Environmental impact assessment of oil refineries in Iran: An AHP-GIS-based multi-criteria decision making

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Abstract

Emissions have negative effects on ecology of the surrounding area of a plant and threaten life of those residing in the neighborhood. Therefore, options of materials transport routes shall be chosen in a way that they do not pass the overpopulated areas. Different facilities and equipment of storage and processing are used in the manufacturing process of refineries. Thus, manufacturing options shall be of higher priority to choose the optimal options in the designing phase. Furthermore, besides observing land use and design bylaws, planning and studies of land preparation, it is essential to assess environmental impacts to confront with environmental pollution. In line with the above measures, environment, local communities, and their activities shall be least influenced by water and air pollutants and disorders in life. The Isfahan oil refinery was selected as a case study as a sample of oil refineries in Iran. Iran oil industry especially in oil refinery section developed in many areas in Iran. In this research for present a model of Environmental Impact Assessment (EIA) of oil refinery by using Analytical Hierarchy Process (AHP) and Geographic Information System (GIS) 1024 maps were provided as EIA final results that they can be a good modeling for EIA of other parts of oil industry in Iran.

Keywords: Isfahan oil refinery, Environmental Impact Assessment (EIA), Iran, Analytical Hierarchy Process (AHP), Geographic Information System (GIS), oil industry.
Introduction
Consequences and environmental adverse impacts of a project may seldom be ignored. However, they can be reduced by possible measures. These measures are called corrective measures or impacts reduction measures. Corrective measures are taken by engineering and management operations and are regarded as an important principle and one of the fundamental elements of reporting the environmental impacts. In an assessment report, details of methods and logical operations based on scientific, technical, and economic principles are noted as corrective measures recommendations. A report, certainly, may not lack corrective measures approved by the Environmental Protection Organization. The main corrective measures or impacts reduction measures of refinery projects are as follows: Refineries have normally impacts as a result of manufacturing, storage, and transport processes. Therefore, assessment of the option of the location of establishment of a plant shall be considered. In addition to outlets of a plant that should be reviewed, transport of raw materials to/from the plant is of paramount importance. In manufacturing process, most of chemical, poisonous and highly inflammable materials are extremely considered. Transport of these materials is a main issue and their environmental impacts are of great importance. Base on the Iranian refining planning and future views two parts (construction and operational stages) of these are being considered in this project. The production of an assessment report is the job of the employers of the plans or projects. To economize on expenses and time, the order of producing the assessment report, its being approved, obtaining or failing to obtain the permit for carrying it out is as follows:

1- Management and systematization
To produce an assessment report an employer would do it in his or her own if she or he has a consultant. Otherwise, she or he would have to be the party of a contract with an authorized real or legal entity.

2- Timing of the studies
The time required to produce an environmental impact assessment report depends on the type, size and complexity of the project. It also depends on geographical and social conditions of the place where the project is going to be carried out. Other factors that affect the time of report production are the amount of the budget, the ease of access to the required information and the efficiency of the consultants. Usually the required time is between 4 to 8 months.

3- Financing and expenses
That fact that the cost of producing reports is high especially for big projects such as refineries is a cause of serious concern. The cost of report production depends on the complexity, importance and the place of the project. It also depends on ease of availability of required experts.

4- Determining the limits of studies
To determine the limits of studies and the extent of geographic impacts of the project is one of the most factors to reduce the costs. It also helps to recognize the exact consequences, to remove ambiguities and complexities, and to gain access to the required information. The main factor in determining the limit of studies is getting familiar with the activities of a suggested plan or project. To do the job of environmental impacts assessments of refineries properly, it is essential to utilize the expert opinions of the related specialists, or related governmental organizations as well as the scientific and research institutes. In doing so, we can mention holding sessions with...
these specialists and these organizations. Determining the geographical impacts of the studies is one important factor in producing the assessment reports.

5-One of cases that assessment report preparation is important definition of geography studies scope.
Definition of place scope or studies geography scope according to limiting sources base done time and human force is defined in assessment of studies for important impacts defining is done placing scope of studies environmental impacts assessment base done geography boarders as following:
Offering projects limits
Determining the geographical limits and scopes of the studies is affected by the limitation of time and workforce. By projects’ geographical limits we mean the setting in which the construction preparation activities, construction activities and operational work of the project in done. It is exactly from this setting that environmental impacts are posed. The geographical limit or scope of the studies on the environmental impacts assessment is done based on the following geographical limits:

6-Ecological limits
By ecological limits, we mean the extent of the spread of the project’s emissions into the environment through the air or water that could lead to negative effects. Also by ecological limits, we mean the areas of the projects that have impacts on the project’s activities from ecological points of view.

7-Social limits
By social limits, we mean social interactions between structures and social systems that are affected by the activities of the projects. Of the three limits of the study, the social limit is the most important one, because the socio-economic life of many social groups are negatively or positively influenced by the different activities of the projects or plans. That is why in producing environmental impacts assessments we should deal with these effects on the lives of different social groups.

8-Administrative limits
By administrative limits, we mean the level to which people of a society can freely embark on economic, social and cultural activities within the scope of their laws and regulations. In other words, these limits are the administrative and governmental beaneries within which people can maneuver, such as the permits issued to make use of forests or mines.
There are some other technical limits for studies, such as the amount of budget, time and workforce; so, these also should be taken into consideration.
The above-mentioned limits, can determine certain geographical boundaries. So, with regard to the available information, timing of the project, the amount of budget provided for producing the assessment report, professional workforce, technologies’, and the methodology the producers of such reports are obliged to set the geographical limits in the studies within ecological, social and administrative limits.
To determine the areas of responsibility, and to be able to predict the impacts of construction and operational work of the projects or plans it is vital to utilize a matrix. This way you can
accelerate the studies, speed up the selection of specialists, and avoid gathering parallel (unnecessarily repeated) information and save expenses. A matrix is a simple credible tool that enables specialists as well as other related people who are not technicians but are anyhow involved in the environmental and managerial aspects of the projects to identify the oncoming phases of the projects, hence resolving problems related to the shortage of information and determining ways to reduce the impacts.

Previous experiences from studies done on the environmental impacts assessments shows us that in some meetings and in completing some matrixes, because of the creation of many environmental problems, the work of producing environmental impacts assessment report was stopped and the conclusion of experts was that the reason for stopping the studies was due to lack of technical, economical or ecological solutions in all the options of the site selection, project construction and operation.

9-Determining the details of studies services

Some international organizations have provided and published different samples of the details of studies services done for refineries’ environmental impacts assessments. The type of these kinds of plans and projects are provided by the Management and Planning Organization of Iran or by technical offices of related governmental organizations.

(i) Providing the basic required information:

Based on the findings, the preliminary detailed list of identifying of the impacts can be known about in the phase of determining the scopes of the works, depth of the study, data needed, statistics and information. Naturally, the producing of information is costly. On the other hand, based on the type of the methods or methodologies applied in the assessment, you will need varied basic information.

To reduce costs and time of studies, and to prevent parallel work (repeated unnecessary work), you can make use of information available in governmental or semi-governmental organizations.

(ii) Writing the report

When producing reports, two types of reports should be produced. One is a brief report that should be done according to the contents of Article 5 of the Environmental Assessment Regulations. Another report is called “environmental impacts assessments” that should be produced based on the contents of Article 6 of the just-mentioned regulations.

The EIA research agenda must evolve and mature if this globally significant decision tool is to fulfill its potentials (Cashmore 2004). The ideas reflected in the proposed model also forms the basis for the assessment criteria consolidated in a Review Protocol and an Evaluation Package which can be used as a tool and a benchmark for assessing the practice of incorporating the RA into the EIAs of high profile projects (Demidova & Cherp 2005). Such learning may conceivably prove to be of equal significance as environmental assessment’s more direct contributions to transforming development plans (Cashmore et al. 2008). The reason for examining documents other than just the EIS was to get a better picture of the EIA process as a whole, rather than just what was reported in the EIS (Cooper & Sheate 2002). These methods usually display extensive databases and fragile qualification instruments to support stakeholders’ decisions (De Siqueira & De Mello 2006). In recent years, the above-said department under the new name of “the Deputy Office for Human Environment” has been re-established. This department is in charge of executing supervisory regulations related to environmental impacts assessments of plans and projects (Dabirie 1994).

Boilers and turbines also release particles that are directly proportionate to the quality of fuels used (Roshanzamir 1991). Refineries produce a lot of solid waste materials
(Aghaie, 1986). One of the ecological problems of refineries that are in coastal areas is their adverse impacts on marine ecosystems (Bahoush 1991). In different processes of production done in coking and catalyst units’ sour water containing phenol, ammonia and hydrocarbons are produced (Golestan, 1985). The main pollutants are sulphur oxide, nitrogen oxide, carbon monoxide, aldehydes, ammonia, particles and hydrocarbons (Jaafarzadeh, 2001). Another source of pollution can be releasing water used for cooling purposes, water used for washing purposes, leakage of substances from tanks, pipelines and loading places (Ghanizadeh, 2001). Hydrocarbons emitted from refineries are the main cause of pollution. They are emitted either from chimneys or from reserve tanks. Some hydrocarbon emissions are the result of evaporation (Sarfehnia 1993). The existing EIA system focuses primarily on the treatment of pollutants after their generation, rather than on the prevention of pollutants before they are created, it encourages enterprises to continue their reliance on the EOP treatment (Chen et al. 1999). Finding financial sources, experts and institutional capacities for this will be only one of the helpful tasks (Brantis & Christopoulos 2005). This is an aspect of both impacts assessment and effectiveness evaluation theory that is critically under-developed (Cashmore et al. 2010). Environmental assessments (the EAs) refer to preliminary studies conducted within the environmental impacts assessment (the EIA) process in the United States; such studies are used to determine the significance of anticipated impacts of proposed actions (Burris R. K., & Canter L. W., 1997). Environmental impact assessments (the EIA) are considered as important tools for the assessment of the impacts of human activities (Cartalis et al. 2000). Seen this way the IA is primarily used to gather knowledge that supports the outcomes of the continuous negotiations of the Commission’s proposals (Backlund 2009). Environmental impacts assessment can be defined as the process of predicting and evaluating the effects of an action or series of actions on the environment (Baratto et al. 2005). Natural resources are in general considered the “inputs” to impacts assessment studies (Bare & Gloria 2008). The Guidelines include a standardized approach to evaluating social impacts that might occur throughout the 4-phase life cycle of a typical industrial or dangerous facility, including: (1) planning/policy development, (2) construction implementation, (3) operation/maintenance, and (4) decommissioning/abandonment (Bass 1998). Human activity has an inevitable impact on the environment and this impact is generally negative. It is unquestionable that society is increasingly aware of the state of the surrounding environment, since it forms the basis for all human activities (Blanco Moron et al. 2009). Process industries involve handling of hazardous substances which on release may potentially cause catastrophic consequences in terms of assets lost, human fatalities or injuries and loss of public confidence in the company (Kalantarnia et al. 2010). Hydrocarbons are among the most important air pollutants that are emitted by petroleum refineries, since they are involved in almost every refinery process (Kalabokas et al. 2001). Environmental impacts assessment (the EIA) is a procedure for assessing the environmental implication of a decision to enact legislation, to implement policies and plans, or to initiate development projects. It has become a widely accepted tool for environmental management (Ramanathan 2001). This would increase the weight of the EIA related arguments in the national appellate procedures and contribute, in some cases significantly, to the substantive influence of the EIA in decision-making (Polonen 2006). The association of the EIA with other environmental management tools, such as environmental management systems or environmental performance evaluation, and sustainable development initiatives will be a priority challenge for all who are engaged in this domain (Ramos et al. 2008). Looking to experience in planning, then, might help in providing insights into some of the
conceptual problems faced in environmental assessments (Richardson 2005). Once the objectives are set, there should be a systematic screening of options – on purely environmental factors in the EIA process involving land use planning, where wetlands were threatened by settlement sprawl, for example (Ruddy & Hilty 2008). This constitutes the evaluation process that involves the aggregation of the individual assessments to a total assessment on the basis of a logical decision or process. (Sankoh 1996a). African countries and the majority of developing countries in the world have not been able to adopt or have never considered adopting a formal EIA (Sankoh 1996b). These limiting indicators can then be used to define exploitation limitations and carrying capacity constraints to define economic development strategies that are environmentally sustainable and economically viable (Schultink G., 2000). In community-based approaches to the EA, a participatory forum facilitates a process of communal dialogue and collective decision making that includes: the development of goals, the sharing of knowledge, negotiation and compromise, problem-posing and problem solving, the evaluation of needs, the definition of goals; and research and discussion usually around questions of justice and equity (Sinclair et al. 2009). Industrial ecosystem is an important approach for sustainable development. (Singh et al. 2007). The findings from this study and future research will be important as practitioners consider opportunities for implementing environmental review alleviation and varying approaches to integrating planning and environmental review processes (Slotterback 2008). Scoping is a crucial yet less-researched-on stage of environmental impacts assessment, in which practicality falls well behind conceptual ideals. We argue that such implementation deficits reflect dilemmas between two key rationales for scoping—environmental precaution and decision-making efficiency—and between technical and participatory conceptions of the decision-making process (Snell & Cowell 2006). The role of the EIA authority is central to the EIA process and to the permit-granting processes. A developer must take into account all the aspects addressed in the authority’s statement (Soderman T., 2006). Through the EIA system, it was hoped to expand the provision of green fields in land development, to minimize topographical changes due to construction, and to allocate additional protected areas in large scale tourist developments (Song & Glasson 2010). In conclusion, the development and application of such a multi-criteria methodology forms a sound scientific base for an overall and more integrated socio-environmental planning in relation to population, urban structure, green and infrastructure network of shrinking cities (Schetke & Haase 2008). The results of an EIA can help an organization to diagnose the occurrence and seriousness of various environmental impacts that may determine its performance (Pun et al. 2003).

Production of Isfahan oil refinery
This refinery has many productions that come in the table below. Table 3.17 Isfahan oil refinery productions.

Table 1 Isfahan oil refinery productions

<table>
<thead>
<tr>
<th>Real average of products</th>
<th>Capacity (1000 liter per day) product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid gas</td>
<td>1173</td>
</tr>
<tr>
<td>Gasoline</td>
<td>1600</td>
</tr>
<tr>
<td>Jet fuel</td>
<td>5980</td>
</tr>
<tr>
<td>Light Naphta</td>
<td>434</td>
</tr>
<tr>
<td>Kerosene</td>
<td>5221</td>
</tr>
<tr>
<td>Gas oil</td>
<td>13264</td>
</tr>
<tr>
<td>Source: Iranian petroleum ministry</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>- Importance of environmental measures of Isfahan oil refinery</strong></td>
<td></td>
</tr>
<tr>
<td>- The project of oil leak into the soil and groundwater surrounding the refinery:</td>
<td></td>
</tr>
<tr>
<td>A- Control of oil pollution of groundwater samples from monitoring wells forty</td>
<td></td>
</tr>
<tr>
<td>B- Installation of more than 300 gas sampling hole (GSH) for measuring the gas in the soil</td>
<td></td>
</tr>
<tr>
<td>C- Order to buy and set gas meter - GPS - interface meter for oil spill project</td>
<td></td>
</tr>
<tr>
<td>2- The dredging project to extract oil from oil sludge tanks</td>
<td></td>
</tr>
<tr>
<td>3- Projects to reduce emissions of ozone depleting gases and replacing fire and refrigeration systems</td>
<td></td>
</tr>
<tr>
<td>4- Make contracts with trusted environmental laboratories for their project statements and monitoring of air pollutants, wastewater and solid waste management company in the quarter for four years.</td>
<td></td>
</tr>
<tr>
<td>5- Several environmental research projects (API odors - The use of urban wastewater treatment plants and industrial purposes .... City Shahinshahr)</td>
<td></td>
</tr>
<tr>
<td>6- Conservation of the 5/114 hectares of green space</td>
<td></td>
</tr>
<tr>
<td>7- Active participation in making landfill monitoring with environmental standards in the local areas</td>
<td></td>
</tr>
<tr>
<td><strong>- Mega Projects in Execution</strong></td>
<td></td>
</tr>
<tr>
<td>1- Gasoline Production Plant (G .P .P)</td>
<td></td>
</tr>
<tr>
<td>The project includes the construction of three units: CCR, NHT and Isomerisation are in progress by the engineering firm plans. The achievements of this project are summarized as follows:</td>
<td></td>
</tr>
<tr>
<td>a. Increased the refinery gasoline production rate of 3 million liters per day; then the gasoline produced by the refinery of 9 million liters to 12 million liters per day increases.</td>
<td></td>
</tr>
<tr>
<td>b. Increase gasoline quality produced by the refinery and Increase octane gasoline production from 87 to 93.</td>
<td></td>
</tr>
<tr>
<td>c. Reduce Imports 3/3 million liters of super gasoline per day to Iran and cut the need of gasoline imports to Isfahan refinery.</td>
<td></td>
</tr>
<tr>
<td>d. The possibility of super gasoline production in Isfahan oil refinery.</td>
<td></td>
</tr>
<tr>
<td>2- Upgrading &amp; Revamping Project (U. R .P)</td>
<td></td>
</tr>
<tr>
<td>The project includes the construction these units: third LPG unit, CDU unit and revamp of existing units and replacing the control system of refinery. The project is not only to optimize refinery operations and safety issues will also meet the operational units and the main part of the meal will be provided downstream units. The achievements of this project are summarized as follows:</td>
<td></td>
</tr>
<tr>
<td>a. Eliminate operating problems, improving communication paths within the refinery, the construction of new reservoirs of gas feed line and the communication between the refinery and the southern part of units.</td>
<td></td>
</tr>
<tr>
<td>b. Replacement of existing pneumatic control system with advanced control system in existing units and monitor all activities via a central control room.</td>
<td></td>
</tr>
</tbody>
</table>
c. Installation the new instruments and operational systems in all units of refinery.

3- Upgrading Project (U.P)

Planning and installation of new refining utilities are in the south of oil refinery. The execution of this project based on the Bottom of the Barrel plan and it will follow the Heavy product & Residue Conversion method and it will Minimum Fuel Oil production.

Material and methods

1. Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) is a multi-criteria decision making tool for dealing with unstructured, complex and multiple-criteria discrete decisions (Partovi, 2007). AHP has been successfully applied to a diverse array of problems (Chang et al., 2009). The use of AHP is suggested to solve the problem of independence among alternative or criteria (Dagdeviren et al., 2008). The basic theory of AHP is the condition of functional independence of the upper part, of the unidirectional hierarchy, from all its lower parts, and from the criteria or sub-criteria in each level (Dagdeviren et al., 2008). AHP is easy to use but it is strong, such that it can handle the complexities of real-world problems.

AHP is a technique that decomposes a problem into several levels of components in such a way that they form a hierarchy. The top element of the hierarchy is the goal for the decision making (Erdogmus et al., 2006). The elements affecting the decision are called criteria, and the criteria can be subdivided into sub-criteria. The lowest level comprises the alternatives as shown in Figure 3.6 (Partovi, 2007). Decision making begins the prioritization procedure to determine the relative importance of the elements in each level. Elements in each level are compared pair-wise with respect to their importance to an element in the next higher level in a hierarchical structure. Starting at the top of the hierarchy and working down, a number of square matrices (preference matrices), are created in the process of comparing elements at a given level (Partovi, 2007). Furthermore, this approach assists the user to appraise the importance of each criterion in relation to the others in a hierarchical structure (Li & Li 2009; Levary & Wan 1999). After forming the preference matrices, the composite weights of the decision alternatives are determined by aggregating the weights throughout the hierarchy. Aggregation is done by following a path from the top of the hierarchy to each alternative at the lowest level and multiplying the weights along each segment of the path. The outcome of this aggregation is an overall weight for each alternative (Partovi, 2007).

In this research for EIA-AHP of Isfahan oil refinery the executive items were came into four general parameters.

Calculate the index weights based on judgment and decision making paired comparisons

To use this method, the matrix of paired comparisons is formed as indicators of the relationship.

\[ D = \begin{bmatrix}
    a_{11} & \cdots & a_{1n} \\
    \vdots & \ddots & \vdots \\
    a_{n1} & \cdots & a_{nn}
\end{bmatrix} = \begin{bmatrix}
    W_1 & \cdots & W_1 \\
    \vdots & \ddots & \vdots \\
    W_n & \cdots & W_n
\end{bmatrix} \]

In this matrix \( a_{ij} \rightarrow \forall i, j = 1, 2, \ldots, n \) represents the personal judgment of the decision maker about the comparison between the pair of indices \( i, j \) index is \( i \). In other words, a decision maker
can be with respect to the index i, j indices have different importance and priorities. For example, it can have the same importance, or rather is much more to use it, it is first preferences to the table 1 and then used a little.

**Table 2** Scale to quantify the qualitative criteria

<table>
<thead>
<tr>
<th>Explanation</th>
<th>Definition</th>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Element i to element j are equally important</td>
<td>Equally Preferred</td>
<td>$a_{ij}=1$</td>
</tr>
<tr>
<td>Element is a rather i to element j</td>
<td>Moderately Preferred</td>
<td>$a_{ij}=3$</td>
</tr>
<tr>
<td>Element i is much prefer the element j</td>
<td>Strongly Preferred</td>
<td>$a_{ij}=5$</td>
</tr>
<tr>
<td>Element i is very much prefer the element j</td>
<td>Very Strongly Preferred</td>
<td>$a_{ij}=7$</td>
</tr>
<tr>
<td>Element i is very much prefer the element j</td>
<td>Extremely Preferred</td>
<td>$a_{ij}=9$</td>
</tr>
<tr>
<td>Intermediate values Preferred</td>
<td></td>
<td>$a_{ij}=2,4,6,8$</td>
</tr>
</tbody>
</table>

On the other hand $\frac{w_i}{w_j}$ is representative of the actual weight index i to index j that the values are unknown and must be determined. With little attention is given:

$$\forall i = j \to a_{ij} = 1$$

The formula is expressed as a ratio to its significance is the same. On the other hand:

$$a_{ji} = \frac{1}{a_{ij}}$$

If the index value index i to index j form decision maker is equal with $a_{ji}$ then the value of index I to index j will be reverse of it and it means $\frac{1}{a_{ij}}$.

For a paired comparison matrix non measurement scaling in this method, each component of the overall decision-making matrix is divided into components corresponding column. This is the mathematical form of the case:

$$ (j=1, 2, ..., n) \quad \text{and} \quad n_{ij} = \frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}} $$

In this formula $n_{ij}$ is representing the normalized value of index i to index j.

**Consistency of judgments**

One of the preferences of analytic hierarchy process is the possible consideration of consistency of judgments compatibility in for determine the criteria’s and sub criteria’s. On the other hand in twin criteria matrix how much, consistency of judgments was observance. When the importance of criteria’s estimated as compared with each other, it is probable the imperfect in judgments. It means if $A_i$ is more important than $A_j$ and $A_j$ is more important than $A_k$ as a rule it should be $A_i$ is more important than $A_k$. But in spite of all efforts preferences and feelings of decision makers most of the time are imperfect and innumerous. Then it should be finding the index that
visible the amount imperfect judgments. The mechanism that considered for imperfect in judgments is the calculation of coefficient named incompatibility coefficient (IR) that obtain from divided incompatibility index (II) to collision index (RI). If this coefficient is equal or less than 0/1 compatibility in judgments is acceptable otherwise it should be revise again. On the other hand comparison twin criteria matrix should set again:

\[ \text{Compatibility index} = I.R. = \frac{\lambda_{\text{max}} - n}{n - 1} \]

Collision index with concern to number of criteria’s (n) can take from this table:

<table>
<thead>
<tr>
<th>N</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.I.</td>
<td>0/58</td>
<td>0/9</td>
<td>1/12</td>
<td>1/24</td>
<td>1/32</td>
<td>1/41</td>
<td>1/45</td>
<td>1/49</td>
<td>1/51</td>
<td>1/48</td>
<td>1/56</td>
<td>1/57</td>
<td>1/59</td>
<td></td>
</tr>
</tbody>
</table>

At last rate of incompatibility matrixes are coming for this formula:

\[ \text{Incompatibility rate matrixes} = I.R. = \frac{I.R}{RI} \]

1. Relative weight criteria’s (indexes) in construction phase for Isfahan oil refinery

With use of geometrical average twin comparisons matrix were calculated. In this method, after provide the twin comparisons matrix, first geometrical average of each line of matrix is calculate, second the column matrix obtained will divided of each indexes to sum of all existing indexes will normalized for correct result. The new column matrix obtained is weighted matrix of concern indexes. The calculation method is here.

\[
\begin{pmatrix}
a_{11} & \ldots & a_{1n} \\
\vdots & \ddots & \vdots \\
a_{n1} & \ldots & a_{nn}
\end{pmatrix} \xrightarrow[1]{1/\sqrt{a_{11} \ldots a_{nn}}} \begin{pmatrix}
\pi_1 \\
\vdots \\
\pi_n
\end{pmatrix} \xrightarrow[2]{\frac{\sum_{i=1}^{n} \pi_i}{\frac{\sum_{i=1}^{n} \pi_i}{\pi_n}}} \begin{pmatrix}
W_1 \\
\vdots \\
W_n
\end{pmatrix}
\]

In this research four main indexes determined in order to priority for main indexes of environmental impact assessment of Isfahan oil refinery. The decision maker twin criteria matrix is in the table 3.

**Table 4** Twin criteria matrix of main indexes of this research

<table>
<thead>
<tr>
<th>The main elements of the environmental impact assessment</th>
<th>Economical</th>
<th>Land Use</th>
<th>Environmental</th>
<th>Social</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economical</td>
<td>1</td>
<td>1.4</td>
<td>2.9</td>
<td>3</td>
</tr>
<tr>
<td>Land Use</td>
<td>0.71</td>
<td>1</td>
<td>4.9</td>
<td>2</td>
</tr>
<tr>
<td>Environmental</td>
<td>0.34</td>
<td>0.2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Social</td>
<td>0.33</td>
<td>0.5</td>
<td>0.5</td>
<td>1</td>
</tr>
</tbody>
</table>

Step one: Preparing the data
First choice of high-performance functions for linguistic variables defined above, and input and output data sets in each stage, the preparation is a process that input and output functions related to participation. I therefore prepared a set of diagrams that show different levels in the decision. Each value in the decision making level in a series of 100 percent 1 to 0% for 0 to join the membership will change. This means that only one of the absolute value Is true is false and all other values, a set Decision making that values it at all values of It is true that from 100% to 0% change. The logic toolbox decision-making software, input and input variable is always on the enamel a numeric value.

Step two: Applying the logical operator
After preparation of the variable input and output functions using decision rules, which can output to a number is obtained higher or lower than the input number.

Step three: Inference rules for decision-making
Control systems are inference rules of decision and rule base, which is a set of rules and decisions are relating to the collection, input and output values. Before applying the inference method, the weights for the (grade 0 to 1) are defined by any law. According to the rules of weight is specified at a minimum level. For example, weight one, to maximum has no effect on output, to exert influence in the relationship between the rules should give the number except one.

Step Four: Merge all outputs and results summarized
Since the decision is with regard to all laws, rules must be in total output are merged, at this stage, the results were not applied for any law to be performed in parallel.

Step Five: TOPSIS (Technique for Order Preference by Similarity to the Ideal Solution)
• In this method two artificial alternatives are hypothesized.
• Ideal alternative: the one which has the best level for all attributes considered.
• Negative ideal alternative: the one which has the worst attribute values.
• TOPSIS selects the alternative that is the closest to the ideal solution and farthest from negative ideal alternative.

Input to TOPSIS
• TOPSIS assumes that we have m alternatives (option) and n attributes / criteria and we have the score of each option with respect to each criterion.
• Let xij score of option I with respect to criterion j we have a matrix X=(xij) m*n matrix.
• Let J be the set of benefit attributes or criteria (more is better)
• Let J’ be the set of negative attributes or criteria (less is better)

Steps of TOPSIS
• Step 1: Construct normalized decision matrix.
• This step transforms various attribute dimensions into non-dimensional attributes, which allows comparisons across criteria.
• Normalize scores or data.

\[ r_{ij} = x_{ij} / \sqrt{\left( \sum x_{ij}^2 \right)} \text{for } i = 1, \ldots, m; j = 1, \ldots, n \]

Other steps of TOPSIS were out of the studies so they did not use.
The relative weights of the criteria (indicators) in operation phase for Isfahan oil refinery

In this study, four major criteria in order to prioritize the main elements of the environmental impact assessment the oil refinery has been detected in the matrix of paired comparisons the decision maker is in Table 9.

Table 5 The main criteria of the paired comparisons matrix of Isfahan oil refinery in operation phase

<table>
<thead>
<tr>
<th>The main elements of the environmental impact assessment</th>
<th>Economical</th>
<th>Land Use</th>
<th>Environmental</th>
<th>Social</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economical</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Land Use</td>
<td>0.5</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Environmental</td>
<td>0.33</td>
<td>0.33</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Social</td>
<td>0.25</td>
<td>0.25</td>
<td>0.33</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 1 Comparing relative elements in Isfahan oil refinery in construction phase

Figure 2 Comparing relative elements in Isfahan oil refinery in operation phase

Figure 3 Compare the relative importance in Isfahan oil refinery in operation phase
After modeling in Expert choice 11 and login paired comparisons matrices, weight criteria and sub-criteria were obtained in figure 11. The main priority of Environmental impact assessment in Isfahan oil refinery in operation phase can be seen with Expert choice 11. As in table 10 can be seen an economical criterion with relative weight 0/45 is the most important, thus the main elements of the environmental impact assessment of the oil refinery is most effective. A land use criterion with relative weight 0/32 is in the next priority. Rate of comparison incompatible pair is 0/05 that because is less than 0/1 this comparison is reasonable consistency.

**Table 6** Non measurement scale matrix and relative weights of the main criteria in construction phase for Isfahan oil refinery in operation phase for Isfahan oil refinery

<table>
<thead>
<tr>
<th>The main elements of the environmental impact assessment</th>
<th>Prioritize</th>
<th>relative weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economical</td>
<td>3</td>
<td>0.45</td>
</tr>
<tr>
<td>Land Use</td>
<td>4</td>
<td>0.32</td>
</tr>
<tr>
<td>Environmental</td>
<td>1</td>
<td>0.16</td>
</tr>
<tr>
<td>Social</td>
<td>2</td>
<td>0.07</td>
</tr>
</tbody>
</table>

**Figure 4** The main priority of environmental impact assessment of Isfahan oil refinery in operation phase

2. Geographical information system

For long time, people have studied the world using models such as globes and maps. In the last thirty years, it has become possible to put these models inside computers; more sophisticated models into smaller computers. These computer models, along with the tools for analyzing them, make up a Geographic Information System (GIS) (Ormsby et al., 2004). GIS is a computer system for collecting, checking, analyzing, and integrating information related to the earth
surface (Krpo, 2004). This system is able to collect and use data related to different location of earth (Navaie Toranie & Adeli Nia, 2004). In fact GIS helps the managers, programmers, engineers, and everybody implementing data as a type of system for management, analyzing, and show data and results (Saadi Mesgari & Ghods, 2005). Therefore, it is a useful tool for integrating data and information, and assisting in decision-making (Liu et al., 2007) that means the purpose of GIS is to provide an objective support for decision making based on spatial data (Taboada et al., 2006). GIS is a powerful software technology that allows unlimited amount of information to be linked to a geographic location. Coupled with a digital map, GIS allows users to see locations, features, events, and environmental changes with unprecedented clarity. In addition it displays layer upon layer of information such as environmental trends, pesticide use, soil stability, hazardous waste generators, dust source points, migration corridors, Lake Remediation efforts, and at-risk water wells. Effective environmental practice considers the whole spectrum of the environment. GIS is used in the entire world. Use of GIS in Europe started for registration of properties documents and preparing of environmental data base. In England the biggest user of GIS is services work such as telephone, water, electricity, gas, and preparing the geographical data base. Users usually implement GIS for monitoring and modeling regarding environmental changes such as in Japan and China. In addition nowadays GIS is used in environmental monitoring, environmental pollution, and protection of water resources for the entire world (Navaie Toranie & Adeli Nia, 2004).

In this research GIS-EIA system modified and designed for Environmental Impact Assessment of oil refinery in Iran as Isfahan oil refinery has been selected for EIA. In this part of research for two case studies as Isfahan oil refinery in four parts of economical, environmental, land use and social items have been considered to provide complete environmental impact assessment results for them. Base on the researches in the part of economical three items have been considered as; workshops, industrial equipments & material shops and economical knowledge. In part of environmental; local environmental changes have been considered for better results. In the part of land use; changing the usage of natural resources and use the lands around the oil refinery for site preparation and effect of oil refinery on the land use changing have been considered to complete the land use part in the field of EIA of oil refinery. In the part of social; cultural effects, Environmental knowledge and historical problems have been considered for effects of these oil refineries on the population parameters and results of them in the field of EIA oil refineries. All of these researches based on the EIA Isfahan oil refinery in two parts: construction and operation. For each refinery 100 effective maps provided for Isfahan refinery in two phases as construction and operation in four general classification as; economical, environmental, land use and social parameters. As specified in each study area, the latitude and longitude of each point of the area was recorded by using a GPS. By using the software Arc GIS 9.3 point data were converted to the regional data. Using the interpolation method, the parameters of the raster maps were prepared. The produced maps were combined together and with respect to the software classification model, different maps were drawn. For better results maps based on geographic location and characteristics of the nature of the information or forms built on land boundaries are identified in the study, were drawn. Also raster for map drawing has been considered as information which distinctive visual elements (multiple layers) are displayed (pixels).

Then for complete the EIA study data integrity done as, data integrity means that using one or multiple databases, multiple tables with multiple layers of information, the information can be viewed on a map. In the next step maps were drawn as, view single physical forms part of the
surface which is graphically displayed on a flat surface. Drawings signs, symptoms, and spatial relationships between the forms show. All maps provided with zooming capability in order to view details parts of geographic information big and bigger. For better analysis in EIA-GIS system in the maps data integration has been considered as, data integration means using one or multiple databases and multiple tables and data layer, the information can be seen on a map. In the next phase polygon of the maps for EIA results provided as, a polygon shows that the area on the map and the form of the curve that it can be defined with it.

**Result and discussion**

Obviously, the implementation of GIS in any organization is its complexity. As studied in this project for Isfahan oil refinery the successful result of study is coming for final action plan of GIS-EIA. However, for the successful implementation of a system for GIS-EIA, the following actions should be taken as follow;
- Requirements Analysis of EIA oil refinery.
- Implementation of a pilot project (Pilot) for more accurate identification of needs and problems, in this case Isfahan oil refinery.
- Conceptual design, logical and physical database.
- Maps, drawings and specifications needed to produce guidelines.
- Produce a map and descriptive information collection requirements.
- Design and implementation of GIS-EIA of oil refinery.
- Providing hardware and software requirements, and training of personnel.
- Development of the database is designed to cover specific applications for the system.
- Application development and data analysis functions.
- Development of information exchange standards and processes
- Development the GIS-EIA and the development and maintenance of information processing of EIA.
- Full implementation of GIS-EIA as integrated systems in other operational units and dependent organizations same as workshops, material shops and personnel.
- Full implementation of GIS-EIA as Environmental and Social Action Plan (ESAP) as effects of oil refineries in social parameters same as; historical, environmental knowledge, cultural problems.
- Development of GIS-EIA as land use parameters and its effects on population and environment.
- Design and implementation of GIS-EIA as economical parameters such as workshops, material industrial equipments & material shops.
- Development of GIS-EIA as environmental parameters base on the lab tests and their effects on the located area on the maps.

In this project GIS-EIA of Isfahan oil refinery GIS-EIA part in most effective areas around it (Dehno, Khomeynishahr, Mahmoud abad, Shahinshahr) and different parameters (economical, environmental, land use and social) have been considered to provide the maps based on data collections, expert system decision-makers and GIS information. All these areas pointed on the maps and sat-images of their area on the GIS-EIA study of each oil refinery.
Table 7 Different parameters maps of Isfahan oil refinery and located area around it during the project implementation (2008-2012)

<table>
<thead>
<tr>
<th>Location</th>
<th>Parameters</th>
<th>Economical</th>
<th>Environmental</th>
<th>Land use</th>
<th>Social</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dehno</td>
<td>36</td>
<td>28</td>
<td>28</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>Khomeynishahr</td>
<td>36</td>
<td>28</td>
<td>28</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>Mahmoud abad</td>
<td>36</td>
<td>28</td>
<td>28</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>Shahinshahr</td>
<td>36</td>
<td>28</td>
<td>28</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td></td>
<td>144</td>
<td>112</td>
<td>112</td>
<td>144</td>
<td></td>
</tr>
<tr>
<td>Total maps</td>
<td>512</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

All maps designed and implementation of four parts of GIS-EIA of oil refineries as case studies, Isfahan oil refinery. Total maps of this project are 1024 maps for two case studies in four years by developing of four parameters effects on their locations.

Table 8 Different kinds of GIS maps provided for each case study during the project implementation-Isfahan oil refinery (2008-2012)

<table>
<thead>
<tr>
<th>Special Geographical GIS maps</th>
<th>Numbers of maps of Isfahan oil refinery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dehno</td>
<td>Khomeynishahr</td>
</tr>
<tr>
<td>Hill shade</td>
<td>16</td>
</tr>
<tr>
<td>Layers</td>
<td>16</td>
</tr>
<tr>
<td>Land use</td>
<td>16</td>
</tr>
<tr>
<td>Sat-image</td>
<td>16</td>
</tr>
<tr>
<td>Slope</td>
<td>16</td>
</tr>
<tr>
<td>Tin</td>
<td>16</td>
</tr>
<tr>
<td>Zoning</td>
<td>16</td>
</tr>
<tr>
<td>Total maps</td>
<td>112</td>
</tr>
</tbody>
</table>

Final zoning map for Isfahan oil refinery are available for construction and operation phase in economical, environmental, land use and social parameters.
Figure 5 Environmental parameters (2008-2012)  
Figure 6 Economical parameters (2008-2012)  
Figure 7 Social parameters (2008-2012)  
Figure 8 Land use
Figure 10 EIA Isfahan oil refinery final weightings map in construction phase during (2008-2012)

Figure 11 EIA Isfahan oil refinery final weightings map in operation phase during (2008-2012)

Conclusion
A- Brief assessment report:
To exercise an accurate and substantive management on the production of the brief assessment report, it is necessary to comply with the guidelines in the assessment regulations.

B- Environmental impacts assessment report:
The contents of an “environmental impacts assessments” report for refineries’ should include as follows:
• Non-technical summary
• Defining the plan or the project
• Explaining the current ecological conditions of the project location
• Predicting the environmental impacts of different options
• Assessing all the options
• Plans of measures to be taken to reduce negative impacts
• Plans to manage the environment
• Summing up and conclusion
• References and sources
• Report on the qualifications of the providers
• Appendices

(iii) Non-Technical Summaries
The summary non-technical with aim prevent of irresponsible ambiguity, decision making maker and beneficiary of groups that no avail themselves from environment expertnesses is forming therefore included topics in non-technical of summary must have been writing simple characteristic, and if possible is devoid of technical and science.

(iv) Defining the plan or the project
In this part of the report, which is mainly an introduction of the project or plan, items such as different justifications, different phasing of the operations and different options are reiterated.

(v) Explaining the current ecological conditions of the project location
In this part, the ecological conditions (physical, biological, economical, social, and cultural) of the site project and the impact of the project on them are dealt with. This part needs employment of experts, because it is a complex, important and costly process that needs search or production of basic information.

(vi) Predicting the impacts of the projects or plans
The impacts of refinery projects differ in their intensity, prominence and scope in their different phases of constructions or operations. To assess the refineries’ impacts different effects should be analyzed. The main items of these are:
- Irrevocable impacts, such as the distraction of the habitats of endangered species
- Renewable impacts, such as making use of rivers
- Positive effects, such as creating employment opportunities
- Certain negative impacts, such as emission of dangerous substances
- Short-term impacts: such as bothering noises in the phase of the construction
- Long-term impacts: such as the noise made when loading or unloading products or equipment at site
- Strategic impacts: such as causing change in the ethnic structure of the place where the projects are being carried out.
- Initial impacts: such as increase in the amount of sediments created during the construction work
- Secondary impacts: such as disturbing the ecological balance of the rivers during the construction phase of the project
- Tertiary impacts: such as a reduction in the amount of fish catch by the fishermen
- Indirect impacts: such as an increase in the revenues of the locals
- Direct impacts: such as job creation for the locals
- Accumulative impacts: such as emission of waste water containing fuel oil in the rivers, lakes or streams near the refinery where the amount of oxygen in water is low.

To anticipate general impacts of a refinery we should take into account the followings:
A - The physical and chemical environment
- Certain impacts of the activities on the climate that cannot be overlooked
- Certain impacts of the activities on the quality of soil that cannot be overlooked
- Certain impacts of the activities on the stability of soil that cannot be overlooked
- Certain impacts of the activities on the environmental erosions in the vicinity of the refinery that cannot be overlooked
- Certain impacts of the activities on the topography of the land near the projects that cannot be overlooked
- Certain impacts of the activities on the rivers, streams or underground water that cannot be overlooked
- Certain impacts of the activities on the patterns of drainage of water that cannot be overlooked
- Certain impacts of the activities that may cause flood or landslides
- Certain impacts of the activities on the quality of air and the amount of pollutant emissions into the air that cannot be overlooked
- Certain impacts of the activities that increases air pollutants and affect the provision and quality of the water used for consumption in the area that cannot be overlooked.
- Certain impacts of the activities from the view point of intensity, scope, significance and state of the pollutants in the air
- Certain impacts of the activities from the view point of intensity, scope, and the significance of the provision of and access to surface or underground water
- Certain impacts of the activities on hydrology and hydrographic in the region from the view point of regime, current and direction
- Certain impacts of the activities on the present laws and regulations about water sources
- Certain impacts of the activities on the quality and quantity of the surface and underground waters in the areas near the refineries
- Certain impacts of the activities on changing the course of waters from one water field to the other
- Certain impacts of the activities on the coastal waters in lakes or seas
- Certain impacts of the activities on fish catch and the extent of this impact
- Certain impacts of the activities from the view point of the emission of dangerous substances into water reservoirs near the area
- Certain impacts of the activities on the increase in the amount of the sediments in water reservoirs
- Certain impacts of the activities on the temperature of the waters in the area near the refinery
- Certain impacts of the activities from the view point of bothering noises for humans
- Certain impacts of the activities from the view point of bothering noises for the wildlife
- Certain impacts of the activities from the view point of the increase in the solid waste materials
- Certain impacts of the activities from the view point of the type and qualitative properties of solid waste materials
- Certain impacts of the activities from the view point of the increase in the amount of dangerous waste materials
- Certain impacts of the activities from the view point of the effects of the dangerous waste materials in the environment
- Certain impacts of the activities from the view point of the increase in heat, waves, electricity, radioactivity, vibrations and the extent of turbulences
• Impacts on climate and weather quality

Certain effects of some activities such as using vehicles, constructing work and increase in the emissions can lead to changes in microclimates in the areas near refineries. The creation of smog can cause diseases or even death in people with heart or lung ailments who live around. An increase in the amount of dust and other particles in the air can reduce the visibility that in turn affects activities. Reduced visibility also means less sunlight that damages the plants nearby. We can classify the impacts of the pollution into different facets such as impacts on health, economy, society, and plants.
Acknowledgement
In recent years, worldwide information technology costs has increased in organizations, whether small or large, service based or manufacturing based, profit-making or nonprofit ones. Expenses of office automation, manufacturing automation, including computers, application packages, software development according to needs, communications, computer networks and Internet investment is usually considered. But these costs come with some rewards, such as increasing the effectiveness and the efficiency of organizations, as well as maintaining and improving the competitive edge of organizations. Unfortunately, all information technology investments do not fulfill the expected results. This fact, along with the rapid pace of change in information technology be it hardware or software platforms, or management of the organization makes long-term investment planning for information technologies meaningful. Input-output model project is compared to develop the main program and provides management information systems in several ways, including planning techniques, business planning systems and information engineering approach to produce such a program. In addition, this project will be a new method for planning environmental impacts assessment information, it is also trying to fix weaknesses of existing methods, and emphasizing on their strengths. Managers, companies and organizations, both private and state-run ones, each year, expend a lot in the field of information technology environment (software, hardware, networking, training, manpower recruitment, organization and evolution). Survival and growth of organizations involved with environmental issues depends on changing attitudes to information as one of their main sources. Objectives and achievements of this project are numerous, but its main purpose is to show to a manager how to invest in information technology.
References


