competitive advantage. Considering the type of process and field of operation, the life cycle indices in Shazand Petrochemical Company were determined based on the international standards and models. The results obtained in this study can be used in most of the similar domestic petrochemicals. Moreover, the related researchers can promote development of the proposed model and improve it by employing it in compliance with the national and regional requirements and standards in the similar petrochemical industries.

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CONFLICT OF INTEREST

The authors declare that there is not any conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/or submission, and redundancy has been completely observed by the authors.

LIFE SCIENCE REPORTING

No life science threat was practiced in this research.

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