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Modeling of Environmental Impact Assessment Based on RIAM and TOPSIS for Desalination and Operating Units

Amin Padash*

Academic Center of Education, Culture and Research (ACECR), Sharif University of Technology Branch, Technology Development Institute, Industrial Ecology Department, Tehran, Iran

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Abstract

An environmental impact assessment is an assessment of the possible positive or negative impact that a proposed project may have on the environment, together consisting of the natural, social and economic aspects. Environmental Impact Assessment (EIA) of Masjid-I-Sulaiman desalination and operating unit's project in the southern of Iran using Rapid Impact Assessment Matrix (RIAM) method is presented. The field is located between 32° 06' 53.60" North and 40° 10' 54.18" East, in the Masjid-I-Sulaiman area. It is planned to produce rate of 55,000 oil barrels per day. In this study, an attempt was made to identify and assess the likely key impacts of desalination and operating units in two phases: Construction and Operation. In the evaluation process, positive and negative environmental impacts of Masjid-I-Sulaiman desalination and operating units were assessed based on the results of multi-disciplinary team approach and the field survey data using RIAM method. In this regard, given that in today's world for a closer look at the environmental impact of development projects and achieve a safer reply, using new implementation methods such as MCDM can be appropriate. The results of assessment reveal that the percent volumetric positive effects in alternative 1is more than percent volumetric negative impact on the second alternative, therefore the implementation of the project with some mitigation plans and monitoring program for the alternative 1 was chosen as a best option is accepted. Then on the basis of current evaluation suggest monitoring program and mitigation plans.

Keywords: EIA Modeling, Desalination and Operating Units, Masjid-I-Sulaiman, RIAM, TOPSIS

Introduction

In recent years, there has been a remarkable growth of interest in environmental issues – sustainability and improved management of development in harmony with the environment. Environmental Impact Assessment (EIA) is the tool most widely used in environmental management. The first EIA process was established in the USA in 1969. EIA systems have been set up worldwide and become a powerful environmental safeguard in the project planning process. EIA has been established in various forms throughout the world, beginning with Canada in 1973, Australia in 1974, Germany in 1975, and France in 1976 ; (Thors & Thóroddsson, 2003) and later in other countries. Many countries have adopted their own EIA

* Corresponding author E-mail: apadash@ut.ac.ir

procedures. Every country that has developed a process for making Environmental Impact Assessments has given it a different name and some slightly different meaning (Roberts, 1991).

Environmental impact assessment (EIA) is concerned with the systematic identification and evaluation of the potential impacts (effects), both beneficial and harmful, of proposed projects, plans, programmes or legislative actions related to the physical–chemical, biological, cultural, and socio-economic components of the total environment. The primary purpose of the EIA process is to encourage the consideration of the environment in planning and decision making and to ultimately arrive at actions which are more environmentally compatible (Canter, 1996). Although the quality of data analysis for EIA has improved over the years, the judgments made in an EIA are essentially subjective. The author's experiences show that although these subjective conclusions can provide a suitable basis for EIA, the problem lies in recording the transparency of the assessment. To carry out EIA analysis, the impacts of the identified environmental factors need to be further identified, predicted and assessed. The identified environmental impacts can be assessed on the grades of Table 1, which are also the grades used for evaluating the total environmental impact (Pastakia, 1996; Pastakia & Bay, 1998; Pastakia & Jensen, 1998).

Table 1. Assessment criteria for RIAM (Pastakia & Jensen, 1998)

Group	Category	Scale	Description
(A) criteria	A1 Importance of Condition	4	Important to national/international interests
		3	Important to regional/national interests
		2	Important to areas immediately outside the local condition
		1	Important only to the local condition
		0	No importance
	A2 Magnitude of change/effect	+ 3	Major positive benefit
		+ 2	Significant improvement in status quo
		+ 1	Improvement in status quo
		0	No change/status quo
		- 1	Negative change to status quo
		- 2	Significant negative dis-benefit or change
		- 3	Major dis-benefit or change.
(B) criteria	B1 Permanence	1	No change/not applicable
		2	Temporary
		3	Permanent
	B2 Reversibility	1	No change/not applicable
		2	Reversible
		3	Irreversible.
	B3 Cumulative	1	No change/not applicable
		2	Non-cumulative/single
		3	Cumulative/synergistic

The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is a multi-criteria decision analysis method, which was originally developed by Hwang and Yoon in (1981), with further developments by Yoon in (1987), and Hwang, et al. in (1993). TOPSIS is based on the concept that the chosen alternative should have the shortest geometric distance from the positive ideal solution and the longest geometric distance from the negative ideal solution. It is a method of compensatory aggregation that compares a set of alternatives by identifying weights for each criterion, normalizing scores for each criterion and calculating the geometric distance between each alternative and the ideal alternative, which is the best score in each criterion.

TOPSIS has been widely applied to the research of evaluation and selection problems and risk analysis problems (Balli & Korukoglu, 2009; Chamodrakas, Alexopoulou, & Martakos, 2009; Chen & Tzeng, 2004; Chen, Lin, & Huang, 2006; Chu, 2002; Chu & Lin, 2003; Dagdeviren, Yavuz, & Kilinc, 2009; Deng, Yeh, & Willis, 2000; Ertugrul & Karakasoglu, 2009; Wang & Elhag, 2006; Wang & Lee, 2009; Ye & Li, 2009).

An assumption of TOPSIS is that the criteria are monotonically increasing or decreasing. Normalization is usually required as the parameters or criteria are often of incongruous dimensions in multi-criteria problems. (Yoon et al., 1995; Zavadskas et al., 2006).

Compensatory methods such as TOPSIS allow trade-offs between criteria, where a poor result in one criterion can be negated by a good result in another criterion. This provides a more realistic form of modeling than non-compensatory methods, which include or exclude alternative solutions based on hard cut-offs. (Greene et al., 2011)

Project Description and Importance

The field is located between 32° 06' 53.60" North and 40° 10' 54.18" East, in the Masjid-I-Sulaiman area. Elevation ranges between 1384 m at the north east of Masjid-I-Sulaiman area. The Masjid-I-Sulaiman desalination and operating units is planned to produce rate of 55,000 barrels per day.(See Figure 1)

Location options and technical design

Considering the environmental sanitation conditions (Rep. Act Environmental Protection and Improvement Act 06/18/1974) operation and also prevent environmental destruction, the path chosen location as the only option, and is considered technically the best option.
The project includes four general steps are as follows:
A- Detailed design and construction of a network of oil collected from area oil fields and also the design and construction of oil pipeline
B- Detailed design and construction of production unit
C- Detailed design and construction of desalting unit
D- Detailed design and construction of other needed facilities
E- Testing and commissioning (Technical affairs ministry of oil, 2005)

Regulatory Framework

In Iran; Department of Environment (DOE) is responsible for the protection of the environment and ensuring legitimate and sustainable utilization of natural resources to guarantee sustainable development, pollution control and prevention of the destruction of the environment. Iran is one of the few countries that have the principle of environmental protection built into its constitution.

Article 50 of the constitution of Iran states: “Environmental conservation in Iran is a public duty. Therefore any economic or other activities which cause environmental pollution or other irreversible damage to the environment are forbidden”. EIA in Iran is enabled by Note 82 of the law for the second economic, social and cultural development plan of the country in 1994. It is implemented through decree 138 dated 04/12/1994, of the Environmental Protection High Council (EPHC). The enabled law requires that large manufacturing and projects are subjected to EIA process prior to execution. The EPHC determines both the interpretation of a large project and the guideline for the assessment. The EPHC has defined seventeen project

types are subjected to EIA, including; oil and gas pipelines projects, petrochemical plants, power plants, refineries, dams, bridges, airports, freeways, railroads, industrial city, irrigation projects, forestry projects etc. (LPAO-DOE, 2009)

Environmental Baseline Data

The compilation of environmental baseline data is essential to assess the impact on environment due to the project activities. This part of the study is concerned with describing existing environmental conditions of Masjid-I-Sulaiman field.

Physical-Chemical (PC) environment

1. Soil:
Study area soils have *Uostic* regime and *Hyper termic* thermal regime. Physiographic consists Of Mountain and Hills; Area soils based on the comprehensive soil classification method and according to the chemical and physical properties, miner logically and morphological has been classified and belong tow category Inceptisol and Entisol.

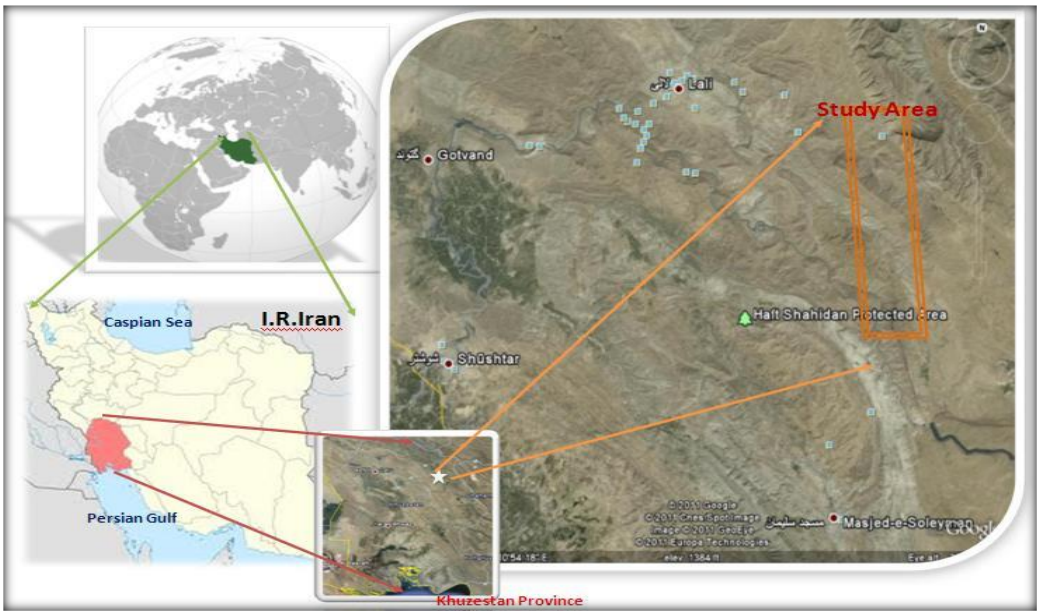

Figure 1. Study Area (ISC, 2008)

2. Geology:
Study area is located in the folded Zagros block and torn down Dezful; also important contracture like Gachsaran, Mishan, Aghajari and Bakhtiari is located in that area.

3. Water resources:
- *Surface water resource:*
Karun catchments Area of Karun and Dez basin with a total area of 69 thousand square kilometres has been formed which is composed of 47 thousand kilometres (68% of the total catchments area) is about logic mountain and is about 22 thousand square kilometres (32% of total catchments area) areas and plains of Khuzestan province. Karun basin excluding Dez River is about 45 thousand square kilometres. Average Dischary, Maximum and Minimum order is 387, 6441, 95 cubic meters per second. The approximate length of 860 km and volume Medium River is estimated 1220 million cubic meters per year.

- *Underground water resources:*
Total number of wells within the study is 292 rings deep and semi deep with evacuation 85 million cubic meters and the number of springs is 13 bit with evacuation 2.5 million cubic meters. For underground water in western district from North and West for the Eastern regions and in the parts of Eastern is from Northeast toward the West side.

4. Climate and air quality:
Khuzestan follow height variation and the range of the Persian Gulf has a diverse climate, the study area is located in warm and semi-arid areas. (Thors et al., 2003)

5. Rainfall:
Origin of precipitation are mist Mediterranean air currents in the catchments Karun; Rainfall period beginning from Nov and ends May. Average annual rainfall for Gotvand station is 33 mm and for station Sar Dasht is about 48 mm. (Weather Almanac country, 2007)

6. Land use:
The most available land use belong to pasture with an area of 37,779 hectares and then they are clouding too steep and rocky pasture with about 13,602 hectares and pasture with about 1797 hectares and forest about 6811 hectares.

Biological-Ecological (BE) Environment

1. Flora and Vegetation:
Study area of ecological is located in warm semi-steppe region close to the steppe and pasture vegetation with a low to very poor condition and management trends are negative. Important tree species can be pointed to the following species:
- *Ziziphus spina* – Christi (The most important of the area tree)
- *Ziziphus nummularia* (The most important of a shrub)
- *Vitex pseudo – negundo*

2. Wildlife (Fauna):
Mammals of the region are divided into groups of *Carnivore* like wolf, fox, jackal, hyena, wild cat and herbivore group like porcupine, rabbit, and *Omnivore* group like hog. Birds are divided into groups of fish eating birds like green head, bittern and *Carnivore* group like eagles herbivore like pigeons and *Omnivore* group like raven. (Nabavi et al., 2010)

3. Protected Area by Department of Environment
The proposal does not pass any of the four areas under the management of Department of Environment; there for areas closest proposed pipeline route is including *Shimbar* and *Haft Shahidan* protected areas which the distance to route proposal is respectively 42.5 and 7.5 Kilometres. (DOE, 2008)

Sociological-Cultural (SC) Environment

1. Population:
The study area is located in Khuzestan, the city of Masjed Soleiman and Lali section and south of rural districts; Lali County has a city, 4 rural districts, 219 villages, 3 independent farms. Based on 1385 census part population have been nearly 210,000. (Khuzestan Cultural Heritage and Tourism, 2008)

2. Literacy and Education:
In Lali 8842 are literate people it shows approximately 60.18 percent of the population.

Economic-Operational (EO) Environment

1. Job and Employment:
In Lali county 3169 people working in social, economic and cultural, it form approximately 66/18 percent the total population.

2. Cultural and Historical works (Tourism):
Lali which located in study area is considered resource-rich historical province, there are places like Rostam castle, Sheikh Suleiman, Chefa hill, Rack mill including the historical works that tale of the historical significance of the region. (Khuzestan Cultural Heritage and Tourism, 2008)

Method and Analysis

The methodology that use for evaluation and analysis is Rapid Impact Assessment Matrix (RIAM) combined with the TOPSIS method.

Impact Assessment

The Rapid Impact Assessment Matrix (RIAM) method is based on a standard definition of the important assessment criteria, as well as the means by which semi-quantitative values for each of these criteria can be collected to provide an accurate and independent score for each condition. The impact of project activities is evaluated against the environmental components; and for each component a score is determined, which provides a measure of the impact expected from the component (Pastakia, 1998). The important assessment criteria fall into two groups:

- Group A: Criteria that are of importance to the condition, and which can individually change the score obtained.
- Group B: Criteria that are of value to the situation, but should not be individually capable of changing the score obtained.

The value ascribed to each of these groups of criteria is determined by the use of a series of simple formulae. The use of multiplier for group (A) is important for it immediately ensures that the weight of each score is expressed, whereas simple summation of scores could provide identical results for different conditions. Scores for the value criteria group (B) are added together to provide a single sum. This ensures that the individual value scores cannot influence the overall score, but that the collective importance of all values in group (B) are fully taken into account. The sum of the group (B) scores is then multiplied by the result of the group (A) scores to provide a final assessment score (ES) for the condition. The process can be expressed: (a1)_(a2)_aT, (b1)_(b2)_(b3)_bT, (aT)_(bT)_ES.

Environmental Components

The RIAM requires a specific evaluation of the components to be defined through the process of “scoping”, and these environmental components will be in one of four categories that are described as follows:

- Physical-Chemical (PC): Covering all physical-chemical aspects of the environment

- Biological-Ecological (BE): Covering all biological aspects of the environment
- Sociological-Cultural (SC): Covering all human and cultural aspects of the environment
- Economic-Operational (EO): Qualitatively identifying the economic consequences of the environment change, both temporary and permanent impacts.

Assessment Criteria

The criteria should be defined for both groups, and should be based on fundamental conditions that may be affected by changes rather than be related to activities of the project (Table 1). The method of the RIAM makes it possible to carry out a global analysis of the results based on the individual environmental scores (ES) for each component, which are classified in ranges and so can be compared to each other. Table 2 provides the established ranges for the conversion of those obtained.

The results of the assessment for the Masjid-I-Sulaiman desalination and operating units' field are presented in Tables 3 and 4 and for both phases construction and operation.

Most impacts are of class (–A), and there is a majority of positive impacts and No major negative impact has been identified by RIAM.

• The lower limits of 'significant change' can be taken as the point when a condition is outside local boundaries (A1=2) but is of major importance (A2=3), yet is temporary (B1=2), reversible (B2=2) and non-cumulative (B3=2) and it is (ES=36).

A 'major change' will occur at a point when the condition extends to a regional/national boundary (A1=3) and is of major importance (A2=3). Such a change would also be permanent (B1=3), irreversible (B2=3), though it could be non-cumulative (B3=2) and it is [(3*3)*(3+3+2) = 36]. Once the ES score is set into a range band, these can be shown individually or grouped according to component type and presented in whatever graphical or numeric form that the presentation requires.

Table 2. Environmental classifications according to RIAM (Pastakia & Jensen, 1998)

Environmental Score (ES)	Value of Class (Alphabetic)	Value of Class (Numerical)	Description of Class band
108 to 72	E	5	Major positive change/impact
71 to 36	D	4	Significant positive change/impact
35 to 19	C	3	Moderate positive change/impact
10 to 18	B	2	Positive change/impact
1 to 9	A	1	Slight positive change/impact
0	N	0	No change/status quo/not applicable
-1 to -9	-A	-1	Slight negative change/impact
-10 to -18	-B	-2	Negative change/impact
-19 to -35	-C	-3	Moderate negative change/impact
-36 to -71	-D	-4	Significant negative change/impact
-72 to -108	-E	-5	Major negative change/impact

Ideal alternative Solution

TOPSIS is a multiple criteria method to identify solutions from a finite set of alternatives. The basic principle is that the chosen alternative should have the shortest distance from the positive ideal solution and the farthest distance from the negative ideal solution. (Huang, et.al., 2011). The procedure of TOPSIS can be expressed in a series of steps:

Step 1:

Create an evaluation matrix consisting of m alternatives and n criteria, with the intersection of each alternative and criteria given as x_{ij}, we therefore have a matrix$(x_{ij})_{m*n.}$.

Step 2:

The matrix $(x_{ij})_{m*n}$ is then normalized to form the matrix $R = (r_{ij})_{m*n}$, using the normalization method $r_{ij} = x_{ij}/pmax(v_j),\ i = 1,2,\dots,m,\ j = 1,2,\dots,n$ where $pmax(v_j)$ is the maximum possible value of the indicator $v_{ij} = 1,2,\dots,n$.

Step 3:

Calculate the weighted normalized decision matrix $T = (t_{ij})_{m*n} = (w_j\, r_{ij})_{m*n}, i = 1,2,\dots,m$.

Where $w_j = W_j/\ \sum_{j=1}^{n} W_{j,} j = 1,2,\dots,n$ so that failed to parse (unknown error), and W_j is the original weight given to the indicator $v_{ij} = 1,2,\dots,n$

Step 4:

Determine the worst alternative (A_w) and the best alternative (A_b):

$A_w = \{\langle \max(t_{ij}\,|i = 1,2,\dots,m)|j\epsilon J_{-}\rangle, \langle min\ (t_{ij}\,|i = 1,2,\dots,m)|j\epsilon J_{+}\rangle\} = \{t_{wj}\,|j = 1,2,\dots,n\}$

$A_b = \{\langle \min(t_{ij}\,|i = 1,2,\dots,m)|j\epsilon J_{-}\rangle, \langle max\ (t_{ij}\,|i = 1,2,\dots,m)|j\epsilon J_{+}\rangle\} = \{t_{bj}\,|j = 1,2,\dots,n\}$

Where,

$J_{+} = \{j = 1,2,\dots,n|j$ associated with the criteria having a positive impact, and

$J_{-} = \{j = 1,2,\dots,n|j$ associated with the criteria having a negative impact.

Step 5:

Calculate the L2-distance between the target alternative i and the worst condition A_w

$$d_{iw} = \sqrt{\sum_{j=1}^{n}(t_{ij} - t_{wj})^2} \quad i = 1,2,\dots,m$$

And the distance between the alternative i and the best condition A_b

$$d_{ib} = \sqrt{\sum_{j=1}^{n}(t_{ij} - t_{bj})^2} \quad i = 1,2,\dots,m$$

Where d_{iw} and d_{ib} are L2-norm distances from the target alternative i to the worst and best conditions, respectively.

Step 6:

Calculate the similarity to the worst condition:

$s_{iw} = \frac{d_{ib}}{d_{iw} + d_{ib}}, 0 \le s_{iw} \le 1, i = 1,2,\dots,m.$

$s_{iw} = 1$ If and only if the alternative solution has the worst condition; and

$s_{iw} = 0$ If and only if the alternative solution has the best condition.

Step 7:

Rank the alternatives according to $s_{iw} = (i = 1,2,\dots,m)$.

Processes and operations anticipated in the project

There are lots of sub project that has been done in these project but the main activity in the project included these affairs:

- Civil affairs
- Mechanical affairs

- Instrumentation affairs
- Power state

Priority-weighted index, TOPSIS output

The results of TOPSIS method for all three socio-cultural environments, physical, chemical and biological parameters based on the criteria most important socioeconomic, cultural, physical, chemical and biological presented.

The results of TOPSIS method to rank the alternatives and identify the most important environmental impacts of the project were used from the 32 indicators.

Finally, the resultant of scores obtained in order to provide 21 potential impacts and set the mitigation measures action for adverse environmental effects, for all three socioeconomic and the cultural, physico-chemical and biological parameters in the form of Environmental Management Plan (EMP) implemented.

Table 3. Summed the number and range of effects for 1 and 2 alternatives in Construction stage:

Environmental Score (ES)	Value of Class (Alphabetic)	Value of Class (Numerical)	PC		BE		SC		EO		Total	
			A1	A2	A1	A2	A1	A2	A1	A2	A1	A2
108 to 72	E	5	0	0	0	0	0	0	0	0	0	0
71 to 36	D	4	0	0	0	0	1	0	2	0	2	0
35 to 19	C	3	0	0	0	0	0	0	0	0	0	0
10 to 18	B	2	0	0	0	0	1	0	2	0	2	0
1 to 9	A	1	0	0	0	0	0	0	0	0	0	0
0	N	0	1	21	1	9	1	3	3	2	3	35
-1 to -9	-A	-1	19	2	12	8	3	1	31	1	31	12
-10 to -18	-B	-2	1	0	1	0	0	2	4	0	0	0
-19 to -35	-C	-3	2	0	3	0	0	0	5	1	5	1
-36 to -71	-D	-4	0	0	0	0	0	0	0	0	0	0
-72 to -108	-E	-5	0	0	0	0	0	0	0	0	0	0

Table 4. Summed the number and range of effects for 1 and 2 alternatives in Operation stage:

Environmental Score (ES)	Value of Class (Alphabetic)	Value of Class (Numerical)	PC		BE		SC		EO		Total	
			A1	A2	A1	A2	A1	A2	A1	A2	A1	A2
108 to 72	E	5	0	0	0	0	3	0	2	0	5	0
71 to 36	D	4	0	0	0	0	1	0	1	0	4	0
35 to 19	C	3	0	0	1	0	0	0	0	0	1	0
10 to 18	B	2	0	0	1	0	0	0	0	0	1	0
1 to 9	A	1	0	0	2	0	0	0	1	0	3	0
0	N	0	5	6	4	6	1	1	0	0	10	13
-1 to -9	-A	-1	3	0	5	3	0	1	0	2	8	5
-10 to -18	-B	-2	0	2	0	0	0	2	4	0	0	2
-19 to -35	-C	-3	1	1	0	4	0	0	5	0	1	5
-36 to -71	-D	-4	0	2	0	0	0	4	0	2	0	8
-72 to -108	-E	-5	0	0	0	0	0	0	0	0	0	0

Table 5. Final environmental impact of Desalination and Operating Units with TOPSIS method based on priority-weighted index

Row No.	Attribute Options	Indicator	Switch	Weight Indicator (Cl+)	Relative closeness to the ideal solution (d+)
1.	A1	Water Pollution	Effect on Groundwater	0.892	1
2.	A3	Groundwater quality	Effect on Groundwater	0.880	1
3.	A29	Landscape	Effect on Landscape	0.875	1
4.	A26	Employment and Unemployment	Effect on the economy and security	0.808	1
5.	A2	Quality of surface waters (rivers)	Effects on surface water	0.798	1
6.	A24	Income	Effect on the economy	0.764	1
7.	A7	Soil texture and structure	Effect on the soil	0.649	1
8.	A30	Local Culture	Acceptability and sustainability plan	0.649	1
9.	A23	Hygiene	Effect on Health	0.649	1
10.	A21	Awareness	Impact on Cultures	0.645	1
11.	A14	composition and density of vegetation	Effects on Vegetation	0.643	1
12.	A31	Development projects	Impact on regional development	0.643	1
13.	A4	Noise Pollution	Effect on Health	0.632	1
14.	A19	Population density	Quality of Life	0.605	1
15.	A27	Agricultural activities	Effect on the economy	0.484	0
16.	A22	Emigration	Impact on the people	0.484	0
17.	A32	Historical and religious	Effect on regional prosperity	0.484	0
18.	A8	Soil Pollution	Effect on soil	0.464	0
19.	A10	Form of Ground	Effect on Ground	0.404	0
20.	A5	Vibration	Effects on health and safety	0.382	0
21.	A9	Soil erosion	Effects on soil and habitat	0.382	0

Environmental Monitoring and Audit

The review of other EIA experiences suggest that Environmental Mitigation Plans should be proposed for this plan; in addition to an environmental monitoring and audit (EM&A) program will be implemented for the Project, to check effectiveness of the recommended mitigation measures and compliance with relevant statutory criteria. (Yousefi et al., 2008) There are some important environmental components which should be monitored in Masjid-I-Sulaiman project area to avoid future socio-economic problems:

- Chemical analysis of Karun river water in scope of project area
- Periodic analysis of Air pollution in the site
- Periodic measurements and analysis of Noise pollution
- Take care of biological area in the North and West of the field
- Evaluating the population of the wild life by sampling and bird watching method
- Take participation of local people in the project and help them in their accommodation
- Direct supervision of contractors up through the rules and procedures of Health, Safety and Environmental (HSE) checklists (Padash et. al., 2010)
- General education courses and specialized training in personal safety degree, environmental health, environmental protection and technical workshop. (Padash et. al., 2010)

Conclusions

The obtained results reveal two alternatives for EIA in the current project, including: Option 1 and Option 2. Option 1 refers to the implementation of the plan with respect to the environmental measurements during the operation and construction. Another one, option 2, focuses on avoiding initiating the project. The mentioned project compare the number and range effects of project activities involved in options 1 and 2 in construction and operation stage. Option 1 in construction stage has 31 small negative effects, 4 typical negative effects, and 5 moderate negative effects. As with regard to the option 2, or non-performance plan, 12 small negative effects, 2 typical negative effects, and 1 moderate negative effect in the region are created. Option 1 or performance plan, with observing of the environmental considerations and arrangements in construction stage, showed 2 positive effects and 2 typical positive effects, while option 2 or non-performance plan did not show any positive effect in the area.

Table 6. Compare the number and range of effects options 1 and 2 in the construction stage

Range of Effect	-E	-D	-C	-B	-A	N	+A	+B	+C	+D	+E
Option 1	0	0	5	4	31	3	0	2	0	2	0
Option 2	0	0	1	2	12	35	0	0	0	0	0

Table 7. Compare the number and range of effects in options 1 and 2 in the operation stage

Range of Effect	-E	-D	-C	-B	-A	N	+A	+B	+C	+D	+E
Option 1	0	0	1	0	8	10	3	1	1	4	5
Option 2	0	8	5	2	5	13	0	0	0	0	0

In operation stage, the option 2 or non-performance plan did not show any positive effect in area. However, option 1or performance plan showed some effects. The small positive effects of option 1or performance plan showed 3 effects, typical positive effects showed 1 effect, moderate positive effects showed 1 effect, specified positive effects number showed 4 effects, and useful and large positive effects number showed 5 effects. Despite of the fact that option 1 showed 8 small negative effects, 1 moderate negative effect, against 5 small negative effects, 2 typical negative effects, 5 moderate negative effects, and 8 specified negative effects of option 2, it can be concluded that option 1 has better situation. Thus, option 2 has no positive effect in construction and operation phases, while option 1 has 3 small positive effects, 3 typical positive effects, 1 moderate positive effect, 6 specified positive effects and 5 positive and useful effects. Investigation of the negative effects of options shows option 2 has 40 small negative effects, 14 typical negative effects, 7 moderate negative effects, and 9 specified negative effects, but option 1 despite of having 39 small negative effects have only 4 typical negative effects and 6 moderate negative effects. It is also without any specific and large negative effect.

Table 8. Compare the number and range of effects in options 1 and 2 in both stages

Range of Effect	-E	-D	-C	-B	-A	N	+A	+B	+C	+D	+E
Option 1	0	0	6	4	39	13	3	3	1	6	5
Option 2	0	9	7	14	40	13	0	0	0	0	0

Thus, there are more positive effects of National and Regional effects that show more preference towards option 1 than option 2. Therefore, option 1 will be approved as the final option. This RIMA study identified and assessed potential environmental impacts of the Masjid-I-Sulaiman project in the surrounded environment.

As the analysis results obtained TOPSIS table:

Water pollution index, with a weight of 0.892; Groundwater quality, weight 0.880; Index landscape, weighing 0.875; Employment and unemployment, weighing 0.808; Quality of surface waters (rivers), weighing 0.798; Exchange technology and revenue, with a weight of 0.764; Regional income, weighing 0.649; Soil structure, weighing 0.649; local cultures, weighing 0.649.

There are important factors that are the highest priority. Therefore, the environmental impacts caused by the project are certainly if the project would be severe impacts on the indicators listed.

Employment and unemployment indicators, impact on surface water quality and aquatic species, including those that are important at the next level.

Also, some indicators can also be considered as a positive effect on the region, including exchange technology and income, weight, 0.764, regional income, weighing 0.649, indigenous cultures, weighing 0.649, awareness, weight 0.645, and on the historical and religious parameters with weight 0.484, not much important.

Overall, the study predicts that with the implementation of the recommended environmental control measures during the drilling, construction and operational phases, the Project would comply with Department of Environment's (DOE) criteria and government and parliament legislations. This EIA has also demonstrated the acceptability of residual Impacts from the geothermal project and the protection of the population and environmentally sensitive biological resources. An EM &A mechanism have been recommended for implementation to check environmental compliance.

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