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A GIS-based system for environmental impact assessment of oil refineries in Iran

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

Abstract

The increasing importance of the oil refinery industry in Iran is important for investigation of environmental, economical and social parameters. Oil refinery industries are the different kinds of activities in each country as part of the economic activity in the industrial and social skills and stimulate economic development. Tehran city is full of attractions that have diversity the rationale for having fertile soil, abundant groundwater aquifers, natural resources and reputation. It features "Industrial City" with various natural cover in around Tehran city is distinctive in the province. In this research to achieve the Environmental Impact Assessment (EIA) two items were used as; Environmental Risk Assessment (ERA) for evaluation tool, Geographical Information System (GIS) for providing EIA map and prepare the final EIA of Tehran oil refinery as a model for other EIA oil refinery plans in Iran. In this EIA plan construction and operation phases have been considered as two major parts of Tehran oil refinery. In this study 512 maps were provided in different cases such as environmental parameters and oil refinery activities. All maps were provided as laboratory tests, field studies, overlapped on together and achieved to final EIA oil refinery plan. This model can use for other EIA oil refineries in Iran as a general EIA plan.

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Introduction

In the seventies in Iran, particularly in the final years of the decade, negative consequences of the environmental destruction and pollution were obvious. This work is aimed at correcting the attitudes of policy makers with regard to the environment. Sustainable development means development with minimal negative consequences on the environment. In this context, the Environmental Protection Council Act requires companies to provide an environmental assessment report when doing their feasibility studies and during their site selection. Considering the harmful effects and sometimes irrecoverable and costly consequences of many development projects, environmental assessments as a powerful tool for achieving sustainable development gained legal attention in 2004 in Iran.

1. Article 105 of the Third Development Plan Act, ratified in 1379 (March 20, 2000).
2. Upon the request of private sectors or the cooperative sectors for establishing oil refineries or other oil-related industries, alone or with cooperation of other parties, and provided their budget is sufficient and their plan has economic and environmental feasibility, according to Clause A of Article 4 (120) of the document for the Third Economic, Social and Cultural Development Plan, the National Iranian Oil Company can issue the required permit for them to do so.

In theoretical base studies for strategic environmental assessment it can lead to environmental impact assessment policy for each projects (Fischer T.B., 2003). Oil refineries studies for environmental protection were examined researches and studies about climate change (Huang *et al.* 2005). Different methodologies in Europe for strategic impact assessment to proceed to a plan for environmental screening make a real recognition of environmental assessment and screening such as Spain in large scale studies (Garcia-Montero *et al.* 2008). The instruments potential for sustainable development, environmental parameters and assessment usually are not required for judgment (George 1999). The EIA in Europe has different items and some important corrections to directly consequences is needed in overview such as Ireland (Geraghty 1996). The EIA and strategic environmental assessment are necessary tools that utilization of programming lead to find the major environmental problems (Gontier *et al.* 2006). Planning the EIA for different phases, sustainable development, important changes and predicts the correct analysis for every project is necessary and large scale vision (Haapio & Viitaniemi 2008). Commonly, in the case of industrial plants in larg scale environmental problems have been most interested for assessment (Hanssen 1998). The responsibility of planning to consumers, environmental banderol, production phases, and methods for impact assessment need to deep analysis and much information about the pollutants (Hertwich *et al.* 1997). The EIA plan consists of analysis of impact sources, ecosystems, connection between impact source and targets, measurements and sustainable development (Hoepner 1999). Environmental impact assessment (the EIA) was conceived entirely in and for a developed, Western society situation in the 1970s and 1980s. Today, most states apply the EIA in one way or another, including the "countries in the transition" phase from socialism to a market-based economy and political democracy (Holm-Hansen J., 1997). In products the environmental life cycle assessment (the LCAs) identity parameters (Huijbregts *et al.* 2005) in many countries such as Canada base on the environmental impacts, integration of public participant and environmental monitoring (Hunsberger *et al.* 2005) are methodological issues for examine and evaluate the decision-making process (Ijäs *et al.* 2010). Experimental studies have disclose the EIA targets with measurement of parameters and decision-making process (Jay *et al.* 2007) for study area, criterion study, area work maps (Joao 2002) in different goals of environmental assessments systems, effective environmental management with integration sustainable development in many countries for environmental management (Keen &

Sullivan 2005). The EIA system is a developed study base on the environmental correction process, environmental performances in developing countries (Keysar *et al.* 2002) by introducing the industrial pollutions, air pollutions and ecological damages (Krieg & Faber 2004) but for Europe countries such as Norway the value of environmental parameters and its damages integrated for EIA planning by consideration of strategic environmental assessment (Kværner *et al.* 2006). The EIA modifications for different projects with especial factors (Lattemann & Höpner 2008) are based on the social, political and relations between them with economical items (Lawrence 2000). But the point is EIA plan should have international standards (Lenzen *et al.* 2003) with consideration of public involvement and decision-making process (Leu *et al.* 1996). In fact a quantitative assessment of construction phase is a good help for decision-makers in this phase (Li *et al.* 2010). In operation phase especially for green and environmental friendly products need to necessary design (Park & Seo 2006) and for investment with consider of environmental values (Lim & Park 2009) the EIA process with its laws and regulations has potential profits (Lindhjem *et al.* 2007). The purpose of this study was to increase executive capabilities in environmental engineering in oil refining industries.

Materials and methods

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

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

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 Tehran oil refinery.

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.

Summing up and analysis of the results of the interactions reveals all impacts of establishing an oil refinery in both design-construction and exploitation stages. By using GIS software and ERA method, environmental risk assessment of four major parameters such as environmental, economical, land use in construction and operation phases were done completely. Doing the jobs of planning and designing using this software is easy for everyone. The results will be specified and help decision makers to run a refinery in an environmental friendly way. In this way the negative consequences would be specified and reduced greatly whether in the construction phase of oil refineries or when they are in the operation phase, thus preventing the environmental pollution in the future of Iranian oil refineries.

In order to understand what is meant by environmental risk assessment it is important to be familiar with the concepts of hazard and risk. These terms have different meanings and are not interchangeable. The following definitions are used here. Hazard: is the inherent potential for something to cause harm. Hazards can include substances, machines, energy forms, or the way work is carried out. Risk: is the likelihood that harm will actually be done by the realization of the hazard during the work being carried out or by the way something is used. Risk = Hazard × Exposure. In general, the term environmental covers the physical surroundings that are common to everybody including air, water, land, plants and wildlife. The definition used in the Environmental Protection Act 1990 is that the environment consists of all, or any, of the following media, namely the air, water and land.

Geographical Information System (GIS)-Oil refineries

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

- One case study
- Construction and operation phase
- Four determined parameters

Case study

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 4. Tehran oil refinery productions.

Real average of products	Capacity (1000 liter per day) product
Liquid gas	1259
Gasoline	1700
Jet fuel	6989
Light Naphtha	383
Kerosene	3442
Gas oil	12872
Furnace oil	7549
Crude engine oil	1878
Bitumen production feed	2160

Source: Iranian petroleum ministry

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 environmental. 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. The Fig. 1, 2, are maps, legends of Tehran oil refinery.

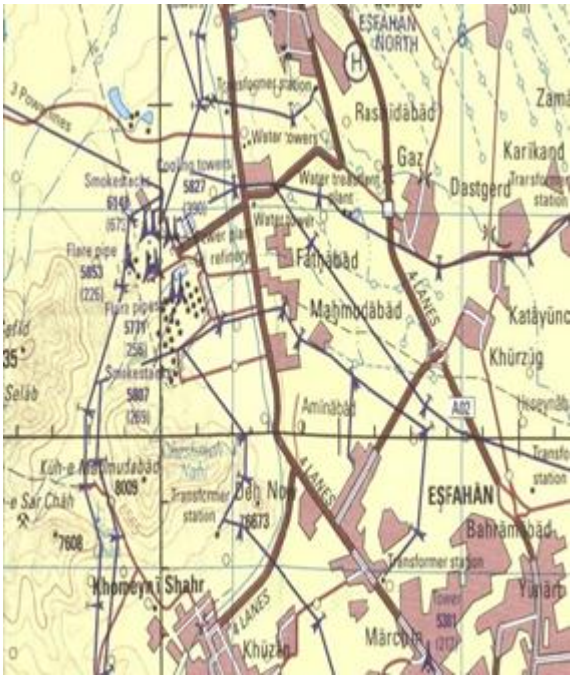

Fig. 1. Tehran map consisting of Tehran oil refinery.

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.

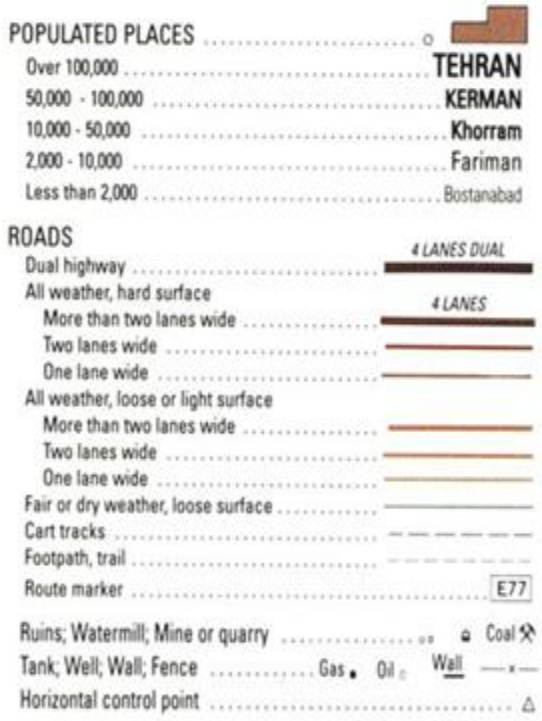

Fig. 2. Tehran oil refinery map legend.

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. 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)

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. Fluctuations in the prices of goods and services in local area pointed and determined on the maps

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. 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.

3. 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.

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

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

3. 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.

4. Social inequalities resulting from the presence of high-income workers in low-income segments were studied for EIA plan.
5. All social research findings were put in the ERA-GIS process and the social risk maps were provided for two case studies completely.

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) 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 Tehran oil refinery and located area around it during the project implementation (2008-2012).

	Parameters			
Location	Economical	Environmental	Land use	Social
Azim abad	36	28	28	36
Bagher city	36	28	28	36
Dorsoun abad	36	28	28	36
Esmaeil abad-e-moein	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, Tehran oil refinery 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-Tehran oil refinery (2008-2012).

Special Geographical GIS maps	Numbers of maps of Tehran oil refinery			
	Azim abad	Bagher city	Dorsoun abad	Esmaeil abad-e-moein
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.

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 3 and 4 shows the points with GIS system in case of oil content leakage (oil pollution) and So_2 as a factor for air pollution in Tehran 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 7 and 8 results of the most important factors in land use parameters for Tehran oil refinery. The GIS with complete data can give the most effective point in case of land use studies for Tehran oil refinery. Figures 5 and 6 show the oil refineries economical affected points. Figures 16 and 19 are land use zoning in the area of Tehran oil refinery. Table 11 Occupancy levels and types of land use area of major land use for Tehran oil refinery

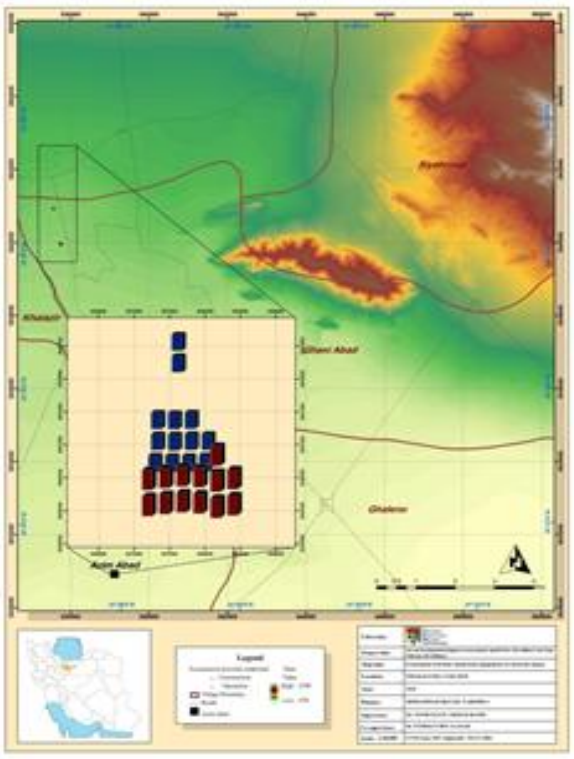

Fig. 3. GIS map located points in case of economical studies for Tehran oil refinery.

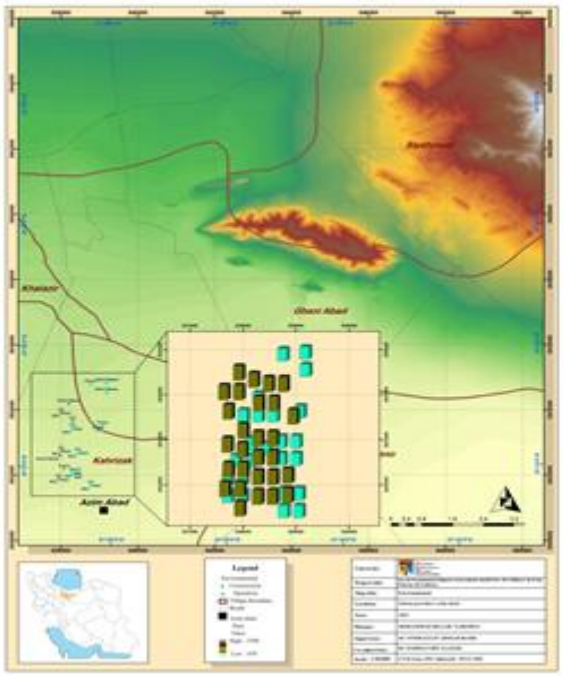

Fig. 4. GIS map located points in case of oil content and So2 pollution for Tehran oil.

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

Row No.	Type of land use	Occupancy levels (Km²)	Total %
1	Residential	177	28/8
2	Commercial-Administrative	26	4/2
3	Industrial-Workshop	27	4/4
4	Transport-Storage	30	49
5	Road network and access	114	18/6
6	Urban services	50	8/1
7	Green area	70	11/4
8	Agriculture (Crop- Garden)	35	5/7
9	Military	44	7/2
10	Arid and No construction	41	6/7
	Total land use	614	100

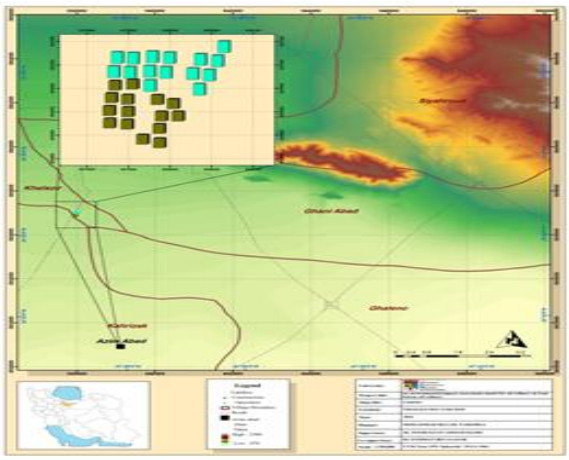

Fig. 5. GIS map located points in case of land use for Tehran oil refinery.

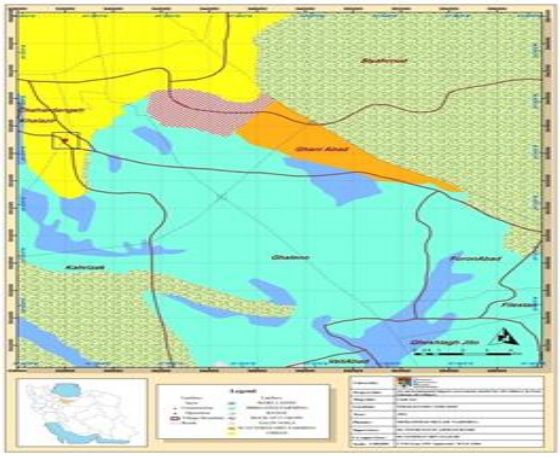

Fig. 6. GIS zoning map in case of land use for Tehran oil refinery.

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 Tehran 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 Tehran oil refinery. Figures 5 and 6 show social parameter studies most effective points in case of Tehran oil refinery.

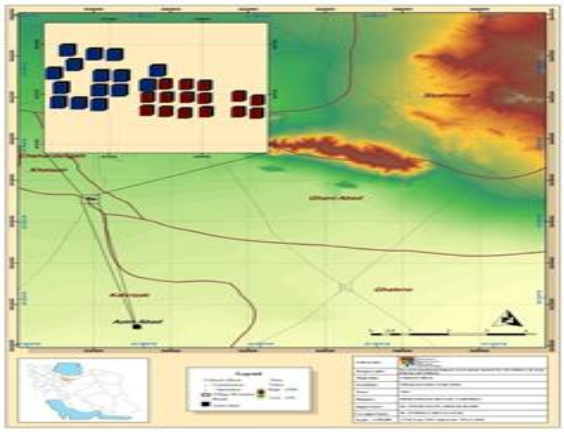

Fig. 7. GIS map located points in case of social studies for Tehran oil refinery.

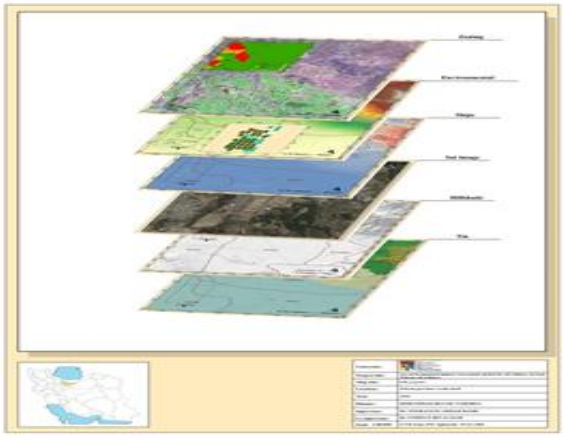

Fig. 8. GIS-EIA map layers of Tehran oil refinery, in year 2012.

Conclusion

The EIA study in both construction and operation phases, data analysis and effective points have been found inside and around Tehran oil refinery indicate that pollution for oil refinery personnel and population centers around it caused by Tehran oil refinery.

Acknowledgment

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 studies as Tehran 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.

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