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Multi-criteria GIS-based place of Isfahan oil refinery for environmental impact assessment modeling in Iran

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Abstract

Environmental Impact Assessment (EIA) for oil refineries in Iran is a major factor to environmental protection in oil industries. Geographical Information System (GIS) was used as a tool for understanding the effects of oil refineries activities on environmental parameters in case of Isfahan oil refinery as a research plan for other oil refineries in Iran. In this case 1024 maps were provided that overlapped on together for final EIA of Isfahan oil refinery plan. This EIA modeling tried to prepare as a plan for EIA to other parts of oil refinery industries in Iran. The Environmental Risk Assessment (ERA) methodology has been used as an evaluation tool for EIA plan. The reason was to make the correct possible risk points and areas for each phase of oil refinery activities as construction and operation. All parts of this research were based on field studies, laboratory tests, Geographical Information System (GIS) software, put the information on maps and made raster in maps by GIS and finally EIA plan were prepared for Isfahan oil refinery. The most important part of this study was the EIA plan for oil refinery in Iran that can be use in other oil refineries in Iran as a major EIA plan.

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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 al.* 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). Environmental protection agencies in many countries focuses on the major projects EIA plans and they gives the ranking to the environmental impact statements reports (Tzoumis 2007; Tzoumis & Finegold 2000). Oil and natural gas is the main source of economy around the world and decision-making in the field of development of these industries with environmental damage reduction is very important (Uihlein & Schebek 2009; Underwood & Chapman 2003). The EIA guidelines is available in many countries but the main different between them is identify the environmental and social problems although the EIA plan in all countries prepare decision-making with important factors (Vanclay 2006; Viikari 2004).

To obtain the EIA and sustainable developing plan targets together for projects implementation needs to methodology to assessment the impacts on environment completely (Villarroya & Puig 2009; Vries & Boer 2010).

Specify the environmental parameters in local development plans are very important for EIA programming and different environmental quality contain human judgment on them (Wang *et al.* 2003; Wang *et al.* 2006). The biodiversity role in EIA always consider by governmental protection agencies, NGOs and other authority organizations for pay attention of serious environmental impact such as climate change, environmental toxicity and other major problems (Wegner *et al.* 2005;Werf *et al.* 2009).

Multi-criteria environmental problems, different production mechanisms, eco-environmental indexes and different methodologies for environmental protection provide various procedures for EIA specify and related experimental tests and control (Wiedmann *et al.* 2007; Wilson. 1998). There

are some steps for cumulative impact assessment in many countries such as specify the environmental effects, selection valued environmental factors and test the cumulative effects and planning the environmental friendly productions for producers (Xue *et al.* 2004; Zhou & Schoenung 2007).

Some effective factors have been cited in choosing the Environmental Risk Assessment method. Upon completion of the phase of identifying the environmental risks, the probable environmental consequences arising from implementation of development project shall be assessed. It means that a qualitative or quantitative conclusion of the identified risks shall be made and the plans for responding to the identified risks shall be judged. Some of the main parameters and effective factors in choosing the environmental risk assessment method are:

- Research phase of ERA
- Basic available information level
- Ecological sensitivity of the research scope
- Professional workforce of ERA team
- Period allocated to conducting research
- Budget allocated to conducting research
- Type, nature, and specifications of development project

Accordingly in this research we introduced a new method in industrial environmental studies. Specifically, oil refineries in Iran were investigated.

Materials and methods

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 a case study of Isfahan oil refinery.

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. 3, 4, 5, and 6 are the locations of Isfahan oil refinery.

Production of Isfahan oil refinery

This refinery has many productions that come in the table below. Table 4 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.

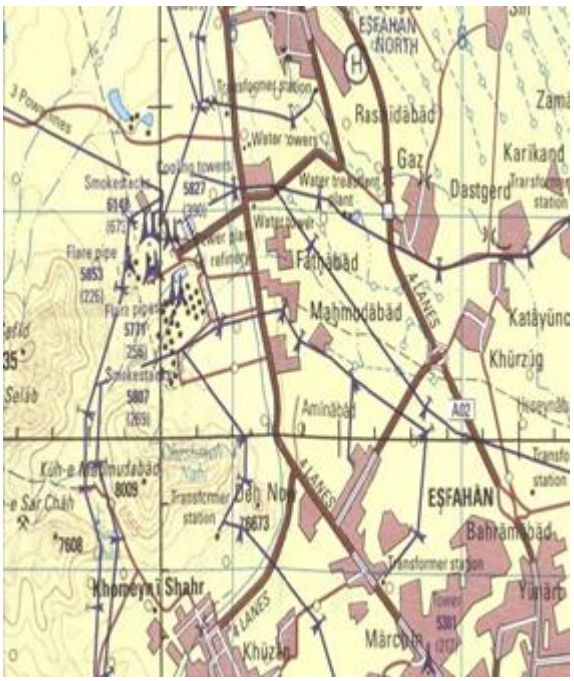

Fig. 1. Isfahan oil refinery map.

Results

EIA management plan and decision making process in oil refineries in Iran during two Phases such as Construction and Operation should consider to these items:

-Chemical and bacteriological sampling and sample preservation of water and wastewater

-Equipment preparation, bacteria medium and dilution water for bacterial logical examination of water and wastewater

-Framework to identify and assess environmental hazards

-Regulations and executive management plans in industrial wastes and especial oil industry wastes

-Instructions and procedures for transportation of special wastes

-Instructions and procedures for waste depot and special storage

-Chlorination and disinfection of effluent from sewage purification

-Bacteriological examination of water and wastewater

ERA-GIS (ENVIRONMENTAL)

1. ERA-GIS results for environmental parameter in each phases
2. Reaction risks between project activities and environmental items were found completely on prepaid maps
3. Capable ERA Zoning maps were provided for future studies
4. Provided a framework for ERA-EIA, so as to reduce duplication and overlap as well as, confusion and competition between the various parties involved.
5. Establish a comprehensive database for various environmental indicators, evaluate their accuracy, strengthen existing scattered data, and develop maps of environmentally sensitive areas.

ERA-GIS (Economical)

1. ERA-GIS results for economical parameter in each phases
2. Increase investments maps were determined Oil related industries economical developments maps were provided in each part of studies area
3. Value-added goods and services effective points were determined on the maps
4. Costs and economic benefits of oil refineries and zoning maps of them were provided for EIA
5. Fluctuations in the prices of goods and services IN local area pointed and determined on the maps
6. All points and maps were layered on together for final economical risk map

ERA-GIS (Land use)

ERA-GIS results for land use parameter in each phases

1. 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.
2. According to EIA-oil refinery studied land use classified ERA points and maps were provided in different parts.
3. With consideration of other land uses around oil refineries and oil refinery development plan, land use map were provided for each case studies.
4. Other land uses such as; farms, business, roads and routes, factories were specified on the land use maps.
5. Land use layer of oil refinery provided in case of ERA-GIS studies.

ERA-GIS (Social)

1. ERA-GIS results for social parameter in each phases
2. Effects on increase the different life classification from so rich to poor people and its growing.
3. Social pressure on majority of people without oil expertise
4. Social inequalities resulting from the presence of high-income workers in low-income
    a. Statements were studied for EIA plan.
5. Oil refinery implementation is occurred social problems, resentment, inequality, gap between social classes, inequality and social facilities were fully investigated for ERA-EIA plan.
6. All social research findings were put in the ERA-GIS process and the social risk maps were provided for two case studies completely.

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. The research 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 5 presents results of the most important factors in land use parameters for Isfahan oil refinery. The GIS with complete data can give the most effective point in case of land use studies for Isfahan oil refinery. Table 5 presents Occupancy levels and types of land use area of major land use for 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 oil refinery. 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 refinery.

Table 5. Occupancy levels and types of land use area of major land use for Isfahan oil refinery.

Row No.	Type of land use	Occupancy levels (Km^2)	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

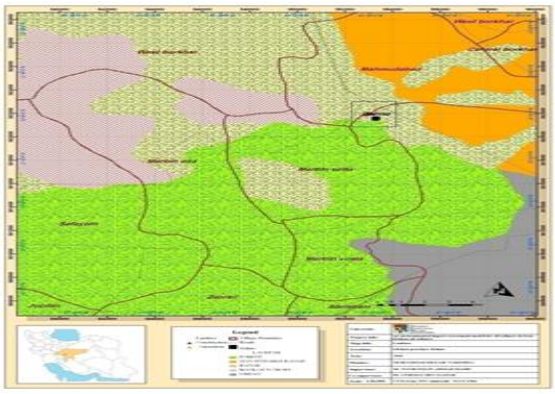

Fig. 3. GIS zoning map in case of land use for Isfahan oil refinery.

Results of GIS-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 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 Isfahan oil refinery in two parts: construction and operation. For each refinery 100 effective maps provided for each refinery (Isfahan) in two phases as construction and operation in four general classification as; economical, environmental, land use and social parameters. In this project 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 6. Different parameters maps of Isfahan oil refinery and located area around it during the project implementation (2008-2012).

	Parameters			
Location	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. 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 7. 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			
	Dehno	Khomeynishahr	Mahmoud abad	Shahinshahr
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

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.

Discussion

With this method as EIA oil refinery in Iran these important indexes have been achieved completely in six years studies such as; the appropriate, high reliability, applicable EIA plan in other oil refineries as case studies, capability to propose the proper implementation and development oil refinery location in different geographical and topographical locations, ability to provide the accurate EIA method for oil refineries in Iran to complementary development planning and implementation with notice the different case study as Isfahan oil refinery, ability to develop and change in the future for new oil refineries, capability to use for oil refinery feasibility studies and EIA complete method to understand the EIA oil refineries development plan, recognition problems, scientific studies in different parts as; environmental, economical, land use and social parameters, and determine the proper EIA method for oil refineries in Iran.

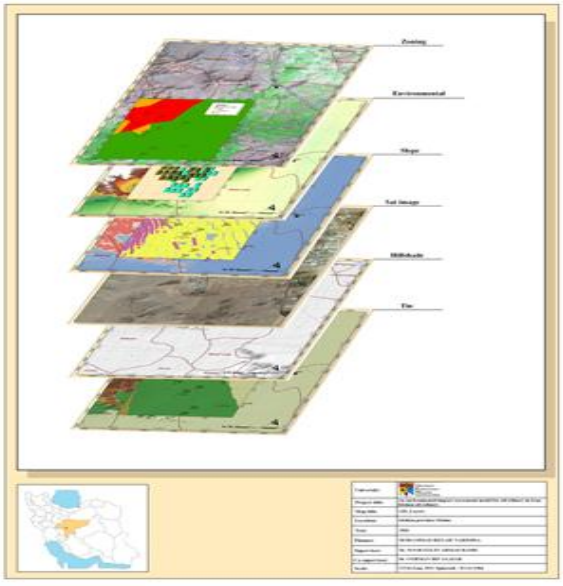

Fig. 4. GIS-EIA map layers of Isfahan oil refinery, environmental section, in year 2012.

Acknowledgment

As a prerequisite, Iranian oil industries and other related industries should address environmental needs. It is clear that a sustainable development would not be possible if environmental issues are not taken into consideration in development plans. In recent decades, the topic of pollution caused by oil products has found a special place in environmental talks across the world. Spilling millions of liters of crude oil due to accidents into the sea and the leakage of oil products into the soil caused by land transportation are the main causes of land and water pollution oil and other related industries produce.

Issues to consider:

• Environmental Protection in Petroleum Industry

The Ministry of Petroleum and HSE (Health, Safety an Environment) companies and other related industries has created an optimal management system, especially with regard to the environment, yet a long way is ahead before we can reach required standards in this field. It also requires strong determination and strategic planning. To meet these ends the following conditions should be provided for:

1. Try to provide a way for understanding the problem's between Oil Ministry people and Environmental Protection Organization.
2. People all agree on the necessity to create an effective mechanism of interaction between the strategic and effective institutions in this area.
3. Agreements on the necessity for environmental strategies in oil and gas industries.
4. Determining the environmental strategies as prerequisites for oil and gas industries.

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