Environmental impact assessment planning of oil refineries in Iran, Tehran oil refinery, using AHP and GIS analysis

Mohammad Rezaie Narimisa
Iranian Social Security Organization, Azadi St, No 345, PO.BOX; 1457965595

Manouchehr Rezaie Narimisa
Oil Industries Engineering and Construction Company (OIEC)-Iran, Kamranieh, Pasha Zahri, Pirooz Alley, No 2, PO.BOX; 1937956751

Abstract

Iran’s oil industry was developed around the country. Environmental Impact Assessment of oil refineries in Iran is based on the evaluation of environmental impacts reports, field study assessments, environmental monitoring and decision-making process. Recognition of environmental damages, identifying the effects of economic, social and cultural conditions, use of the public opinions in the process of decision-making of the project, identify problems that lead to environmental damages due to the projects; prediction of important environmental impacts, identifying and evaluating the environmental effects of projects before, during and after the implementation. Balance between short and long term goals of developing the oil refineries in line with environmental protection, design software models to assess environmental impact of oil refineries in Iran, according to operational needs in the region. In this case Tehran oil refinery was selected as case study. In Environmental Impact Assessment (EIA) of this study economical, environmental, land use and social parameters were considered in the EIA plan. By using Analytical Hierarchy Process (AHP) and Geographic Information System (GIS) 1024 maps were provided for EIA. Then the maps were overlaid on together final result of EIA maps in four parameters obtained based on the study plan for EIA of oil refineries in Iran.

Keywords: Iran, Tehran oil refinery, Environmental Impact Assessment (EIA), Analytical Hierarchy Process (AHP), Geographic Information System (GIS).
Introduction
The research is related to the oil refineries of Iran that are under design-construction or operation, but it should be possible to use the results of the research in future and for other countries. The study emphasis on environmental protection, revised the environmental impact assessment methods in Iran oil refineries, better oil refinery positioning and oil pollution risks. It provides the most accurate advice for the end-users of the system who are engineers, contractors, developers, decision-makers and others in oil industry. Environmental impacts assessment of oil refineries is a new topic for academic research in Iran. Thus, data collection is only from those who are familiar with the related areas of study. It also concentrates on Iran environmental conditions. One construction site located in Iran Tehran oil refinery is selected as a case study. Data is taken from Petroleum Ministry of Iran, Tehran oil refinery for site characteristics, construction and operational stages and environmental monitoring. Data collection is done for site map, construction and operation stages, and environmental status within the site, baseline data, environmental quality monitoring, standard level, site area air quality monitoring, oil content monitoring and solid waste measurements. The important environmental quality monitoring parameters considered during construction and operation activities are results for measurement reports of environmental quality related to site area including oil content monitoring, air quality measurements reports, solid waste measurements reports. The Importance environmental impacts of refineries include emissions in the forms of gas, wastewater, and sold waste materials. They also include noise and odor pollution as well as creating ugly scenes in their surroundings. They are as follow:

(1) Air Pollution
Air pollution in refineries mainly occurs when the refineries are in their operational phase. Based on the age of the facilities used, the sources of this kind of pollution are: processes employed; fires that may occur in reservoirs and tanks; vapor tanks, furnaces, pumps, compressors, reserve tanks, bubble towers, and some other equipment. The main pollutants are sulphur oxide, nitrogen oxide, carbon monoxide, aldehydes, ammonia, particles and hydrocarbons. 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. Sulphur oxides that are resulted from burning of fuels are also released through the chimneys. In the process of burning, nitrogen oxides are released especially from installations such as boilers, compressors, catalyst reducers and scattered in the air. Boilers and turbines also release particles that are directly proportionate to the quality of fuels used. A small portion of pollutants, such as ammonia and aldehydes are also released into the air from the cracking units.

Air pollution resulted from refineries are considered as the main drawback of refineries. These pollutants are from catalytic cracking units, sulphur recycling processes, heaters, chimneys, or the production and reserve tanks of the raw materials. The mixture of all these emissions can produce a very unpleasant odor in the vicinity of the refineries. Unpleasant odors from refineries are because of many substances such as mercaptans, hydrogen sulphides, and organic gases containing sulphur, aldehydes, and ammonia. Many such gases are produced due to evaporation of crude oil, analysis of substances containing sulphur, reserve tanks, sewages, accumulating ponds, and catalysts reduction.
(2) Water pollution
In washing, cooling and vapor production processes in refineries large amounts of water is used. Main water contaminants are oil, grease, ammonia, phenol compounds, sulfites, organic acids, chromium and other metals that can cause change in BOD5, COD and all organic carbon. Releasing sewage water in the environment can lead to water and soil pollution. 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.

In refineries, many types of waste materials are produced. Refineries that usually do not contain oil or organic substances and the water or vapor they use is not mixed with oil, produce less pollution. The waste water in some refineries are subject to accidental oil pollution. Non-oily sewage water that is from hygienic facilities are released in the environment or are refined. Sewage water from different processing units of the refineries contains oily substances, solvents, acids, and other pollutants. Rivers, streams or underground water that are in contact with these pollutants are contaminated. In different processes of production done in coking and catalyst units’ sour water containing phenol, ammonia and hydrocarbons are produced.

One massive problem related to refineries’ waste emissions, is the leakage of contaminants into water sources. This leakage comes from pipelines, docks, piers, or even accidentally and has many negative impacts on marine life, it also makes water impossible for consumption by people. Another cause of concern is the leakage of these contaminants into underground water sources.

(3) Solid waste
Refineries produce a lot of solid waste materials. The main sources of these kinds of solid waste materials are cracking units, coke making units, refining units, slimes produced from tank cleaning activities or activities of separating oil from water and refining systems. Because they contain large quantities of oil, acids, or heavy metals, solid waste materials are among the most dangerous waste materials.

(4) Noise
Refineries are among noise making installations. The sources of noise are high-speed compressors, control valves, turbines, engines, ventilators, chimneys, cooling towers, heaters, valves, pumps, and signaling systems (sirening systems).

(5) Dangers and accidents
The emission of dangerous chemicals as waste materials from refineries has massive adverse impacts on marine ecosystems that can lead to disasters. Negative impact of refineries on ecosystems can be irreversible and because of that the site selection of refineries should be done in such a way that has the least amount of negative impacts on local societies, wildlife and marine ecosystems. The appearance explosions of petroleum refineries manufacturing products from explosion characteristic and upper fire have profit. This occurrence incidents can personnel and health and hygienic inhabitants of life petroleum refineries in near exposed to endangerment been settle.
(6) Damaging ecosystems

One of the ecological problems of refineries that are in coastal areas is their adverse impacts on marine ecosystems. Leakages of substances containing hydrocarbons during loading or unloading processes have negative effects on human hygiene. Some consequences the emissions of these kinds of substances have are as follows:

- By human dangerous arises from marine articles of food use:
- The danger of consuming polluted sea foods by humans
- Death of marine animals and sea weeds
- Damaging food chains in marine ecosystems because of the reduction of the population of some animals that play important roles in these food chains
- Pollution of sea resorts and coastal recreational places
- Damage to the fishermen due to reducing or polluting the fish stocks

In fact, what always attracts the attention of all experts and officials of oil industries and environmental issues as "the environmental pollution problems", especially oil pollution, now requires more and deeper attention (Daryalal 2002). In today world, there is a huge amount of findings and advances in various aspects of environment to which the conducted researches on environmental impacts assessment shall be added too. Currently, environmental impacts assessment for oil refineries is taking into consideration and improving the natural resources via environmental assessments is seen as the best available method for environment protection (Houshiar 2001).

The challenge of collecting, processing, analyzing and reporting information can be partially met by the use of various computer and information technologies (computer-assisted systems) (Muthusamy and Ramalingam 2003). In the past the environmental impacts of refineries were given very little attention in developing countries but now they are gradually coming into the focus of attention. And now refineries are considered as those projects with short-term and long-term effects on the environment (Momenzadeh 2006). The goal of this evaluation software model for environmental impacts assessment for oil refineries is to make sure that we are in line with sustainable development and that our economic objectives will be followed in a way that the least amount of destruction is done to renewable and non-renewable resources (Monavarie 1999). Therefore, we must see environmental problems from a wide perspective and law makers should create laws to make sure that the development of infrastructures in Iran as well as the economic development be achieved with environmental protection issue being kept in minds (Shariat 2001).

Theoretically, one must investigate the impacts of all possible indices in each EIA. In the future study, detailed data such as waste composition, technology and equipment must be taken into account (Pai et al. 2008). Environmental impacts assessment (the EIA) evolved as a tool to assess the likely impacts, both beneficial and adverse, of a proposed development project (Parashar et al. 1997). A development proposal for which there is concern of adverse impact on the environment should prepare an environmental impact statement (the EIS) for the first-stage of the EIA, and then transfer the EIS to the competent authority for review (Liu & Yu 2009). Life Cycle Assessment (the LCA) allows the estimation of the environmental impacts of a process or product. Those environmental impacts depend on how efficient these operations are carried out (Lozano et al. 2009). Previous studies have examined the Cumulative impacts assessment efforts at the federal level but little is known about how states assess the cumulative
impacts of nonfederal projects (Ma et al. 2009). Due to better environmental practices, water use, and especially the release of contaminants into water resources, as well as air emissions (due to very efficient dust management), are reduced considerably (Mangena & Brent 2006). 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 (Branis & Christopoulos 2005). The goal of ES development effort is supposed to be a workable system for production use (Ketata et al., 2000). During the prototype begins function satisfactory, the system performance criteria can be defined for developing system (Negnevitsky, 2005). User involvement in design and implementation of expert systems is generally encouraged in the literature, but actual involvement of users in expert systems development is usually ignored (Azadeh et al., 2009). The answers to these questions are used as input to determine the element or factor (Yang et al. 2001). As the project proceeds the ES needs to be periodically tested and evaluated to assure that its performance and results are converging toward established goals. ES testing and validation are vital before their effective employment in the intended user environment; therefore, system validation has received considerable interest among many AI researchers (Er & Dias 2000; Mosqueira & Moret 2000). The adoption of an environmental management system (the EMS) can guarantee several benefits, such as improved environmental performance, reduced liabilities, better compliance, improved public image, reduction of costs and better access to capital, therefore helping the firms to be more effective in achieving environmental goals (Bevilacqua & Braglia 2002). The enforcement of legislations can help in implementing and monitoring the EIA effectively and successfully (Alshuwaikhat 2005). Implementation of the new SEA directives into national legislations will therefore bring (similar to the EIA procedure) a need not only to establish new unplanned monitoring systems (or significantly extend the existing ones) but will prepare and agree on a set of simple (well measurable, internationally comparable) variables, and that is indicators, organize centrally managed and methodologically supported storage and dissemination of relevant information to governmental and nongovernmental bodies including public entities. Finding financial sources, experts and institutional capacities for this will be only one of the helpful tasks (Branis & Christopoulos 2005). The science of risk analysis which has emerged as a major branch of knowledge in recent years to forecast the likelihood of accidents, to assess the consequences of likely accidents, to work out strategies to prevent accidents and also to lessen any adverse impacts in case an accident occurs (Khan & Abbasi 1999). 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). With the use of this study the process of environmental assessments in the country would be done in a more systematic way. Thus this would lead to more effective environmental assessment reports. Recently, many industrial, regulatory, and community leaders have expressed concern that the current environmental regulatory structures disregards multi-diminentional environmental impacts, and that they provide few incentives to develop and use new technologies, and fail to consider site-specific conditions (Elcock et al. 2000). 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). New software package for conducting rapid risk assessment (RRA) in chemical process industries and the system of methodologies on which it is based are described. The objectives behind the development of the package are to achieve greater breadth and depth, sophistication, and user-friendliness in conducting RRA (Khan & Abbasi 1999). Regional environmental risk assessment can be defined as risk assessment which deals with a spatial scale that contains multiple habitats with multiple sources of many stressors affecting multiple endpoints (Xu & Liu 2009). Environmental risk assessment is an essential element in any decision-making process in order to minimize the effects of human activities on the environment (Darbra et al. 2008). Methods for measuring environmental risk and environmental performance, in relation to all types of environmental effect, should be agreed and used in a consistent fashion across the business from strategic considerations to specific projects. Mechanisms for setting goals/targets based on these measures should be made explicit and agreed (Slater & Jones 1999).

-Tehran oil refinery

Oil refinery and environment interactions were studied given the size of the job and environmental features in the framework of different units of an oil refinery (executive, constructional, operational and processing) and different environmental (physical, biological, socio-economical and cultural) parameters. The major environmental impacts and consequences of oil refineries include gas emissions, effluents, solid wastes, noise, odor and negative visional and aesthetic impacts (Ardalanie, 1989).
The following are the details of the oil refinery facility of the case study:
Name: Tehran Oil refining Co.
Date of establishment: 1965-1968
Date of operating: 1969 (South refinery) - 1973 (North refinery)
Nominal capacity: 220,000 barrels per day
Operational capacity: 240,000 barrels per day
Feed: Light crude oil of Ahvaz – Asmari oil field, crude oil of Maroon/Shadgan, Middle Asia
Production units: Crude oil distillation, viscosity control unit, liquid gas recovery, gasoline hydrogenated refining and gasoline conversion, hydrocracker, Hydrogen, Nitrogen, Sulfur recovery, Amine gas treatment (Khosravanie, 2001).

**Table 1** Tehran 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>1259</td>
</tr>
<tr>
<td>Gasoline</td>
<td>1700</td>
</tr>
<tr>
<td>Jet fuel</td>
<td>6989</td>
</tr>
<tr>
<td>Light Naphta</td>
<td>383</td>
</tr>
<tr>
<td>Kerosene</td>
<td>3442</td>
</tr>
<tr>
<td>Gas oil</td>
<td>12872</td>
</tr>
<tr>
<td>Furnace oil</td>
<td>7549</td>
</tr>
<tr>
<td>Crude engine oil</td>
<td>1878</td>
</tr>
<tr>
<td>Bitumen production feed</td>
<td>2160</td>
</tr>
</tbody>
</table>

Source: Iranian petroleum ministry

**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 Tehran 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.

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

In this matrix \( a_{ij} \rightarrow \forall i, j = 1, 2, \ldots, n \) 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:

\[ \forall i = j \rightarrow a_{ij} = 1 \]

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:

\[(j=1, 2, \ldots, n) \quad \text{and} \quad n_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}\]

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:

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

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

**Table 3** collision index with consideration of number of indexes

<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</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>
</tr>
</tbody>
</table>

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

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

1. **Relative weight criteria’s (indexes) in construction phase for Tehran 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.

\[
\begin{bmatrix}
a_{11} & \cdots & a_{1n} \\
\vdots & \ddots & \vdots \\
a_{n1} & \cdots & a_{nn}
\end{bmatrix}
\rightarrow
\begin{bmatrix}
\sqrt[n]{a_{11} \cdots a_{1n}} \\
\vdots \\
\sqrt[n]{a_{n1} \cdots a_{nn}}
\end{bmatrix}
\rightarrow
\begin{bmatrix}
\frac{\pi_1}{\pi_2} \\
\vdots \\
\frac{\pi_n}{\pi_n}
\end{bmatrix}
\rightarrow
\begin{bmatrix}
\frac{\sum_{i=1}^{n} \pi_i}{\pi_1} \\
\vdots \\
\frac{\sum_{i=1}^{n} \pi_i}{\pi_n}
\end{bmatrix}
= \begin{bmatrix}
W_1 \\
\vdots \\
W_n
\end{bmatrix}
\]
In this research four main indexes determined in order to priority for main indexes of environmental impact assessment of Tehran 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 $x_{ij}$ score of option I with respect to criterion j we have a matrix $X=(x_{ij})$ 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.

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum x_{ij}^2}} \text{ for } i = 1,...,m; j = 1,...,n$$

Other steps of TOPSIS were out of the studies so they did not use.

Environmental impact assessment of oil refinery in Iran is one of the most important parts for the environmental protection. So the scope of this project can contain all the oil refineries in Iran because all of the oil refineries have similar action and their products are the same. So the scope for this project can cover all the oil refineries in Iran for environmental impacts assessment and knowledge of environmental management for oil refineries to help protect the environment.

Table 1 shows the activities of operation phase of Tehran oil refinery. The operational phase is under test and the productions and materials need to quality control as technical programming and flow sheet of major unit operations and material balance flow is under revise for till getting better results of productions.

Table 5 Paired comparison matrix non measurement scaling and relative weight in construction phase of Tehran 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>0.15</td>
</tr>
<tr>
<td>Land Use</td>
<td>4</td>
<td>0.11</td>
</tr>
<tr>
<td>Environmental</td>
<td>2</td>
<td>0.45</td>
</tr>
<tr>
<td>Social</td>
<td>1</td>
<td>0.29</td>
</tr>
</tbody>
</table>

Table 6 The non measurement scaling and the relative weights of the main criteria in the operation phase for Tehran 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>0.184</td>
</tr>
<tr>
<td>Land Use</td>
<td>4</td>
<td>0.110</td>
</tr>
<tr>
<td>Environmental</td>
<td>1</td>
<td>0.377</td>
</tr>
<tr>
<td>Social</td>
<td>2</td>
<td>0.329</td>
</tr>
</tbody>
</table>
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 (Kropo, 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 Tehran oil refinery has been selected for EIA. In this part of research for two case studies as Tehran 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 environment; 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 Tehran oil refinery in two parts: construction and operation. For each refinery 100 effective maps provided for Tehran 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**

Results are coming in two parts AHP and put the AHP in GIS software.

**The results for AHP-EIA Tehran oil refinery**

After modeling in Expert choice 11 and login the paired comparisons matrices, weight criteria’s and sub-criteria in the method as follow was obtained. In the figure 1 the main priority of Environmental impact assessment in Tehran oil refinery in the construction phase with Expert choice 11 software. As can be seen in Table 4 environmental criteria with relative weight 0.45 is the most important criteria. Thus the environmental criterion is the main elements of the environmental impact assessment of the oil refinery are most effective. A social criterion with relative weight 0.29 is in the next priority. Rate of comparison incompatible pair obtained as 0.05 that because it is less than 0.1 compatibility of these comparisons is acceptable.

**Figure 1 Prioritization of major criteria environmental impact assessment of Tehran oil refinery construction phase in Iran with expert choice 11 software**

After modeling in Expert choice 11 and login paired comparisons matrices, weight criteria and sub-criteria were obtained in figure 2. The main priority of Environmental impact assessment in Tehran oil refinery in operation phase can be seen with Expert choice 11. As in table 6 can be seen an environmental criterion with relative weight 0.38 is the most important, thus the main elements of the environmental impact assessment of the oil refinery is most effective. A social criterion with relative weight 0.33 is in the next priority. Rate of comparison incompatible pair is 0/007 that because is less than 0/1 this comparison is reasonable consistency.
Figure 5 Prioritization of environmental impact assessment of Tehran oil refinery operation phase with Expert choice 11 software.

The results for GIS-EIA Tehran oil refinery

Obviously, the implementation of GIS in any organization is its complexity. As studied in this project for Tehran 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 Tehran 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 Tehran oil refinery and effects on located areas around it (Azim abad, Bagher city, Dorsoun abad, Esmaeil abad-e-moein) 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 Tehran oil refinery and located area around it during the project implementation (2008-2012)

<table>
<thead>
<tr>
<th>Location</th>
<th>Parameters</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Economical</td>
<td>Environmental</td>
<td>Land use</td>
<td>Social</td>
</tr>
<tr>
<td>Azim abad</td>
<td>36</td>
<td>28</td>
<td>28</td>
<td>36</td>
</tr>
<tr>
<td>Bagher city</td>
<td>36</td>
<td>28</td>
<td>28</td>
<td>36</td>
</tr>
<tr>
<td>Dorsoun abad</td>
<td>36</td>
<td>28</td>
<td>28</td>
<td>36</td>
</tr>
<tr>
<td>Esmaeil abad-e-moein</td>
<td>36</td>
<td>28</td>
<td>28</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>144</td>
<td>112</td>
<td>112</td>
<td>144</td>
</tr>
<tr>
<td>Total maps</td>
<td>512</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, Tehran 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-Tehran oil refinery (2008-2012)

<table>
<thead>
<tr>
<th>Special Geographical GIS maps</th>
<th>Numbers of maps of Tehran oil refinery</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Azim abad</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>

The criteria used to determine the score and weight maps for each of the criteria and sub-criteria classification in Expert choice 11 the achieved weight in preparation software. After the raster with Raster calculator in Arc GIS 9.3 they have been overlapped. Figure 6 Map of weighting factors for each of the above shows. Figure 7 to 10 Final plans zoning EIA-Tehran oil refinery as digital displays for construction phase and figure 11 to 14 final plans zoning EIA-Tehran oil
refinery as digital displays for operation phase. The map of the objectives are in the study and use of software EIA and effective points in the region with four exciting classification, low, moderate, high, extremely high.

Figure 6 Economical parameter (2008-2012)  
Figure 7 Land use (2008-2012)
Figure 8 Environmental parameter (2008-2012)

Figure 9 Social parameter (2008-2012)

Figure 10 EIA Tehran oil refinery final weightings map in construction phase during (2008-2012)

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

Environmental Protection in Petroleum Industry

During the investigations, the different features of establishing a refinery including construction and operating stages, the various environmental features including physical, biological, socio-economical and cultural environments had been studied. The interactions among features and parameters were studied too. These studies and investigations were performed in two parts of refinery constructional and operational activities. Environmental features were taken into consideration in the framework of categories designated as physical, biological, social-economical and cultural environments. Also given the various construction and operating stages, the interactions among environment and operations were studied. In order for planning and making decisions in oil industries not to be only of short-term nature, we need more parties and organizations involved, such as Environmental Protection Agency, Ministry of Petroleum, Ministry of Agriculture, Ministry of Health, Ministry of Roads and Transportation (Ports and Shipping Organization and Meteorological Organization), the Islamic Consultative Assembly, Interior Ministry and research and study centers. This strategy, if carefully designed and implemented together with determination can be the master key to solve environmental problems in oil and gas industries and its side industries. It can even become a model and pattern for other industries.

Adjustment measures necessary for old units: Some oil refineries and their parts were built in old times when environmental concerns and laws as we know today did not exist. These oil refineries are main sources of pollution now. It is not easy to stop their operation now due to economic issues. On the other hand we cannot ignore their polluting the environment on the grounds that these oil refineries are old. So it is needed to introduce measures to deal with the pollutants emitted by these old refineries. Evaluation of environmental strategy in oil and gas (Strategic Environmental Assessment-SEA), Strategic environmental assessment, systematic process and dynamic evaluation of environmental quality and environmental consequences of development perspectives and objectives that help policies, programs and projects become realized. When planning development projects we should take into consideration biological, economic and social issues. There must be a national framework for applying strategic environmental assessment procedures to create practical models for production methods. However, in the past years, efforts by the environmental organizations to achieve these goals have not been that efficient. Formation of interdisciplinary teams (multidisciplinary team) can use best methods for maximizing the capacity and expertise in both institutions. The team of environmental experts along with experts in the dominant processes in these industries, along with other specialists is needed to do comprehensive studies and environmental assessments together. For oil refineries considering the environmental friendly technologies: Today technologies that are environmentally friendly are emphasized more than they were in the past, because the international criteria and laws are stricter. Discussions related to CDM (Clean Development Mechanism) and clean processes are also discussed today. However, in this regard, perhaps the universities and research centers have heavier duties and should work on these categories.

Acknowledgment

With consideration of environmental protection, uncontrolled designs in the Tehran oil refinery and other oil refineries, oil pollution risks and strategic planning the goal is creating integrated information architecture and stage three subgroups with software to help the decision makers to
install and commissioning of new petroleum refineries. Registration processes at this stage that the fundamental processes during the analysis is obtained, as a general process and is independent of the observed and recorded. At this stage, data entity can be drawn as relationship diagrams for each of the above processes. It should combine of conceptual graphs in a chart in project. At this stage a combination of the above diagrams and removal of overlapping entities and entities covered by a forgotten enterprise-level is created and forms a conceptual diagram. Implementation of each activity system analysis of detailed information needs to shape its needs. The results of analysis of the above required information for the development of a conceptual diagram provide enterprise. The environmental impact assessments of oil refinery programs are clear but not all of them have special software because the preparation of the software and work with that needs complete programming and it is a cause of concern for providers.
References


