PROCEEDINGS, Thirty-Fourth Workshop on Geothermal Reservoir Engineering
Stanford University, Stanford, California, February 9-11, 2009
SGP-TR-187

ENVIRONMENTAL IMPACT ASSESSMENT OF SABALAN GEOTHERMAL POWER PLANT, NW IRAN

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ABSTRACT

Environmental Impact Assessment (EIA) of Sabalan geothermal power plant project in the northwestern part of Iran using Rapid Impact Assessment Matrix (RIMA) method is presented.

The Sabalan geothermal power plant is planned to produce 50 MW electricity in 2011 in cooperation of the Ministry of Energy (MOE) and Renewable Energy Organization of Iran (SUNA).

In this study, an attempt was made to identify and assess the likely key impacts of geothermal exploration, drilling and operation. Then on the basis of current evaluation suggest monitoring program and mitigation plans. Present state information on the regions environment including physical, biological and social environment was collected during 2000-2003, before starting the proposed project activities.

In the evaluation process, positive and negative environmental impacts of Sabalan geothermal power plant were assessed based on the results of multi-disciplinary team approach and the field survey data using RIMA method.

The results of assessment reveal that the 57% of the impacts are positive and 43% are negative, therefore the implementation of the project with some mitigation plans and monitoring program is accepted.

INTRODUCTION

Geothermal energy is generally accepted as being an environmentally benign energy source, particularly when compared to fossil fuel energy sources. Aside from this consensus of experts, the last 40 years experiences of developments have shown that it is not completely free of environmental adverse effects.

All geothermal fields contain heated fluids or vapors trapped beneath the earth's crust, but depend on the location, geology, depth, pressure, temperature and chemical characteristics of them can vary significantly from field to field. Therefore environmental impacts from geothermal development will vary between the countries, fields and various phases of geothermal energy development.

Although the quality of data analysis for EIA has improved over the years, the judgments made in an EIA are essentially subjective. The author's experiences show that although these subjective conclusions can provide a suitable basis for EIA, the problem lies in recording the transparency of the assessment.

Rapid Impact Assessment Matrix (RIAM) method (Pastakia, 1998) seeks to overcome the problems of recording subjective judgments by defining the criteria and scales against which these judgments are to be made; and by placing the results in a simple matrix that allows for a permanent record of the arguments in the judgment process.

EIA process was implemented for a new 50 MW geothermal power plant which will be built at the NW Sabalan geothermal field in northwestern part of Iran. The location of the project is on the northwestern portion of Sabalan volcano, approximately 16 km SE of Meshkinshahr city, in the province of Ardebil, NW Iran. The study area is Khiav River catchment and comes about 130 km^2. Figure 1 shows the location map and access of the NW Sabalan geothermal field (Yousefi et al, 2008a).

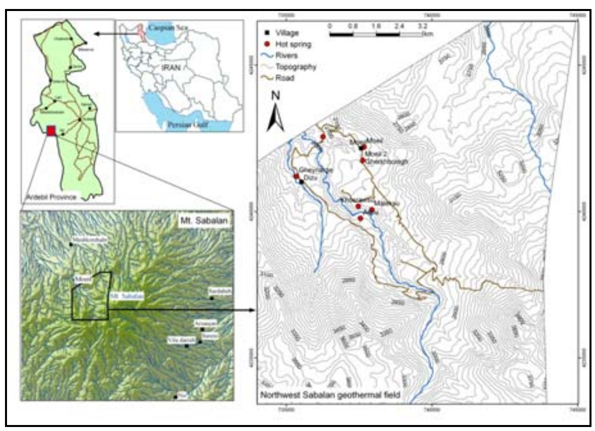

Figure 1. Study area (Noorollahi et al, 2008)

Environmental baseline components of NW Sabalan geothermal field are described briefly and the impacts of 50 MW Geothermal Power Plant (GPP) on the environment are evaluated in this paper.

PROJECT DESCRIPTION

After some initial interest in the nineteen seventies in the development potential of geothermal resources in north of Iran, a series of progressively more detailed investigations have been undertaken into the geothermal potential of the Sabalan area in NW Iran. The work was undertaken in two separate stages since 1998. Stage 1 includes a review of previously collected field data, re-sampling and analysis of surface thermal features, a detailed MT geophysics survey, detailed geological mapping and integrating all geo-scientific data to produce a pre-drilling exploration model. Stage 2 includes a three deep well exploration drilling and testing program.

The wells drilled during 2003/2004 and vary in depth from 2265m to 3197m. Two of the wells were successfully discharged hot fluid with enthalpies in the range of 950 to 1000 kJ/kg. A preliminary resource assessment confirms the presence of a geothermal resource with temperatures within the drilled area up to 250 °C and with at least 5 km^2 of proven commercially exploitable resource and possible expansion over a likely resource area of 19 km^2. A first stage geothermal power development of 50 MW has been committed for commissioning by the end of 2011 according to an engineering feasibility study conducted for assessing possible development options for the field. This will be the first geothermal power development in both Iran and the Middle East. The plan includes drilling more 20 wells (delineation, production, and re-injection) as well as plant construction with allocated total fund of approximately 100 million EURO (Chitchian, 2008).

The field is located between 38° 12' 52" and 38° 20' 00" North, and 47° 40' 30" and 47° 49' 10" East, in the Sabalan area. Elevation ranges between 2200 m at the village of Moeil in the north, and 3700 m in the south, close to the peak of Mt. Sabalan.

LEGAL FRAMEWORK

It is important to know that EIA is a law-based procedure (Yousefi et al, 2007). In Iran; Department of Environment (DOE) is responsible for the protection of the environment and ensuring legitimate and sustainable utilization of natural resources to guarantee sustainable development, pollution control and prevention of the destruction of the environment.

Iran is one of the few countries that have the principle of environmental protection built into its constitution. Article 50 of the constitution of Iran states:

"Environmental conservation in Iran is a public duty. Therefore any economic or other activities which cause environmental pollution or other irreversible damage to the environment are forbidden".

EIA in Iran is enabled by Note 82 of the law for the second economical, social and cultural development plan of the country in 1994. It is implemented through decree 138 dated 12/04/1994, of the Environmental Protection High Council (EPHC).

The enabled law requires that large manufacturing and projects are subjected to EIA process prior to execution. The EPHC determines both the interpretation of a large project and the guideline for the assessment. The EPHC has defined seventeen project types are subjected to EIA, including; power plants, refineries, dams, bridges, airports, freeways, railroads, industrial city, irrigation projects, forestry projects etc. EPHC may also require an EIA for any other large project like geothermal (Yousefi, 2004).

Geothermal energy utilization and its environmental impacts are discussed from the standpoint of sustainable development, including anticipated patterns of future energy use, and subsequent environmental issues in Iran and to avoid of future environmental, social or economical adverse effects or struggle it is highly recommended to apply for an EIA in all geothermal energy developments.

The technical staffs of environmental group of Iran Energy Efficiency Organization (SABA) figured out that the Sabalan areas are very sensitive area for geothermal activities. They suggested a detailed EIA process and report as a Decision Support System.

ENVIRONMENTAL BASELINE DATA

The compilation of environmental baseline data is essential to assess the impact on environment due to the project activities. This part of the study is concerned with describing existing environmental conditions of Sabalan geothermal field.

Physical-Chemical (PC) environment

Geology

Sabalan is a large stratovolcano, consists of an extensive central edifice built on a probable tectonic horst of underlying intrusive and effusive volcanic rocks. Enormous amounts of magma discharge were involved in the formation of a collapse caldera about 12 km in diameter and a depression of about 400 m. The lava flows in Sabalan volcano are mostly trachyandesite and dacites with alternating explosive phases. Exposed at the surface in the Moeil valley are altered Pliocene volcanic, an unaltered Pleistocene trachydacite dome (Ar-Ar dated at 0.9 Ma) and Quaternary terrace deposits (SKM, 1998). These units have been divided into four major stratigraphic units that in order of increasing age are:

- Quaternary alluvium, fan and terrace deposits
- Pleistocene post-caldera trachyandesitic lava flows, domes and lahars

- Pleistocene syn-caldera trachydacitic to trachyandesitic domes, lava flows and lahars
- Pliocene pre-caldera trachyandesitic lavas, tuffs and pyroclastics.

The geology assessment includes the effects of the project on geology, and potential adverse effects of the project that could result from possible geologic hazards, such as seismically-induced, surface ruptures, ground shaking, ground failure, slope stability failure or subsidence. Each of these possible effects and concerns should be evaluated in an EIA.

Land Use

The land in the study area is mainly used to grazing and for growing crops. Where the native vegetation is mostly grass or shrubs, the sheep and cattle are allowed to graze, with consequent damage due to overgrazing. Only about 20% of the land is used for agriculture, the main obstacle being the steepness of the terrain and the lack of water for irrigation.

The crop-growing (agricultural) areas are at low elevations in the northwestern part of the study area where there is access to water from the Khiav River and from cold springs. Due to climatic conditions, agricultural activities are restricted to spring and summer.

Land cultivation is the second economic activity in the area; the main crops are potatoes, onions, tomatoes, carrots, cucumbers and watermelons. Alfalfa (lucerne) and other plants are also grown to feed cattle during the winter.

The development of a geothermal power project that could cover some 160 hectares will reduce the amount of land available for agriculture and grazing, and increase the pressure on endemic plant communities. For the development strategy to be sustainable, land use and degradation will have to be kept to a minimum.

Climate

Basically GPPs release a variety of gaseous to the atmosphere. From an environmental perspective the most important gaseous contaminants are CO_2, H_2S, NH_3, CH_4, Rn, Hg, H_3BO_3 and As.

The experiences of other geothermal power plants show that the principle gases of concern in their surrounded environment are H_2S and CO_2 and other constituents are less likely to have a significant adverse effect on the local environment.

The potential flow rate of these gases depends on the steam chemistry and geothermal power plant technology. The dispersion type of gases and average removal rate depends on the meteorological conditions such as wind directions, wind speed, precipitations, atmospheric stability and surface roughness and topography. Determination of the effects on air quality, the affected area and the area under risk depend on the background concentrations of the gases, national standard and morphology of the ground surface (Yousefi, et al 2008b).

H_2S distribution prediction model was prepared as a essential part of this study to find the impacts on local air quality from the planned 50 MW geothermal power plant in the NW Sabalan geothermal field.

The results show that there is no adverse effect of H_2S concentrations in 98% of the area and only 2% will be impacted close to the wells in site A and C.

The concentrations of H_2S in the under risk areas will be 28-31 ppb and at least once a year the concentration of H_2S will be exceed than national air quality standard (Figure 2) (Yousefi, et al 2008b).

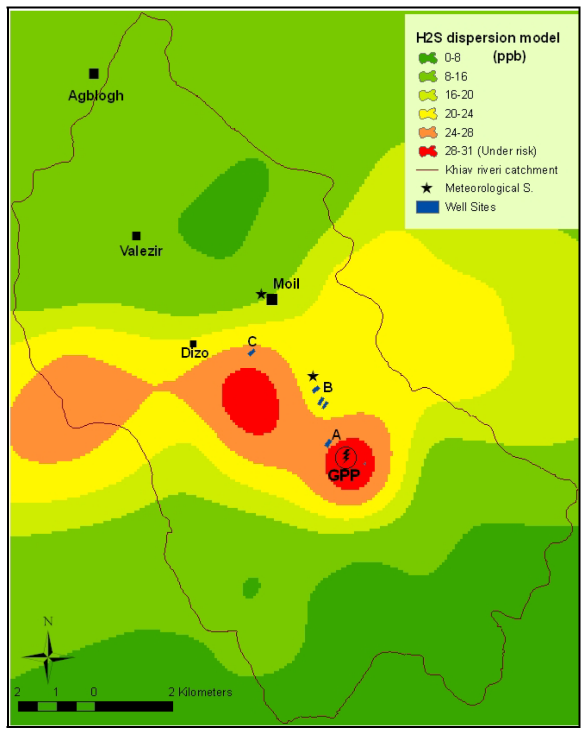

Figure 2. Final prediction dispersion model of H_2S and the area under risk, NW Sabalan

Hot springs

Several hot springs, with temperatures in the 20°-85 °C range, exist in the study area; they discharge mainly from the gravel of the Dizu Formation (one of the main geology formation under the Dizu village includes Quaternary alluvium fans, terrace deposits and thin airfall ash interlayered with thick lahar and debris flows). These springs are divided into two groups according to their water chemistry:

a) Neutral-Cl-SO_4 springs. The Gheynarge, Khosraw-su, Malek-su and Ilando springs discharge neutral-Cl-SO_4 waters with up to 1500 ppm of chlorides, 442 ppm of sulfates, relatively high concentrations of magnesium (up to 24 ppm), and a pH between 6.1 and 6.8. The waters show a simple dilution trend, indicating mixing with varying amounts of shallow groundwater. They also exhibit strong seasonal cyclic variations in flow rate, but very little change in temperature or chemistry (Noorollahi et al, 2008).

b) Acid-SO_4 springs. The Moeil, Moeil 2, Aghsu and Romy springs are acidic, with a pH of 4.3, 3.2, 3.5 and 2.8, respectively. The Moeil 2 and Aghsu springs produce typical acid-SO_4 waters formed by condensation and oxidation of H_2S, implying boiling at depth.

Water quality

Khiav River is basically a spring and snow based river and it starts from a high elevation (3600 m a.s.l) in Mt. Sabalan. The river is about 50 km long and after passing through Meshkinshahr city and several villages; it finally joins the Aras major river at the boundary of Iran and Azerbaijan and discharges into the Caspian Sea. The river water is not only used as potable water for Meshkinshahr city but also during the spring and summer seasons conveyed into several canals to use in agriculture and horticulture.

The Sabalan geothermal project is close to the source area of the river at a higher elevation than the river basin. It is located between the two main branches. The area is harsh mountainous land and the average elevation difference between the three well sites in the Moeil plain and the river base in the Geynarjeh valley is about 300 m (Yousefi, 2004).

To determine the chemical characteristics of river water and spring discharges before any development the monitoring program was planed and done during the years 2002 to 2004 in 22 locations of river and 19 major hot and cold springs in different seasons. The results of analysis and monitoring reported to the Ministry of Energy for future studies or assessment.

Based on the altitude of the drinking water station which is located in the lower part of Khiav River it is expected that the pollution from drilling activities, surface runoffs or ground water discharges can enter in the potable water. Therefore daily monitoring program has been done in this station.

Surface water run-off on any developed areas will have to be carefully controlled to prevent gully erosion problems. This may well be best achieved by lined open channels and for particularly high flows or steep slopes, in-line structures to dissipate energy.

Whilst the geology and relatively high natural permeability would favor soakage pits these should be designed and located with care due to the susceptibility of the local soils to piping and internal erosion /cavitations problems.

The phreatic surface to natural groundwater under the gently sloping terraces of the Dizu Formation will be well below the depth of influence of any foundations or earthworks for the power plant and steam field development. However, within the Dizu Formation there will be layers, beds or material zones with highly variable permeability and there will inevitably be associated perched water tables.

Hydrological studies show that the ground water flow in the study area is with the slop from southeast to west and northwest and these waters finally are discharged into the river in base of several cold and hot springs (Noorollahi and Yousefi, 2005).

To guard against fluids leaking into shallow fresh-water aquifers, well casings are designed with multiple strings to provide redundant barriers between the inside of the well and the adjacent formation. Nevertheless, it is important to monitor wells during drilling and subsequent operation, so that any leakage through casing failures can be rapidly detected and managed.

Noise

Utilization of geothermal resources for energy developments such as electricity generation have the propensity to produce significant levels of unwanted sound in the local environment. Depending upon where this noise is received, its level, character and duration, this noise can be a significant environmental effect. Therefore, it is important to evaluate the potential environmental noise effects prior to development of any geothermal field as a part of EIA process.

The potential for disturbing noise levels depends on the intensity relative to existing noise levels. Thus, to undertake an impact assessment, it is necessary to determine the existing noise environment in the absence of noise from the project. In addition, it is necessary to obtain information about the noise level from the project during its various phases. Also, data on background noise levels are important from the noise impact assessment point of view, because it is the difference between the background noises and the project-related noise that disturbs the public.

Environmental noise impact assessment of Sabalan geothermal power plant was done and presented in the Renewable Energy conference 2008 in Busan, Korea (Yousefi et al, 2008c). The results of the assessment shows that noise emissions are expected to be of moderate intensity during the development and operation of geothermal facilities in the Sabalan area. There is no difficulty in meeting the standard of 65 dBA at 0.8 km from the sources. In fact the predicted noise levels are well below than standard. Thus, the noise impact of power plant operations and well drilling will not significant. However, because of the low ambient noise levels, geothermal noise might be audible at distances of below 3.2 km and there is no area under the risk of noise (Figure 3).

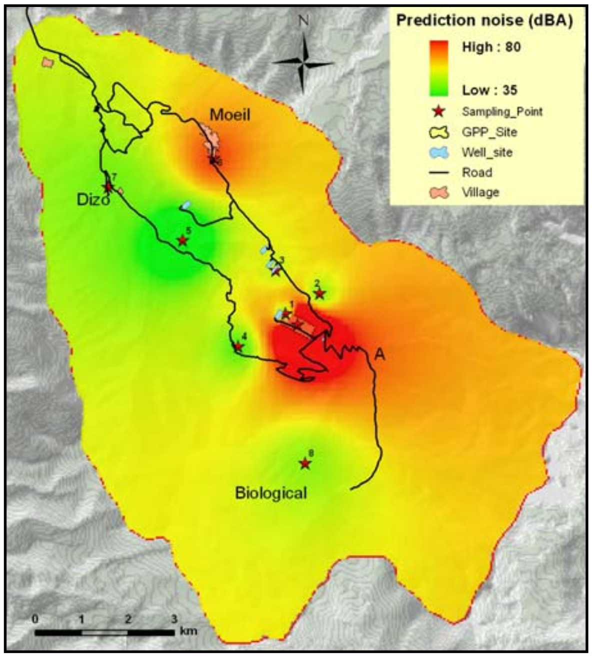

Figure3. Distribution model of noise prediction level

Biological-Ecological (BE)

- Flora and vegetations

The study area, with a mean annual precipitation of 300-450 mm, is mostly covered by steppe flora. The vegetation density is low at high and low elevations, and high at moderate elevations. Different grasses were very common in the past but have been greatly reduced by human activities, particularly by overgrazing. *Artemisia herba-alba* is the predominant shrub and *Aristida plumosa* is the predominant grass in most places.

According to botanical surveys, there are 369 plant species in the study area. About 110 species are used for animal feed, 12 for human use and 15 have chemical and industrial value (Yousefi, 2004).

The vegetation map of the study area was prepared in spring 2004. It shows that whole area is covered by vegetation. The cover density is 15% at elevation above 3200 m, 45% coverage at 2400 m to 3200 m and 30% coverage for elevation below 2400 m.

Animal husbandry is the occupation of the most residents in the Sabalan area and protection of vegetation is very important task for the developers.

Fauna

The fauna is a part of a land's yield and depends on its potential and its fluctuation. If it is not utilized in harmony with this potential, the result may be disastrous for a nation's wildlife. Therefore Sabalan region is very rich in fauna. The mountain feet offer an excellent habitat for natural pastures. This region has remarkably diverse wildlife such as the wild goat, brown bear, fox, deer, wolf, partridge, rabbit, and many different species of birds and mammals. On the other hand Sabalan is originally a wildlife habitat.

Hope the Sabalan geothermal project will not affect the wildlife species especially their habitats and biodiversity. The developer should be carefully monitoring the number of some species like *Phasianus*, *Mergus albelus* and *Aaudial chrysaetos* which are endangered (Noorollahi & Yousefi, 2003).

Sociological-Cultural (SC) environment

Relationship between geothermal activities and social life in the area was investigated. There are three villages located in the study area. Valezir in the northern part comprises 50 families and plant cultivation is the dominant occupation of its inhabitant. Dizo in the northwestern part with 30 families where main occupation is sheep keeping. Moeil is the largest village in the southeastern part of the area with more than 400 families and their occupation is sheep keeping and cultivation.

The project would require both short and long-term employment; some of them could be accommodated by the resident population without the need to import employees, and some should import especially in the case of professionals and high educated and it would be a beneficial impact of the project.

Settlements of educated people and communication with the native residents will bring the positive impacts in the terms of culture, education, archeology, science, recreation and migration.

Economic-Operational (EO) environment

Job

The main occupations of the inhabitants are trading, farming, fish farming and ranching. There are no industrial activities in the area. For several decades this region has suffered from brain drain especially in the case of educated people. After starting the geothermal project activities many new jobs opportunity were opened and in some cases the people can have two jobs at the same time. The developer estimated after operation of GPP around 200 people will get the job in all over the field.

Access road

Transportation of a drill rig, construction of buildings and installation of the GPP and all the accessories and equipments entails the construction of access roads in the area like Sabalan. 16 km paved road connected the field to the nearest city, Meshkinshahr.

After starting the project activities the construction of a 10 km access road in the project site was already done and made the transportation easier for the residents, nomadic tribe, mountain climbers and man power of the geothermal project.

Tourism

The inactive volcano of Mt. Sabalan, which has a peak 4,811 m high, stands southeast of the geothermal field. There is a beautiful lake within its conical crater whose contents are ice and snow. Ice pillars around this lake are a great source of attraction. Sabalan region is very rich in flora and fauna. The mountain feet offer an excellent habitat for natural flowers including the lily, wallflower, buttercup, red rose, etc. This region has remarkably diverse wildlife such as the wild goat, brown bear, fox, deer, wolf, partridge, and many different species of birds, fishes, mammals and etc. The beautiful waterfall of Goorgoor lies on the northern side of the mountain, at its foot.

The marshes of Molla Ahmad and Houshang Meydani have given this region a great deal of attraction. There are numerous preserved areas. A large number of lakes, natural marshes, mineral water springs, impressive mountains, preservations, divers plants and wildlife, and finally its desirable honey make Sabalan one of the most attractive mountain regions of Iran and perhaps Asia.

Opening up the area by way of new roads for a project would change conditions drastically and might bring in a greatly increased number of tourists.

Hopefully the presence of geothermal power plant development produces a new tourist attraction in the Sabalan area and for this reason the natural recovery is extremely important over the vegetation and over the fauna to achieve the positive impacts.

IMPACT ASSESSMENT

This method seeks to overcome the problems of recording subjective judgments by defining the criteria and scales against which these judgments are to be made; and by placing the results in a simple matrix that allows for a permanent record of the arguments in the judgment process (Pastakia, 1998).

The Rapid Impact Assessment Matrix (RIAM) method is based on a standard definition of the important assessment criteria, as well as the means by which semi-quantitative values for each of these criteria can be collected to provide an accurate and independent score for each condition.

The impact of project activities is evaluated against the environmental components; and for each component a score is determined, which provides a measure of the impact expected from the component (Pastakia, 1998).

The important assessment criteria fall into two groups:

- ***Group A***: Criteria that are of importance to the condition, and which can individually change the score obtained
- ***Group B***: Criteria that are of value to the situation, but should not be individually capable of changing the score obtained

The value allotted to each of these groups of criteria is determined by the use of a series of simple formulae. These formulae allow the scores for the individual components to be determined on a definite basis. The process can be expressed (Pastakia, 1998):

If $(a1) * (a2) = aT$ and $(b1) + (b2) + (b3) = bT$

Then $$\mathbf{(aT) * (bT) = ES} \quad (1)$$

Where

- (a1) and (a2) are the individual criteria scores for group (A)
- (b1) to (b3) are the individual criteria scores for group (B)
- aT is the result of multiplication of all (A) scores
- bT is the result of summation of all (B) scores
- ES is the Environmental Score for the condition.

Environmental components

The RIAM requires a specific evaluation of the components to be defined through the process of scoping, as the attempt was made in this paper these environmental components will be in one of four categories that are described as follows:

- ***Physical-Chemical (PC)***: Covering all physical-chemical aspects of the environment.
- ***Biological-***Ecological ***(BE)***: Covering all biological and ecological environmental aspects.
- ***Sociological-***Cultural ***(SC)***: Covering all human and cultural aspects of the environment.
- ***Economical-Operational (EO)***: Qualitatively identifying of the economic consequences of the environmental changes, both temporary and permanent impacts.

Assessment criteria

The criteria should be defined for both groups, and should be based on fundamental conditions that may be affected by change rather than be related to individual projects (Table 1). It is theoretically possible to define a number of criteria, but two principles should always be satisfied: the universality of the criterion, to allow it to be used in different EIAs and the value of the criterion, which determines whether it should be treated as a Group (A) or Group (B) condition (Pastakia, 1998).

The method of the RIAM makes it possible to carry out a global analysis of the results based on the individual environmental scores (ES) for each component, which are classified in ranges and so can be compared to each other. Table 2 provides the established ranges for the conversion of those obtained and Table 3 shows the assessment process.

Table 1. Assessment criteria for RIAM

Group	Category	Scale	Description
A	A1 Importance of condition	4	International importance
		3	National importance
		2	Outside of local condition
		1	Local condition
		0	Not Important
	A2 Magnitude of change-effect	+3	Major positive benefit
		+2	Significant improvement
		+1	Improvement in “status quo”
		0	No change / “status quo”
		-1	Negative change to “status quo”
		-2	Significant negative effect
		-3	Major negative effect
B	B1 Permanence	1	No change / not applicable
		2	Temporary
		3	Permanent
	B2 Reversibility	1	No change / not applicable
		2	Reversible
		3	Irreversible
	B3 Cumulative	1	No change / not applicable
		2	Non – cumulative /single
		3	Cumulative / synergistic

• The lower limits of ‘significant change’ can be taken as the point when a condition is outside local boundaries (A1=2) but is of major importance (A2=3), yet is temporary (B1=2), reversible (B2=2) and non-cumulative (B3=2) and it is (ES=36).

• A ‘major change’ will occur at a point when the condition extends to a regional/national boundary (A1=3) and is of major importance (A2=3). Such a change would also be permanent (B1=3), irreversible (B2=3), though it could be non-cumulative (B3=2) and it is [(3*3)*(3+3+2) = 36].

Once the ES score is set into a range band, these can be shown individually or grouped according to component type and presented in whatever graphical or numeric form that the presentation requires.

Table2. Range bands used for RIAM (Pastakia, 1998)

Environmental score (ES)	Range value (Alphabetic) (RV)	Range value (Numeric) (RVN)	Description
72 to 108	E	5	major positive change
36 to 71	D	4	significant positive change
19 to 35	C	3	moderate positive change
10 to 18	B	2	positive change
1 to 9	A	1	slight positive change
0	N	0	No change / status quo
-1 to – 9	-A	-1	slight negative change
-10 to -18	-B	-2	negative change
-19 to -35	-C	-3	moderate negative change
-36 to -71	-D	-4	significant negative change
-72 to -108	-E	-5	major negative change

Assessment process

Before starting assessment process the type of geothermal system should be taken in account. Based on the first thermodynamic law and accepted theory in the geothermal fields, the magnitude of impacts in high-temperature (>150°C) systems are more than Low-temperature (< 150 °C) systems.

Table 3. Description of components and the impact categories in the Sabalan geothermal field

Physical and chemical components (PC)		A1	A2	B1	B2	B3	ES	RV
PC1	Air quality	2	-1	2	2	2	-12	-B
PC2	Noise	1	-2	3	2	1	-12	-B
PC3	Groundwater	1	-2	3	2	2	-14	-B
PC4	Surface water	1	-2	2	2	2	-12	-B
PC5	Land use	2	-1	2	2	1	-10	-B
PC6	Subsidence	1	-1	3	3	1	-7	-A
PC7	Visual impacts	1	1	1	1	1	3	A
PC8	Soil pollution	3	-1	3	2	1	-18	-B
Biological and ecological components (BE)								
BE1	Fauna	2	-1	3	2	1	-12	-B
BE2	Flora	2	-1	3	2	1	-12	-B
BE3	Vegetation	2	-2	2	2	1	-20	-C
BE4	Habitat lose	1	-1	1	1	1	-3	-A
Sociological and cultural components (SC)								
SC1	Culture	2	1	3	2	2	14	B
SC2	Education	2	2	3	2	2	28	D
SC3	Archeology	1	1	1	1	1	3	A
SC4	Science	3	2	3	2	2	35	D
SC5	Recreations	2	-1	1	1	1	-6	-A
SC6	Migration	2	2	3	1	1	20	C
Economical & operational components(EO)								
EO1	Jobs	3	3	3	1	1	45	D
EO2	Access road	2	3	3	1	1	30	C
EO3	Public services	3	3	3	2	1	54	D
EO4	Tourism	3	3	3	2	1	54	D
EO5	Land prices	1	3	3	2	1	18	B
EO6	Agriculture	3	-1	2	2	1	-15	-B
EO7	Transportation	3	2	3	2	1	36	D

Assessment results

The results of the assessment process for the Sabalan geothermal power plant are presented in Tables 3 and summarized in Table 4.

Table 4. Summary of assessment

ES	RV	RVN	PC	BE	SC	EO	Total	Final	%
72 to 108	E	5	0	0	0	0	0	0	0
36 to 71	D	4	0	0	1	4	5	20	33
19 to 35	C	3	0	0	2	1	3	9	15
10 to 18	B	2	0	0	1	1	2	4	6
1 to 9	A	1	1	0	1	0	2	2	3
0	N	0	0	0	0	0	0	0	0
-1 to – 9	-A	-1	1	1	1	0	5	-5	8
-10 to -18	-B	-2	6	2	0	1	9	-18	30
-19 to -35	-C	-3	0	1	0	0	1	-3	5
-36 to -71	-D	-4	0	0	0	0	0	0	0
-72 to -108	-E	-5	0	0	0	0	0	0	0

As it is reveal from the table most impacts are of class (–B), and there is a majority of positive impacts and No major negative impact has been identified by RIAM. These results are illustrated in Figure 4 and summarized in Figure 5 as a result of the study.

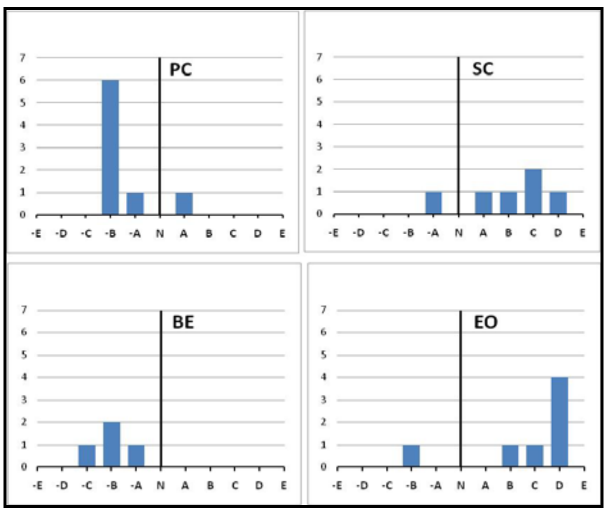

Figure 4. Comparison of positive and negative impacts in and between the categories

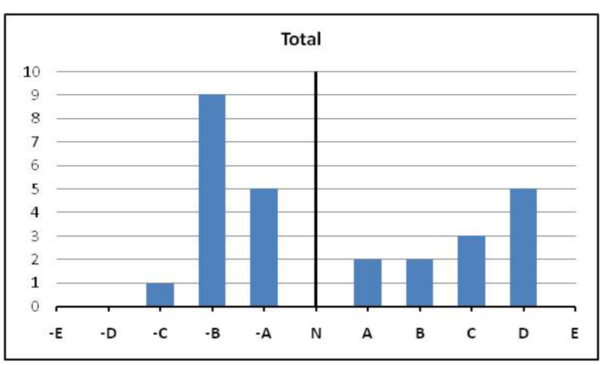

Figure 5. Comparison of total number of positive and negative impacts in the categories

From the final data in Table 4 and Figure 5 which shows the number of positive and negative impacts in the area, figure 6 can be provided.

Figure 6 as final results of assessment by using RIMA method shows around 57% of impacts from the implementation of the geothermal power plant project activities are positive and 43% are negative.

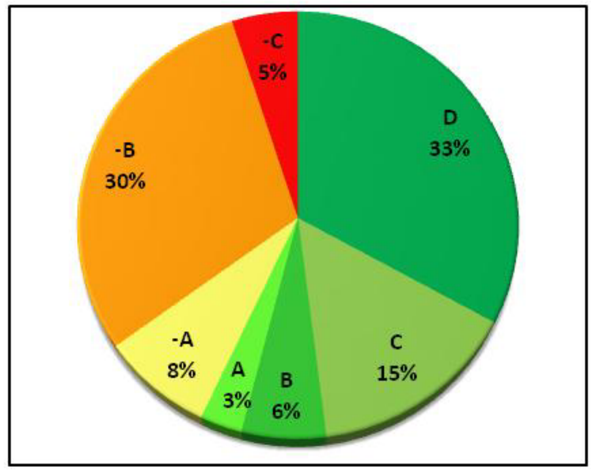

Figure 6. Final results of EIA of Sabalan GPP

ENVIRONMENTAL MITIGATION PLANS

The review of other EIA reports suggest that no one approach will meet all needs for environmental mitigating, at their project, mission or national level.

All the environmental mitigation plans in Sabalan area can be summarized as follows:

All construction sites must have sediment control or retention plans, non-storm water runoff and all construction-related materials, wastes, spills, or residues from the project site should neither be discharged by wind nor runoff into Khiav River, adjacent drainage facilities or property.

ENVIRONMENTAL MONITORING & AUDIT

An environmental monitoring and audit (EM&A) program will be implemented for the project, to check effectiveness of the recommended mitigation measures and compliance with relevant statutory criteria. There are some important environmental components which should be monitored in Sabalan area to avoid future socio-economical problems:

- Chemical analysis of Khiav River water
- Chemical analysis and flow rate of hot springs
- Air pollution parameters especially H_2S
- Noise in 800 m from the sources
- Take care of biological area in the south of the field
- Earthquake, land slide and erosion

CONCLUSIONS

Potential environmental positive and negative impacts of 50 MW Sabalan geothermal power plant project was identified and evaluated by using Rapid Impact Assessment Matrix method.

Final results of the study predicted that with the implementation of the recommended environmental mitigation plans and monitoring program during exploration, drillings, construction and operational phases, the Project would comply with Iranian Department of Environment's (DOE) criteria.

This EIA has also demonstrated the acceptability of residual impacts from the geothermal project and the protection of the population and environmentally sensitive biological resources. An EM&A mechanism have been recommended for implementation to check environmental compliance.

Considering around 57% positive and 43% negative impacts from future geothermal power plant development in the Sabalan area the final results of environmental impact assessment process voted for implementation of the project in the field.

Developer should also apply for an Environmental Management Program including monitoring and mitigation plans.

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