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GIS-based environmental impact assessment mapping for oil refineries in Iran: a case study of Isfahan oil refinery

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Key words: Environmental Impact Assessment (EIA), Iran, Environmental Risk Assessment (ERA), Geographical Information System (GIS), Isfahan oil refinery.

Abstract

Environmental Impact Assessment (EIA) modeling of oil refineries in Iran is a useful tool for environmental protection in oil industry in Iran especially for Isfahan oil refinery and its sensitive environment. In this research Environmental Risk Assessment (ERA) has been used as a tool for oil refineries EIA modeling. During the research process 1028 maps were provided that overlap on together for prepare the final EIA modeling in case of Isfahan oil refinery. In fact the primary target of ERA understands the potential risks and possible effects on the environmental parameters. This view can use in construction and operation of each oil refineries to make at least possible risks effects on environment. The most important part of this modeling is all major environmental parameters and oil refinery project with their risks have been considered in this research. All EIA studies based on field studies, laboratory experiments, find the most effective points, find the most effective areas, using Geographical Information System (GIS), make raster on maps and overlap on together to find out the EIA oil refinery modeling of oil refinery in case of Isfahan oil refinery to make this model as a tool for other EIA oil refineries in Iran.

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Introduction

In some cases the oil spill risk analysis (OSRA) model is an EIA tool for prepare a good plan in oil and gas operation facilities (Price et el. 2003) that can help to specify serious and different environmental impacts (Pun *et al.* 2003). Programming for multiple environmental problems in EIA (Ramanathan. 2001) needs to understanding the environmental priorities, evaluation and sustainable development inventions (Ramos *et al.* 2008) with investigation of major environmental assessments (Richardson. 2005) with use of different kinds of methodologies and management plans (Rodrigues *et al.* 2010).

EIA process consists of land use planning with notice to problems recognition, targets design and screening (Ruddy & Hilty 2008), scoping, measurements and evaluations of impacts for monitoring plans (Sandham & Retief 2010) in specific methods for assessment of problems involving the public participation in many countries (Sanchez-Trian & Ortolano 2001) for better results in programming for natural resources adaptability and project area sensibility (Sankoh. 1996a).

The EIA study in many industrial countries and under developing countries such as formal feasibility study consist of social and political items (Sankoh 1996b) and during these years, different methodologies are being used to both specify the impacts and assessment the data collections (Say *et al.* 2007) in different modifying plans in variety kinds of environmental problem assessments such as air, sound water resources quality (Schetke & Haase 2008).

Sustainable production programming with multi-dimensional environmental parameters in long term strategies (Schultink G., 2000) should be based on environmental assessment studies and new tools of development projects with economical analysis (Senthil *et al.* 2003). Environmental assessment is tool for decision-making consist of developing targets and multiplex science to achieve the sustainable development (Sinclair *et al.* 2009; Singh *et al.* 2007) and review the environmental strategies and review the environmental plans to deep analysis of environmental assessment process and effective decision-making process in sopping the environment in EIA plan (Slotterback 2008; Snell & Cowell 2006).

The EIA task analysis process for authorities should involve all status of authority's conditions in project development and equilibrium between development plans and environmental impacts in the construction phase (Soderman T., 2006; Song & Glasson 2010). In the industrial plans economical parameters are containing in the evaluating impacts and natural resources damages factors in EIA analysis with verification of project objectives (Sonnemann et el. 2000; Steinemann 2001).

Environmental assessment quality for local land use programming has measurement mechanism and development targets containing the society cooperation for decision making process (Tang *et al.*2009; Tao *et al.* 2007). The most methodologies in environmental assessment developing programs and good relations between quality and data availability gives a good intelligence factors for EIA (Therivel 1998; Thomassen M.A., & Boer I. J. M. D., 2005). The EIA of projects containing the environmental alternatives, mechanism for proceeding the targets and effects of different pollution impacts however existing to understand the sharing environmental study is also important (Tukker 2000; Tzilivakis *et al.* 2005).

Environmental risk assessment has different definitions depending on its application and type of the existing problems. Below find some of these definitions.

-Environmental risk assessment includes identifying the affected environment, time modeling, spatial modeling, dissemination, assessment of the main ecological elements taking environmental sensitivities into account, risk quantity estimation in comparison

with the existing criteria and identifying measures for risk reduction.

Among the main objectives of risk assessment process in the environment are:
-Reducing the frequency and severity of accidents
-Minimizing damages to ecosystems
-Supplying safe conditions for the environment (humans, plants, and animals)
-Codifying the relevant rules and regulations
-Omission of risks and hazards, identifying methods of the environment protection, codifying safety plans, preparing documents and reducing the environmental damages are among advantages of environmental risk assessment.

Materials and methods

Two methods have been determined for EIA oil refineries in Iran:

- Environmental Risk Assessment (ERA)
- Geographical Information System (GIS)

Environmental Risk Assessment (ERA)

The ERA method identifies systematically environmental risks linking proposed project activities with potential environmental, economical, land use and social impacts for EIA oil refineries. On the other hand ERA specify risks based on the by assigning ratings to identified risks based on potential impacts, severity impacts, impact types and significant impacts. By using this method risk ratings are as major part of the overall EIA plan and a useful tool to inform oil refinery development of negative impacts mitigation measures.

ERA plan for oil refinery completely done for two case studies, two phases as construction and operation and four specified parameters in five stages;

- Documentary and field studies
- Modeling was provided for oil refinery construction and operation phases
- Description were determined in each parameters
- Value rate tables were prepared for each case studies
- ERA-Oil refinery plans were obtained for case studies

In tables 1 till 3 are Environmental Risk Assessment (ERA) method has been discussed completely. In these tables base of the Environmental Risk Assessment method are already used in this project.

The two parts are combined in this project:
1-Environmental parameters and activities conducted to determine the parameters in the design-construction and operation stages.
2-Environmental Risk Assessment (ERA) has been used in for in the evaluation the method. Base on two these steps the software designed and prepared for EIA of Iranian oil refineries by case studies of Isfahan and Isfahan oil refineries.

Totally ERA laws and regulations based on three stages severity impact, , impact type and significant impact. In each part some items have been considered. These items are the base of evaluation of environmental risk assessment method. Each part discuss of ERA details, terms and conditions. These details give a clear help of user for understanding of steps of decision making base on the ERA. Each subtitle of these five steps describes the effects of construction and operation phases on the environmental parameters by measuring the risks of these effects by decision making of expert team. These formulas are base calculations of ERA method. By using of these items the result of ERA will be consider in the software for getting results of EIA of oil refinery. Base on the ERA framework procedure and EIA of this project evaluation are these tables.

Table 1. Severity impact.

1	Negligible	Tolerable–No significant impact over environment and human
2	Moderate	Tiny change of nature, limited impacts over environment and human
3	Critical	Demolition of environment and moderate controllable pollution
4	Catastrophic	High pollution and impacts over environment and human

Source: National Iranian Oil Company (NIOC)-2012

Table 2. Impact types.

Positive	Desirable, with appropriate impact over economical, social and cultural environments.
Negative	Undesirable, with inappropriate impact over economical, social and cultural environments, unwanted.
No impact	No change, with no impact over economical, social and cultural environments.

Source: National Iranian Oil Company (NIOC)-2012

Table 3. Significant impact.

1 time per month	Green	no impact - low
2 times per month	Yellow	minor impact - moderate
3 time per month	Orange	major impact - high
4 time per month	Red	critical impact - extreme high

Source: National Iranian Oil Company (NIOC)-2012

Function of this method is on the base of environmental impact assessment plan and environmental risk assessment that are modified and mixed together to bring the best result of environmental impact assessment of oil refineries.

Geographical Information System (GIS)-Oil refineries

GIS-Oil refinery completely done in four stages and for these items;

- Two case studies
- Construction and operation phase
- Four determined parameters

- *Isfahan oil refinery*

Esfahan Oil Refining Company's activities in the field of refining crude oil and oil products production and energy security of downstream industries (Esfahan Petrochemical Company, Arak Petrochemical, Sepahan oil refining plant, Jay oil Refining industries and other chemical industries in Iran) began in 1979 and it is now proceeds about 23% of the petroleum products required to produce. The total area of 340 hectares in area and having green space area 5 /114 acres is located in the northwest of Isfahan. Isfahan refinery has seen much progress of crude oil refining per day, so much products in the early 90's, and crude oil refining capacity of the company increased 85% compared to the design capacity of 200 thousand barrels per day has increased to more than 375 thousand barrels (Khosravanie, 2001). Figures no. 8, 9, 10 and 11 are the locations of Isfahan oil refinery.

- *Production of Isfahan oil refinery*

This refinery has many productions that come in the table below. Table 5 Isfahan oil refinery productions.

Table 4. Isfahan oil refinery productions.

Real average of products	**Capacity (1000 liter per day) product**
Liquid gas	1173
Gasoline	1600
Jet fuel	5980

Light Naphtha	434
Kerosene	5221
Gas oil	13264
Furnace oil	8549
Crude engine oil	1998
Bitumen production	3180
feed	4567
Sulfur	17323
Light oil	14562
Heavy oil	

Source: Iranian petroleum ministry

- *Importance of environmental measures of Isfahan oil refinery*

1- The project of oil leak into the soil and groundwater surrounding the refinery:

A-Control of oil pollution of groundwater samples from monitoring wells forty

B-Installation of more than 300 gas sampling hole (GSH) for measuring the gas in the soil

C- Order to buy and set gas meter - GPS - interface meter for oil spill project

2-The dredging project to extract oil from oil sludge tanks

3-Projects to reduce emissions of ozone depleting gases and replacing fire and refrigeration systems

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.

5-Several environmental research projects (API odors - The use of urban wastewater treatment plants and industrial purposes .... City Shahinshahr)

6-Conservation of the 5/114 hectares of green space

7-Active participation in making landfill monitoring with environmental standards in the local areas

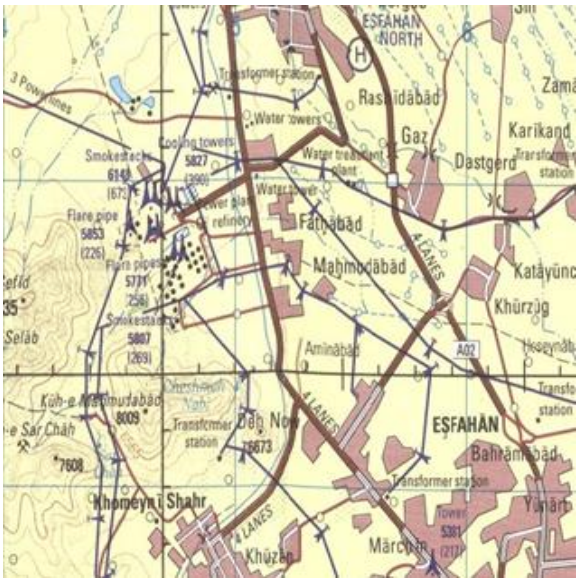

Fig. 1. Isfahan oil refinery map legend.

Fig. 2. Isfahan oil refinery map.

I. Reasons of ISFAHAN oil refineries as case studies for study of EIA of oil refineries in IRAN

- To identify and eliminate of all wrong activities of the environmental impact assessment
- To make the correct way for increase activities in accordance with the environmental impact assessment
- To make systematic pollution control planning for environmental protection

- To act on proper environmental planning in one the most important oil refineries in Iran
- To provide integrated environmental management plan for control the adverse activities
- To prepare an integrated modeling for environmental impact assessment
- To provide a framework for evaluating the oil refinery effects on environment
- To identify the economic-environmental indicators and effects
- To identify the social–environmental indicators and effects
- To review land use indicators and effects in the area around the oil refinery

Results

After identifying all the technical, environmental, social and economic factors of the projects, different options to take into consideration when carrying out the projects are assessed in order to remove the worries of the society and to lessen the adverse impacts as far as possible. One the main option that has to be assessed is the "No Option" or "Not-carrying-out-the-project Option". In this option, it would be made clear that what the environmental state of the area would be like if the project is not carried out. The result of this option would serve as the basis for comparison or a yardstick for the projects or plans. (It shows the differences between when the project is carried out and when it is not carried out). In this phase, the main aim is to provide a basis for acceptance or rejection of options. Therefore, here we should take into consideration not only the environmental issues, but also the economical issues should be taken into account, such as how long it would take for the plan to start making profits. Other issues to be dealt with are whether the project is in line with social or cultural features of the area, and whether the assessments for the costs to improve the ways the environment can be utilized are done and are well known. In selecting options issues such as "the ratio of costs-profits", "public acceptability of the project", or "advantages versus costs" should be considered. In case no option is regarded as not being 100% safe or free-of-damage, the issues to be dealt with would be ways to reduce possible damages to the environment.

Using the software to achieve the EIA oil refineries

- Capable to use in Construction and Operation phases of oil refineries
- Ability to reach all environmental parameters have been studies for the two phases
- Provided effective factors and activities in the construction and operation phase
- Prepared important interaction factors of all items for this project
- *ERA-GIS (ENVIRONMENTAL)*

ERA-GIS results for environmental parameter in each phases

1. Environmental effective points were found
2. Importance ERA indexes were found
3. ERA parameters were completely combined to the different parameters maps
4. ERA Zoning maps were provided for final EIA
5. Environmental pollution maps were provided based on the ERA studies

- *ERA-GIS (Economical)*

ERA-GIS results for economical parameter in each phases

1. Effective economical growth points were found in on maps
2. Direct income people risk maps were provided around the oil refinery
3. Indirect income people risk maps were prepared to determine the correct economical impacts around oil refinery

4. Local business risks maps were provided for EIA

5. Increase new business economical risks were determined in different area

- *ERA-GIS (Land use)*

ERA-GIS results for land use parameter in each phases

1. The effective points of oil refinery land use were found on map.

2. Existing land uses, their distribution and settlement were determined completely.

3. Comparison of per capita and level of each land uses of the current status of the land use plan were found directly related to oil refinery.

4. Comparison of per capita and level of each land uses with consideration of current per capita in Iran and compliance with the criteria were completely done for EIA.

5. According to EIA-oil refinery studied land use classified ERA points and maps were provided in different parts.

ERA-GIS (Social)

ERA-GIS results for social parameter in each phases

1. The effective points of social parameters were determined on the map.

2. Social and cultural reaction impacts on workers and the job process, effects of the people lives, effects of entry and residence foreigners in the region and effects on social activities were studied completely.

3. Effects on increase the different life classification from so rich to poor people and its growing.

4. Social pressure on majority of people without oil expertise

5. Social inequalities resulting from the presence of high-income workers in low-income segments were studied for EIA plan.

1. Development and successful implementation of GIS for EIA oil refinery

Obviously, the implementation of GIS in any organization is its complexity. As studied in this project for two oil refineries (Isfahan and Isfahan) 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;

-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.

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 5. Different parameters maps of Isfahan oil refinery and located area around it during the project implementation (2008-2012).

Location	Parameters			
	Economical	Environmental	Land use	Social
Dehno	36	28	28	36
Khomeynishahr	36	28	28	36
Mahmoud abad	36	28	28	36
Shahinshahr	36	28	28	36
	144	112	112	144
Total maps	512			

All maps designed and implementation of four parts of GIS-EIA of oil refineries as case studies, Isfahan oil refinery and 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 6. Different kinds of GIS maps provided for each case study during the project implementation-Isfahan oil refinery (2008-2012).

Special Geographical GIS maps	Numbers of maps of Isfahan oil refinery			
	Shahinshahr	Mahmoudabad	Dehno	Khomeynishahr
Hill shade	16	16	16	16
Layers	16	16	16	16
Land use	16	16	16	16
Sat-image	16	16	16	16
Slope	16	16	16	16
Tin	16	16	16	16
Zoning	16	16	16	16
Total maps	112	112	112	112

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

Actually for each location and each parameter there are 1024 maps are available as mentioned in the tables above and previous discussion. But for example of GIS-EIA oil refineries two layers maps put here. For final result of GIS-EIA of case studies there are two GIS map layers are coming as follow.

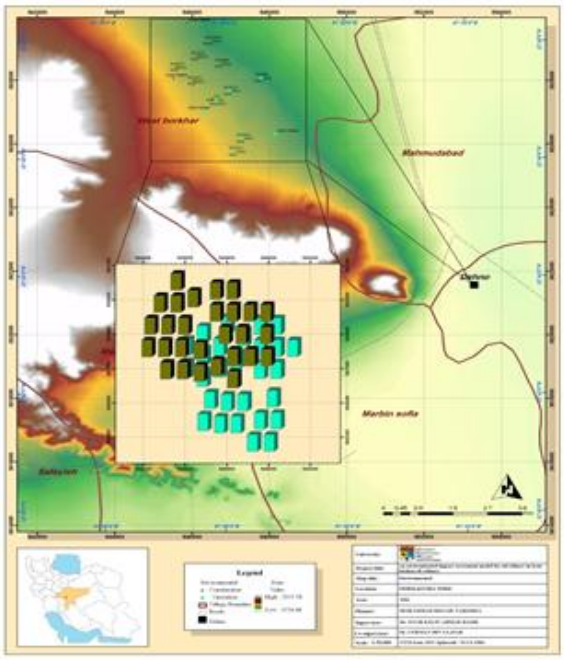

Fig. 3. GIS map located points in case of economic studies for Isfahan oil refinery.

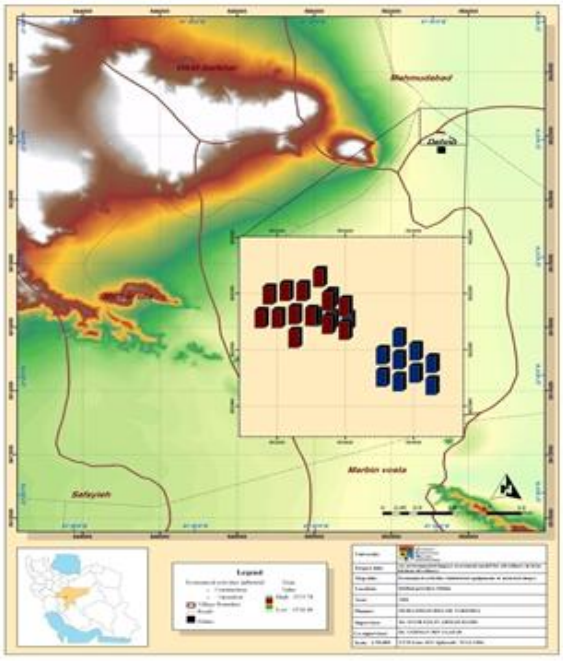

Fig. 4. GIS map located points in case of oil content and So2 pollution for Isfahan oil refinery.

For environmental parameters in case of oil refineries in Iran Oil contents and So_2 parameters have been considered as major problems in oil pollution and air pollution. These items have also high risk in environment and human life. Surface and underground water pollution, land contamination, waste water treatment problems, damage to the facilities and waste materials causes of oil content in oil refineries in Iran. About So_2 effects the most effect of this parameter is air pollution, combined factor with water, soil elements in soil, agricultural products and yellow color effects on plants with sulfur factor. With GIS system user can find the most effective points of oil contents in oil refinery and area around the oil refinery. Figure 14 and 16 shows the points with GIS system in case of oil content leakage (oil pollution) and So_2 as a factor for air pollution in Isfahan oil refinery. Also GIS system can use for locate the future different pollution points.

In part of land use parameter determine the oil refinery future development plans, specify land use around oil refinery, current land use around oil refinery, proximity to residential, industrial and commercial areas, roads and other access routes, possibility of oil refinery relocation and assess the value of areas around the oil refinery. Base on the GIS studies Table 4.5 and 4.6 results of the most important factors in land use parameters for Isfahan and Isfahan oil refineries. The GIS with complete data can gives the most effective point in case of land use studies for Isfahan and Isfahan oil refinery. Figures shows the oil refineries economical affected points. Figures 4.7 and 4.8 are land use zoning in the area of Isfahan and Isfahan oil refinery.

In the field of social studies base on the field studies, data collection and local assessments for oil refineries some items have been noticed for better results in social studies such as; cultural effects, environmental knowledge and historical problems. In summarize of these data the final result obtained for social studies in case of Isfahan and Isfahan oil refineries. These major items are most effective problems for locals to be faced with new changes in their lives, because of oil refineries construction and operation for these reasons like; new people immigration for working in different parts, cultures varieties, religious differences, different educations, ethnic differences,

historical effectives on ancient cultural and religious buildings and monuments. The most effective points by GIS map provided for Isfahan oil refiner.

Table 7. Occupancy levels and types of land use area of major land use for Isfahan oil refinery.

Row No.	Type of land use	Occupancy levels (Km²)	Total %
1	Residential	153	22/3
2	Commercial-Administrative	22	2/2
3	Industrial-Workshop	21	1/5
4	Transport-Storage	27	46
5	Road network and access	106	10/4
6	Urban services	47	5/3
7	Green area	64	4/3
8	Agriculture (Crop- Garden)	32	2/4
9	Military	34	3/1
10	Arid and No construction	37	2/5
	Total land use	543	100

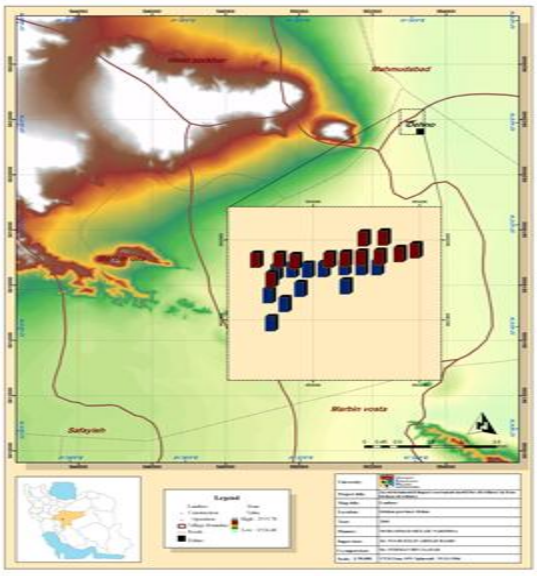

Fig. 5. GIS map located points in case of Land use for Isfahan Oil Refinery.

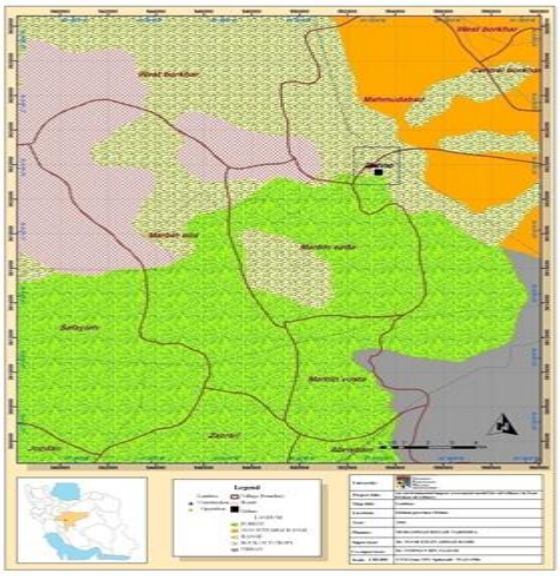

Fig. 6. GIS zoning map in case of land use for Isfahan oil refinery.

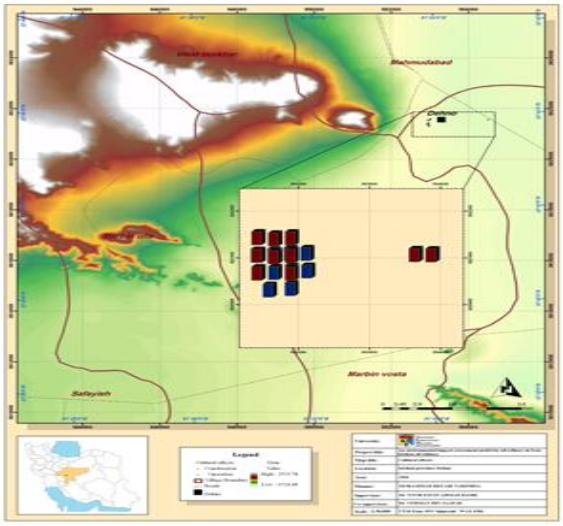

Fig. 7. GIS map located points in case of social studies for Isfahan Oil Refinery environmental section in year 2012.

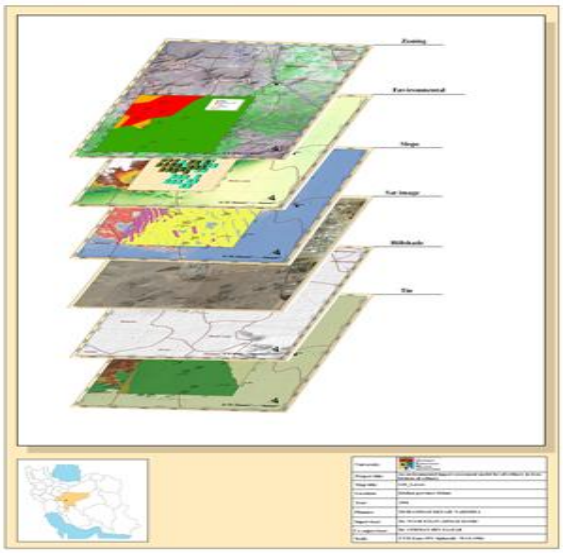

Fig. 8. GIS-EIA map layers of social studies for Isfahan oil refinery.

Discussion

Environmental impact assessment management program for Isfahan oil refinery has different parts. The EIA study in both construction and operation phases, data analysis and effective points have been found inside and around Isfahan oil refinery indicate that pollution for oil refinery personnel and population centers around it caused by Isfahan oil refinery.

Implementation steps

By GIS software with details of environmental parameters and items for design, construction and operation, four major environmental parameters (environmental, economical, land use and social) have been considered in different phases of oil refinery and it can help the decision-makers in these different stages and give propose to environmental pollution reduction, Isfahan oil refinery replace or better area for Isfahan oil refinery implementation.

Different stages of this method are:

1.1. *First stage*

The first stage business process analysis and critical success factors in environmental issues:

This phase consists of the following stages:

1. Management agreement on the definition and creation of business process diagram for the basic organization. At this stage the fundamental business processes that determined the nature of the organization are drawn and their relationship with each other and other organizations is characterized by claimants.
2. Appropriate insights to the managers and experts of Iranian oil industry, understanding customers, goals, inputs and outputs of each process by evaluating this software.
3. New models can achieve new methodology for EIA of Isfahan oil refinery and propose a strong framework to EIA plan in case of other oil refineries in Iran.
4. Understanding and agreement on the management of critical success factors for each basic process with conventional methods and purpose of current.
5. Fundamental analysis of each process under the form of detailed process
6. Understanding of information technology opportunities, along with the application of the current situation in the organization, for each basic process.

1.2. *The second stage*

The second stage is based on environmental monitoring and decision-making and the software capability to solve the problems of the environmental impact assessment of oil refineries: policies, objectives and the way board of managers use environment information system, study and analysis of risk creation information system, finding solutions to minimize the risks. With software development can improve and increase the efficiency of it by use it for other oil refineries in Iran. Ways of the classification and collection of the solutions are that they suit each executive to function for them as guidance for their performance.

1.3. *The third stage*

The third stage data Integration Infrastructure

In this stage, with consideration of environmental protection, uncontrolled designs in the Isfahan 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:

1. 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.
2. Creation of entity relationship diagram for the overall process of the above. At this stage, entity can be drawn as relationship diagrams for each of the above processes.
3. Combination of conceptual graphs in a chart in business. 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.

Acknowledgement

The EIA oil refinery framework for oil refineries in Iran is important for construction and operation phases of oil refineries, oil refineries development plans, oil industry management, environmental engineering and management plans, environmental health plans and social communities round oil refineries. In this case EIA plan can develop for other parts of Iran oil industries such as; petrochemicals, oil terminals and other oil facilities.

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