RESEARCH PAPER

GIS-based approach for optimized place of environmental impact assessment of oil refineries in Iran: A case study of Tehran oil refinery

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Abstract

In this research presented in each of the parameters in the model, such as land, soil, vegetation, lithology, protected areas, climate and water flow rates examined separately. The objective of the proposed model is based on data classification and analysis of Environmental Impact Assessment (EIA) of oil refinery, sum the development zones map, GIS data and rate of effects of oil refinery on environment. The evaluation method was Environmental Risk Assessment (ERA) helped to find the possible risk points and zones for Tehran oil refinery. The Geographical Information System (GIS) were used to provide the EIA maps of Tehran oil refinery. In this research EIA oil refinery found that can use in other EIA oil refineries plan in Iran. The 512 maps were provided and all of them were overlapped on together to achieve the final EIA plan. All studies based on the field studies, laboratory experiments, put data in GIS software, make raster for each part of information and find the EIA map. This EIA oil refinery plan can use as a tool for EIA model of other parts of oil refineries in Iran. Tehran oil refinery has sensitive environment and by using this model can achieve to appropriate EIA plan for environmental protection.

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Introduction

This section will review the aims, necessities and benefits of Environmental Impact Assessment in Oil Refineries. Environmental Impact Assessment of oil refineries in Iran is an essential process enabling the provision of developmental plans in Iranian oil refineries, the establishment of new oil refining companies and the implementation of strategic plans in oil refining industries. The main aim of environmental impacts assessment is to make sure that all the environmental policies and objectives introduced by the government are observed when developmental plans or projects are being carried out. Environmental impacts assessment is an acceptable method to fulfill the objectives of a sustainable development. It is a vital tool at the hands of planners, managers and decision makers for identifying and reducing the adverse impacts development programs may have on the environment. Worries about the impacts of carrying development projects are increasing. Governments and international organizations are after regulations to legally oblige employers of projects and development planners to produce environmental impacts assessments. That is why the necessity for environment impacts assessments is felt greatly by all officials, related governmental and private employers, experts, people and their representatives. The environmental assessment is regarded as a mechanism that offers correct and logical ways to utilize human and natural resources in an economic and efficient way. It has considerable positive effects on our short-term or long-term plans. The awareness among the public will also be increased because the assessments are in relation with planning procedures. The officials will be able to economize on expenses due to clear and certain timing of projects reducing the pressure on government finances. Another advantage of environmental assessment is that it accelerates the pace of planning's; it also helps us prevent irreversible negative impacts on the environment and natural resources (Ghizhanzadeh 2005). The main pollutants are sulphur oxide, nitrogen oxide, carbon monoxide, aldehydes, ammonia, particles and hydrocarbons (Jaafarzadeh,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). Sulphur oxides that are resulted from burning of fuels are also released through the chimneys. 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 (Golestan, 1985). In many decades from 1960s till now around the world and also in Iran many environmental laws and regulations provided for environmental protection, and NGOs and UNEP in United Nation also try to save the environment by Environmental Impact Assessment (EIA). This is the main reason that made EIA is being universal to planning and use in many projects (Ahammed & Nixon 2006). In Iran for EIA system many companies existing that provide the EIA reports but there is not any framework for them (Ahmadvand *et al.* 2009). For new projects strategic plans for environmental parameters can assess the environmental impacts on economy and society (Al-Rashdan *et al.* 1999). A significant majority of environmental problems in strategic plans for investments in projects should be considering for better development (Annandale & Taplin 2003). The EIA plan should have screening, significant effects and technical reviews to be good mechanisms for EIA management plan (Armitage 2005). Complex ecosystems in different environments with multiple conditions needs to accuracy analysis (Atkinson *et al.* 2006). Monitoring the EIA projects is make it effective and successful (Alshuwaikhat 2005). The impact assessment of different parameters such as social economic, and ecological parameters are important to recognize the significant problems and very important for decision-making in every level of EIA (Backlund 2009). Environmental impact assessment can be specified

evaluating the activities on environment (Baratto *et al.* 2005). Impact assessment for protection of natural resources is very important (Bare & Gloria 2008). A good EIA also has social parameters studies for evaluating the social parameters in construction and development of plants (Bass 1998). All human activities are important in effects on environment during the projects (Blanco Moron *et al.* 2009). EIA requirements are different in many projects and in large scale study some items are coming inside of studies and in this case environmental impact statement is very important (Boyle J., 1998). Environmental impact statement is base on the monitoring, tests modeled for provide and knowing the environmental problems for better EIA procedure (Branis & Christopoulos 2005). The EIA process is studding environmental problems to define significant of impacts during the project and future (Burris R. K., & Canter L. W., 1997). EIA reports are bringing up the activities on the environment (Cartalis *et al.* 2000). The EIA study should include the universal decision-making as potential items (Cashmore 2004). Research and development in EIA is different in many countries and depend on laws and regulation inside of each country. It means EIA studies are about human activities impacts and sustainable development with consideration of policies and decisions (Cai *et al.* 2009). Flexible programming for oil refineries in the plan for decision making procedure supply new methodologies in planning and programming (Lai & Hwang 1993). Total interaction between environmental parameters and oil refinery activities needs the good plan with consideration of risk assessment and decision support system (Sen *et al.* 1999). Environmental assessment for development projects can provide the share of direct project plans (Cashmore *et al.* 2008). Currently many industries laws and regulations structures have concerns about environmental regulations for environmental impacts of projects (Elcock *et al.* 2000). Environmental management system improve environmental efficiency can reduce damages, complete adoption and modify public images (Bevilacqua & Braglia 2002). The knowledge of risk

and its analysis in recent years are assess outcomes of industrial projects, accidents, likely accidents and forecast of the and provide plans to prevent the accident in the many industries (Khan & Abbasi 1999). Strategic plans and economic views of oil refineries are new methodologies for management of failure parameters (Bertolini *et al.* 2009). The major air pollution of oil refineries are hydrocarbons (Kalabokas *et al.* 2001). The EIA process prepares a system for technical and decision making in each part of plans and a good way for decision makers to decide in correct and potentially way (Chaytor 1995). The EIA system was planted in many countries around the world as a major system for environmental problem studying such as China for pollutant control and hold up the pollutants (Chen *et al.* 1999). The objective of this study was approaching a new environmental impact assessment plant in Tehran oil refining facilities.

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

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

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 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 figures 1, 2, are maps, legends and of Tehran oil refinery.

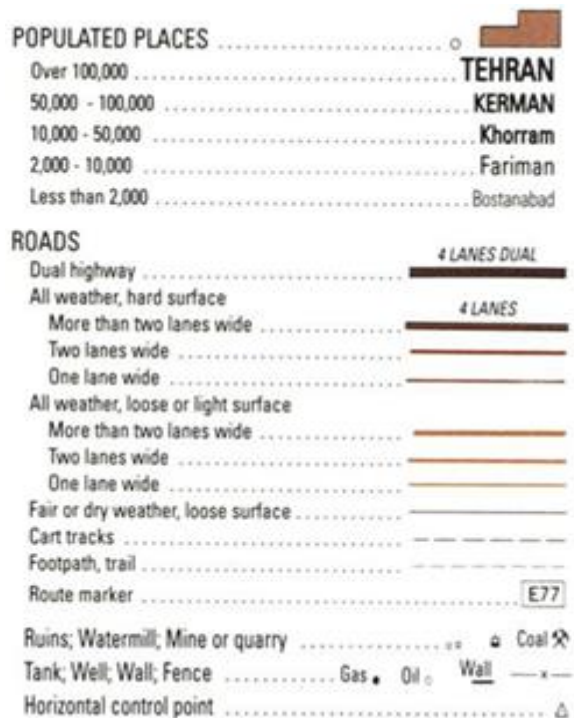**Fig. 1.** Tehran map consisting of Tehran oil refinery.

Fig. 2. Tehran oil refinery map legend.

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.

ERA-GIS (ENVIRONMENTAL)

1. ERA-GIS results for environmental parameter in each phases

2. Environmental pollution maps were provided based on the ERA studies

3. Reaction risks between project activities and environmental items were found completely on prepaid maps

4. Capable ERA Zoning maps were provided for future studies

5. Provided a framework for ERA-EIA, so as to reduce duplication and overlap as well as, confusion and competition between the various parties involved.

ERA-GIS (Economical)

1. ERA-GIS results for economical parameter in each phases

2. Increase investments maps were determined

3. Oil related industries economical developments maps were provided in each part of studies area

4. Value-added goods and services effective points were determined on the maps

5. Costs and economic benefits of oil refineries and zoning maps of them were provided for EIA

6. 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. 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.

2. 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. Oil refinery implementation were occurred social problems, resentment, inequality, gap between social classes, inequality and social facilities were fully investigated for ERA-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.

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

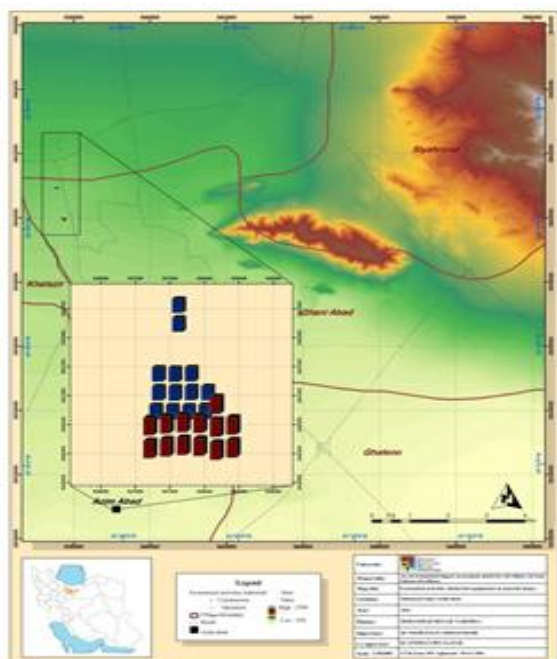| Location	Parameters			
	Economical	Environmental	Land use	Social
Azim abad	36	28	28	36
Bagher city	36	28	28	36
Dorsoun abad	36	28	28	36
Esmaeil abad-e-moein	36	28	28	36
	144	112	112	144
Total maps	512			

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.

Fig. 3. GIS map located points in case of economical studies for Tehran oil refinery.
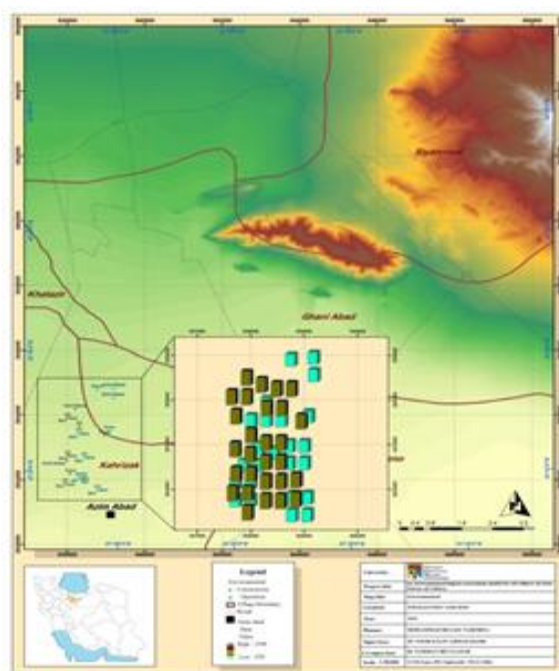
Fig. 4. GIS map located points in case of oil content and So2 pollution for Tehran oil.

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 4 and 5 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 11 and 12 results of the most important factors in land use parameters for Tehran oil refinery. The GIS with complete data can gives the most effective point in case of land use studies for Tehran oil refinery. Figures 4.5 and 4.6 show the oil refineries economical affected points. Figures 16 and 19 are land use zoning in the area of Tehran oil refinery. Table 7 presents Occupancy levels and types of land use area of major land use for Tehran oil refinery

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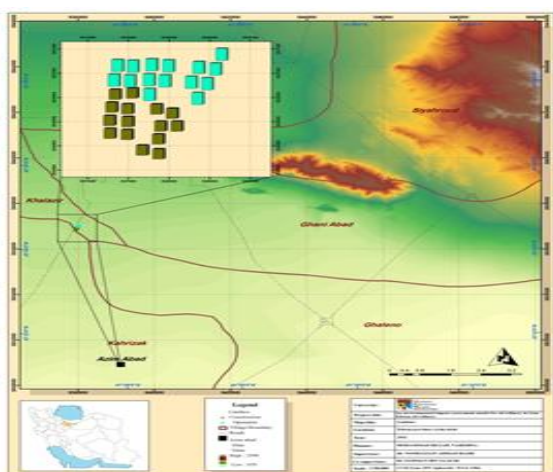
Fig. 5. GIS map located points in case of land use for Tehran oil refinery.
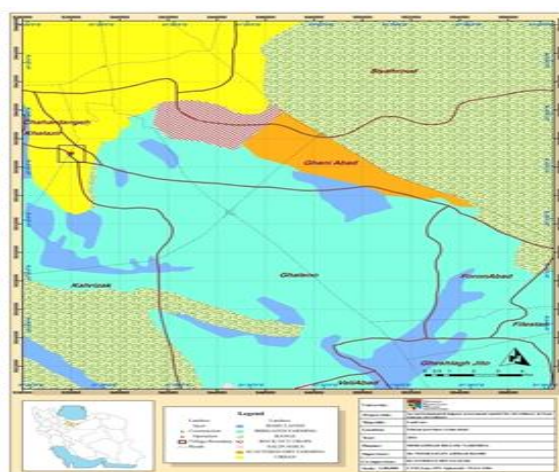

Fig. 6. GIS zoning map in case of land use for Tehran oil refinery.

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 20 and 21 are shows social parameter studies most effective points in case of Tehran oil refinery.
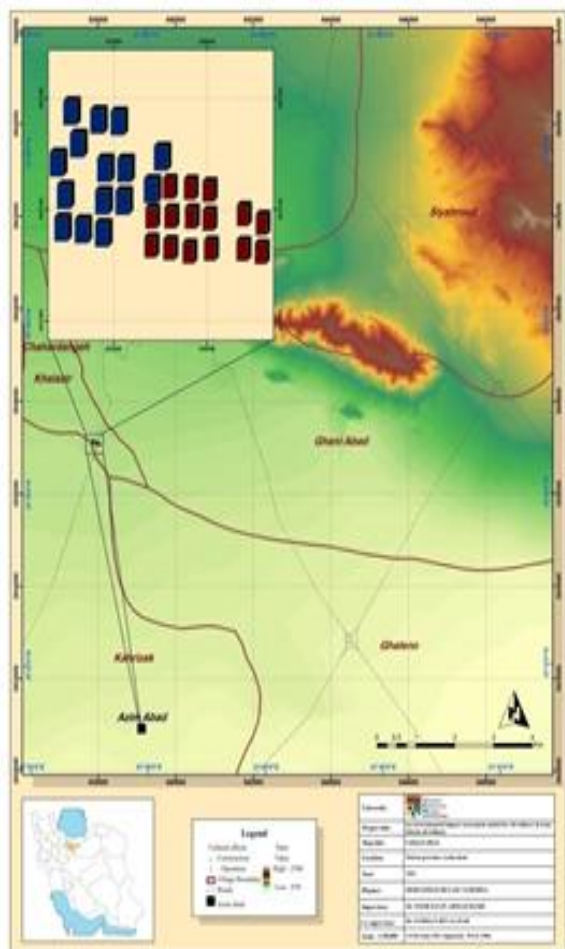
Fig. 7. GIS map located points in case of social studies for Tehran oil refinery.
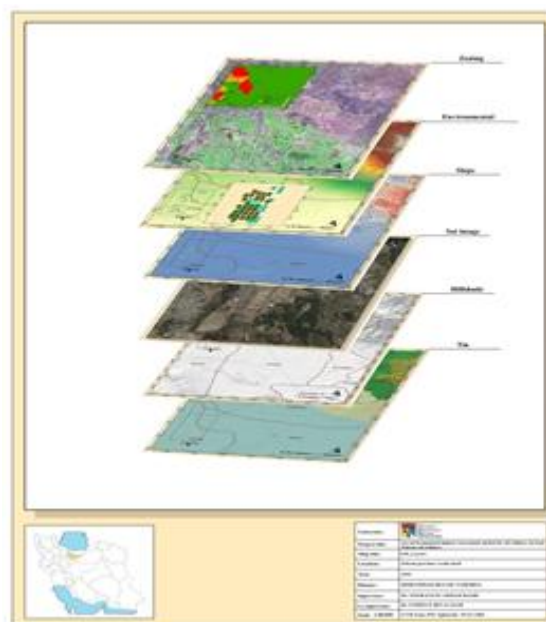
Fig. 8. GIS-EIA map layers of Tehran oil refinery, in year 2012.

Conclusion

Environmental impact assessment management program for Tehran 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 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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