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An Integrated Baseline Geodatabase for Facilitating the Environmental Impact Assessment Process: Case Study of Sabalan Geothermal Project, Iran

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A B S T R A C T

Baseline data represent one of the important stages of Environmental Impact Assessment (EIA) procedure that describes the existing environment of the study area and surrounding areas in enough detail to allow the environmental impacts of the proposed area to be accurately and adequately assessed, and future changes and effects can be measured. Baseline data may be inaccurate, difficult to obtain or non-existent in Iran as a developing country, and it involves huge and diverse environmental data of a spatial nature in the EIA process. Therefore, a useful and effective geographic information system (GIS) approach is developed to integrate geodatabase by acquiring and handling environmental data from different sources related to the proposed project area for the EIA procedure. Based on this approach, a comprehensive geodatabase for baseline data of EIA procedure, called Baseline Geodatabase (BGDB), is designed. The BGDB includes feature datasets (projects, climatology and air quality, hydrology, pedology, general location map of the study area, geology, noise, biology, and socio-economic-cultural data) and tables (fauna). For example, the BGDB for Sabalan geothermal project area, Iran as a case study is developed. This paper provides a practical tool to facilitate the EIA process, environmentally sustainable management, and to support decision-making for environmental specialists and managers in the present and future of the proposed project area.

1. INTRODUCTION

Geothermal energy is known to be of great importance for clean air and environmentally-friendly energy sources. Geothermal energy can be used for different applications divided into two main groups of application: (a) power generation [1] and (b) direct use such as district heating [2], agricultural use [3,4], swimming pools, desalination [5,6], etc.

The aim of EIA as a legal requirement is to analyze, inspect, and evaluate the scheduled activities for minimizing the negative impacts and maximizing the positive impacts of the planned project on the adjacent environment and to ensure environmentally sound development [7–9].

Collecting and managing baseline data is one of the important phases of the EIA process [10]. The term "Baseline" refers to the collection of background information on the physical, chemical, biophysical, ecological, biological, social, economic, and cultural settings of the proposed project area [11]. The duty of collecting baseline data starts right from the beginning period of a project; however, the major portion of this duty may be undertaken during the scoping and actual EIA process [11].

The two main purposes for collecting baseline information include: (a) providing required information to clearly describe the current and on-going status and trends of environmental factors and agents such as air, water, and soil pollutant concentrations of the proposed project against which predicted changes and effects can be compared and evaluated in terms of significance, and (b) providing a means of detecting real changes and effects by monitoring the project from the initial stage; hence, collected baseline data can facilitate the prediction of impacts [11,12]. On the one hand, there are many difficulties for developing countries to prepare the EIA report. One of the main difficulties is collecting and managing baseline social, economic, and environmental data, because these data are of low accuracy, difficult to obtain, or non-existent. On the other hand, the nature of most environmental features is location-dependent (spatial) [10]; thus, for solving the above problems and understanding and manipulating these attributes, appropriate database management system is required to have three important activities: (a) production and gathering of appropriate data, (b) organizing and storing them in databases, and (c) facilitating access to databases to be done [13]. Hence, [14] proposed that by applying GIS, there is an effective, applied, valuable and economic way of storing and presenting required data to undertake EIA. GIS is a useful data-managing tool for managing geographical resources and conducting spatial analysis based on the powerful databases that manipulate the ability to find more and more applications in the fields of EIA process [15]. Therefore, a GIS-based geodatabase is a computer-aided tool that can handle and employ a variety of information, including social, geographic, political, environmental, and demographic information. GIS system not only produces and effectively shows maps, but also can record and analyze descriptive attributes of map features. In addition, the GIS database can help decision-making on spatial planning and emergency planning [16,17].

Ghani et al., [18] demonstrated that a reliable and adequate database system requires to be established to support the subsequent phases of an EIA study. They developed the Expert Database System for EIA (EDEIA) by using FoxPro and CLIPS (C, Language Integrated Production System)

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programs to assist EIA specialists and companies in developing efficient reports. This wide database consists of all information about the description of the existing environment in a specified domain.

Agrawal and Dikshit [10] mentioned that highway construction or expansion is the major source of damage to the environment, and expressed that EIA is a systematic, well documented, and multi-disciplinary procedure that helps to reduce environmental degradation caused by developmental activities. A suitable database was required, because of the involvement of huge environmental data of location-based nature in every stage of the EIA process. Therefore, they applied GIS. Because it can be a potential utility in all EIA stages and provide all desirable requirements and transparency to decide over the possible alternatives; in addition, it can help in many ways to prepare an environmental audit of the same project in later stages.

Say et al. [19] showed that knowledge-based computer-aided systems as skilled systems were applied to regional and local EIAs, environmental planning (EP), and environmental management (EM) since the 1980s. These planning systems achieved problem-solving-based database based on expert knowledge. They applied a software package named Ç-EDINFO, which can be used for EIA practices at energy-generating stations. It is designed based on legal EIA processes in Turkey and developed using the Visual Basic platform.

Zhao and Li [20] developed a spatial support system for EIA of rehabilitation of FuXin coal mine dump, enabling the manager to use quantitative and qualitative criteria to visualize the future conditions. Therefore, GIS as a software product of Titan tools in China that was powerful and user-friendly is used as the main part of the system for storing, obtaining, checking, sorting, and manipulating data that are spatially referenced. In this paper, a georeferenced database was developed in association with elevation data, areas of ecological interest, soil nutrient, land use and plan.

Stevens and Collins [21] referred to a Coastal Assessment and Restoration research work that investigated the coastal developments and natural resources management of the Northern agricultural region to recognize and assess the threats and risks of coastal strip and shoreline using many creations. They introduced GIS datasets as a key source of reference data and information that can be accessed by stakeholders and provided baseline data for coastal managers on the current status of the coastline. These data represent a dynamic and updateable system for future coastal planners and managers.

Khalil et al. [22] illustrated that the efficient management of environmental issues in abandoned and obsolete mines always requires a large amount of data in various fields. The GIS-based environmental geodatabase (EDB) was elaborated from Kettara abandoned Pyrrhotite mine site. This geodatabase includes information related to geology, geochemistry, hydrology, hydrochemistry, land use, and weather. They presented that EDB could be integrated to overcome available difficulties in incorporating many spatially related factors implicated in environmental studies for supporting decision-makers for understanding and predicting the effect of mine pollution on the surrounding ecosystem.

Msangi and Liwa [23] concentrated on designing and applying a GIS-based DSS tool to guide EIA procedures by offering approved and suitable sites for a sewerage pond system in Tanzania. They constructed the geospatial database known as the Shinyanga Municipal Environmental Management Information System-SMEIMS, which enhances and boosts the capacity of data handling, management, analysis, and publication of the urban environmental information and serves as the core for effective and efficient urban managing and planning. The non-spatial factor of the geodatabase contains six interactive tables.

Kordi et al. [17] constructed a special database for Kimberley reefs in Northwest Australia. In this study, a variety of sources were used to promote and maximize data extraction and interpretation. Reefs, coastline, islands, geomorphological zones, habitats and substrates, and other studies and work were derived as a result of this study from designed datasets. Based on an accurately defined approach, they demonstrated ReefKIM as a comprehensive geodatabase to collate and integrate all related information to the Kimberley reefs database.

Although the above investigations demonstrated that EIA surveys and other environmental sciences depend highly on the accessibility of high quality multidisciplinary and huge environmental data, database application also illustrates the importance of using baseline information and creating a database for these types of studies. However, with respect to these studies, there is an existing gap regarding the creation of an appropriate database for baseline information based on GIS in EIA processes for the proposed projects in Iran, not to mention that there is no relevant publication.

The general goal of this study is to facilitate the EIA process and report preparation, improve environmental management, and support decision-making and emergency planning. The specific aims of this study are: (a) accessing to accurate and adequate data; (b) improving the assessment of significant impact of the proposed project on surrounding area by considering clear spatial distribution of features that are often ignored or hidden in the overall decision-making process; (c) preventing data repetition, decreasing errors, and saving the time and expense; (d) providing a key source of reference information and data that can be accessed and used for present and future environmental management and planning; (e) providing a regional figure of the study area of the proposed project site, types, and status for the present and future.

2. ADMINISTRATIVE LEGAL AND FRAMEWORK FOR IRAN'S EIA

In 1969, the first EIA system was formulated legally in the USA and, then, introduced to the law makers of other countries and national and international organizations [24].

In the Islamic Republic of Iran's Constitution, the principle of Environmental Protection is emphasized. Article 50 of Iran's Constitution states: “Environmental conservation in the Islamic Republic of Iran is a public duty. Therefore, any economic or other activities and processes that cause damaging environmental impacts or other irretrievable and unalterable damages to the environment are forbidden” [25].

The Iranian Department of Environment (DoE) is a governmental organization that responds to the issues of protection and safeguarding of the environment and is responsible for maintaining protected lands, certifying legitimate and sustainable use of national resources to ensure sustainable development manner, controlling and tracking down pollution sources, restricting the damage of the environment, and the conserving and maintaining national biodiversity.

Any industrial construction and exploitation of the nature of natural resources in the country need DoE's permission according to the size and type of project and the natural situation of the area. Nowadays, Iran is involved with serious environmental concerns such as water, air, soil pollution, loss of biodiversity, soil pollution and erosion, and drought and drying of the aquatic environments. The main reason for these problems mostly lies in extensive population growth, expanded industrialization, rapid urbanization, high per capita energy consumption, and risky use of rangelands and forests.

3. LEGAL PROVISIONS FOR EIA

Since 1994, the EIA law has been in force in Iran, and it was updated in 1997 [26]. Detailed requirements of EIA law process were defined by the Code of Practice dated 23/12/1997, issued by the Iranian Environmental Protection High Council (EPHC). It also was the amended clause (A) of Article 192 of the Law for the 5th State Economic, Social and Cultural Development Plan of 2011. This law requires the EIA report to be done prior to large-sized manufacturing and service projects. The EPHC has specified 8 plans and 51 projects as subject to EIA, 8 plans in clause (A) of article 192 including Roads and railways, power plants, oil, and gas and petrochemical industries, gas and oil pipelines, industrial and mining, hydraulic structures, services, and agriculture plans. Each of these plans is composed of several projects.

The worthy body for authorizing EIA reports is defined by the EIA law. If the proposed project falls within the predefined projects' categories and is higher than the defined threshold of the category specified by EPHC, the property developer is asked to conduct an EIA report. The DoE has issued a comprehensive guideline for preparing a preliminary impact assessment report for given projects.

Preliminary EIA reports have to be submitted to the local (provincial) DoE office. After gaining approval by local office, it passes to the national EIA organization in Tehran for review. The report can be approved without further evaluation, or the Department of Environment requires further consideration of sensitive and significant issues. The report can be rejected, approved, or accepted with recommended conditions. The EIA reports can be prepared by individual experts and professional companies whose credentials are approved by the legal authorities; then, a primary list will be published when qualified practitioners are called upon (Fig. 1).

4. METHODOLOGY

4.1. Data sources

The information related to baseline data composed of physicochemical, biological, socio-economic, cultural, and environmental data setting the proposed projects area was acquired from various sources. Therefore, the data were obtained by satellite images, Digital Terrain Model (DTM), aerial photos, Digital Elevation Model (DEM), different maps and field data covering the entire study area and other related data that were extracted from many sources such as reports, survey plans, government notes, publications, atlases, books, maps, and encyclopaedias [17,23].

4.2. Baseline geodatabase design

Environmental studies strongly depend on the accessibility of high quality and quantity multidisciplinary data [22]. Due to the baseline data, the stage of EIA procedure involves huge environmental data of spatial nature; therefore, an appropriate spatial geodatabase management system is required [10]. ArcGIS software was used to develop the database due to its high performance, desirable management of data, and wide recognition [17]. The geodatabase is the favorable data structure for ArcMap and is a suitable data format for editing and data management [22,27].

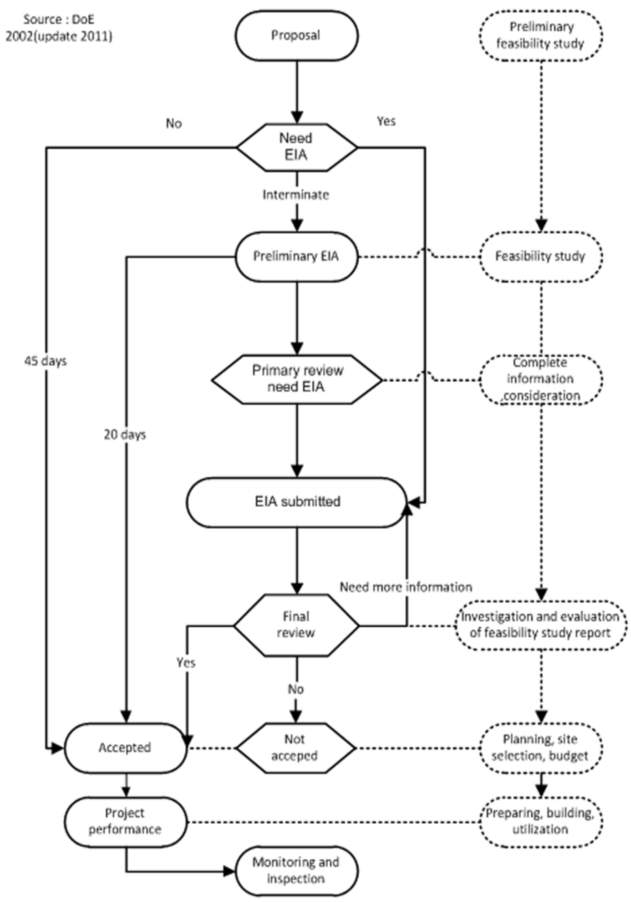


Figure 1. EIA frameworks in Iran [32].

A geodatabase can use a variety of data and information; however, constructing a useful database requires a considerable and significant amount of time series data with different types distributed through both time and space. The geodatabase is based on baseline data, known as the Baseline Geodatabase (-BGDB). In this method, the geodatabase is manually produced using the ArcCatalog package in a personal geodatabase format [28]. Personal geodatabases use the access data structure and are designed for a single user [27,29,30] (Fig. 2).

The geodatabase consists of spatial and non-spatial objects. The spatial objects contain location-based information and are implemented as feature classes. A feature class can stand alone or be a part of a large feature dataset [29]. Often, tables contain descriptive information about geographic features and are connected to an object in a feature class using relationship classes. For regulating the relationship of the feature classes, there are many rules used to group the features into a feature dataset [31].

The BGDB contained nine feature datasets (projects, weather, air quality, hydrology, pedology, general location map of the study area, geology, noise, biology, and socio-economic-cultural) and a table (fauna) where the environmental data will be stored. Selection and classification of the feature datasets and feature classes are based on the main components of the study area environment according to the needs of preliminary assessment reports (see Table 1 and Fig. 3).

4.3. Data integration and processing for baseline geodatabase

The GIS allows digitizing and georeferencing non-digital data to be integrated with digital ones of the proposed project area. Integration facilitates data validation, changes detection, and data updating as well as its application to combine multiple data sources for the same purpose or feature to extract information or may add value to the EIA process [33]. As a result, accurate geodatabase for baseline data is more useful than the original for the proposed project area. The resulting features were stored in a vector format in the geodatabase in which different colors, labels, and symbols for simple differentiation were used [34-36]. Every feature can be linked to its attributes, such as the feature name, type, area, location, and any other related information associated with the needs EIA studies [17].

Basic and enhanced GIS operations such as surface creation, queries, multipath creation, and multi-criteria decision-making systems can be fulfilled on stored data in the combined geodatabase [37]. This step will assess and analyze all aspects of the physical, chemical, biological, economic, social, and cultural environment of the proposed project area and, also, produce resource assessment maps or function maps based on the type of the proposed projects [37,38]. GIS mapping techniques based on geo-statistic tools and algorithms offer an effective means for analyzing spatially variable pollutants [39]. Any sampling point in the proposed project area and their related parameters can be used to undertake the predefined spatial interpolation or extrapolation using geo-statistic analyst. To investigate the created BGDB, the baseline data from the Sabalan geothermal project area in Meshkinshahr, Ardabil were developed for this study.

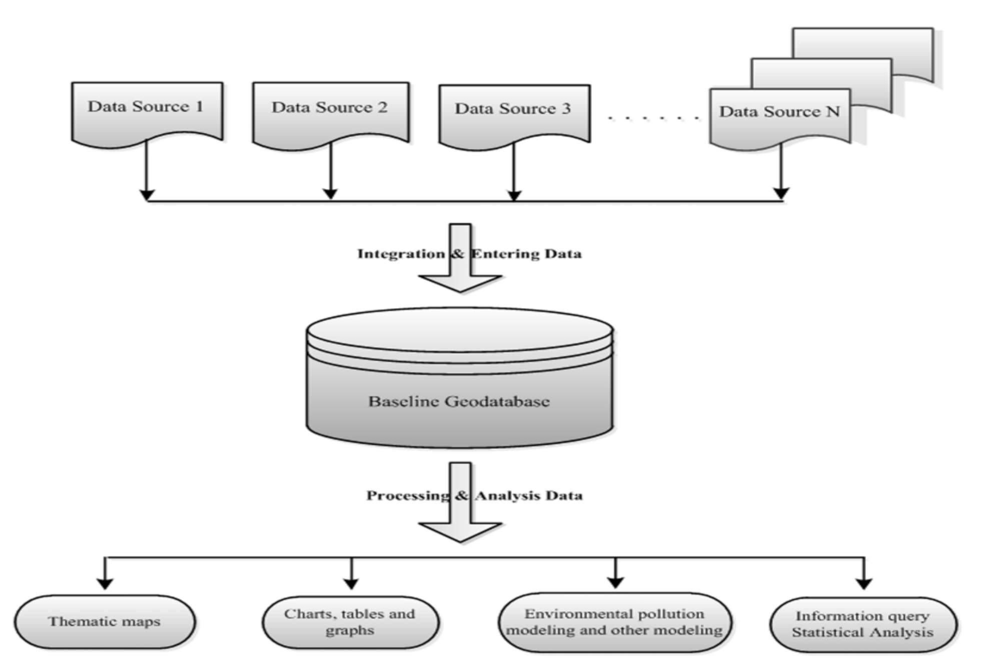


Figure 2. Data acquisition scheme, storage, integration, processing, and analysis for Baseline geodatabase (BGDB).

Table 1. Parameters incorporated to the Baseline Geodatabase (BGDB).

Database topics	Parameters	Implementation
Projects	Project-point, Project-line, Project-polygon	Feature class
General location map of study-area	Boundary-study-area, Province, City, Village-point, Village-polygon, Road, Highway, Sub-cathment, River-line, River-polygon, Stream, Lake, Spring, Wells, Subterranean	Feature class
Climatology-and- air quality	Wind-station, Meteorological-station, CO, NO_2, SO_2, O_3 1Hour, O_3 8Hour, $PM_{2.5}$, PM_{10}, H_2S, Pb, THC	Feature class
Hydrology	Surface-water, Ground-water-well, Ground-water-subterranean, Ground-water-spring	Feature class
Geology	Topography, Stratigraphy, Fault, Earthquake	Feature class
Pedology	Soil-and-quality	Feature class
Noise	Noise-pollution	Feature class
Biology	Habitat-point-identification, Habitat-polygon-identification, Flora-identification, Fauna-identification	Feature class and Habitat-polygon-Id. feature class with relational Fauna table
Socio-economic-cultural	Scio-economical-identification, Cultural-identification, Land-use-identification	Feature class
Fauna	If there are no identified polygons for Fauna, the data of Fauna is added to the Fauna Table for the study area.	dBASE table

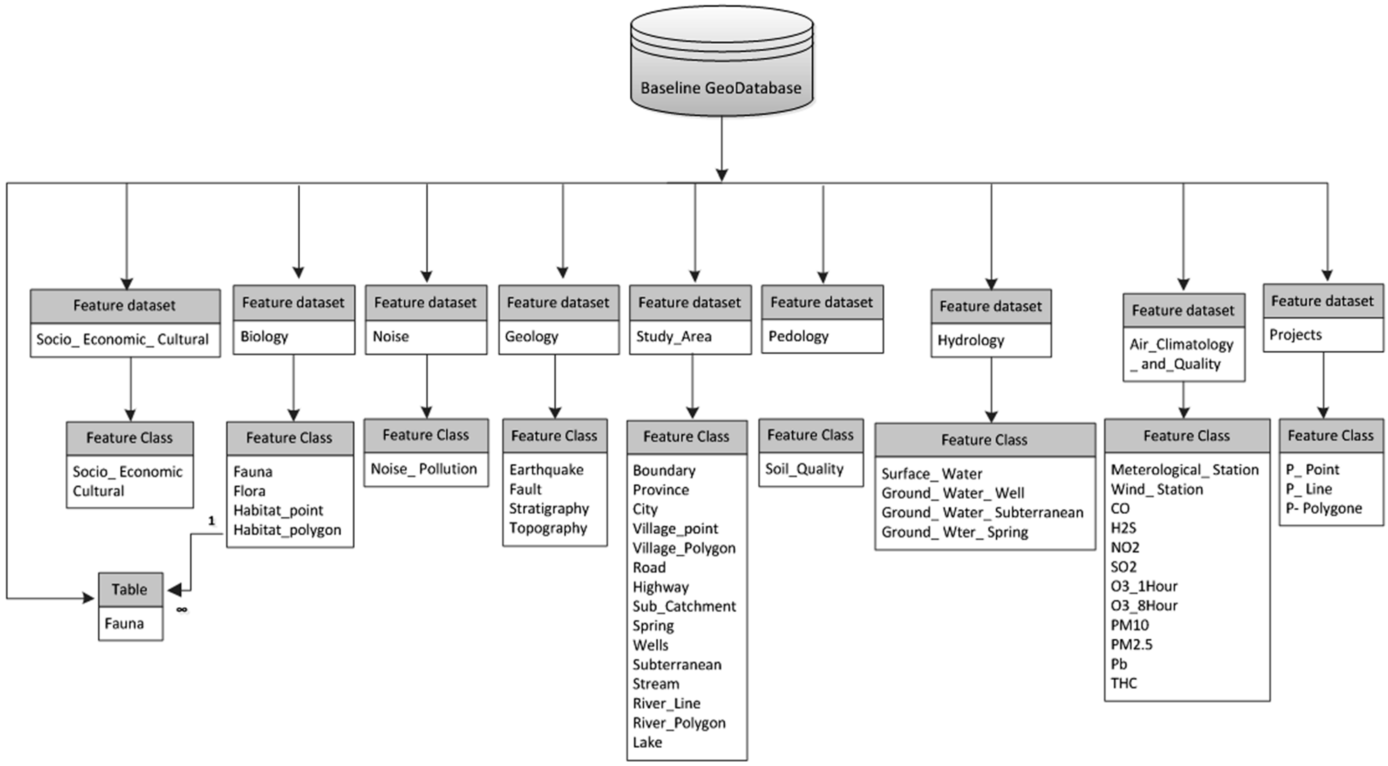


Figure 3. Baseline Geodatabase diagram illustrating feature datasets, feature classes, and relations of them.

5. STUDY AREA

The Meshkinshahr city is located in Ardabil province in the northwest of Iran, The city lies at an elevation of 1400 m a.s.l. It is close to Sabalan Mt. with a moderate, mountainous climate. The Sabalan Mt. is the 2nd highest mountain peak in Iran. It is a Quaternary volcano complex that goes as high as 4811 m a.s.l. The geothermal field selected for geothermal exploration is 132 km^2 and is a part of the Khiav River watershed; the elevation of the study area is 2200 m a.s.l. at the Moeil village in the northern flank to 3700 m a.s.l. in the south part close to the main peak of Kasra Mt. The Khiav River is the largest and most deep-channel river and is located in the western part of the Moeil valley. The eastern part of the geothermal field is dominated by the lower slopes.

The Sabalan geothermal field is located on 38°11'55" and 38° 22'00" in North and 47°38'30" and 47°48'20" in East. The villages of the Valezir, Moeil, and Dizo are located in the study area. A high-quality road provides accessibility to the Sabalan geothermal field from Meshkinshahr city to the Moeil villages; then, access is made possible by the paved road to the valley in the south of the village. The location of the study area is shown in Fig. 4.

6. RESULTS AND DISCUSSION

EIA is known to assess the likely negative and positive impacts of a planned executive project on the surrounding environment, considering natural (chemical, physical, biological, and ecological), cultural, social, and economic aspects. The absence of reliable and non-existent baseline data is a hindrance and difficult, which in agreement with the EIA report preparation [40]. Therefore, a geodatabase was constructed by ArcGIS software and termed Baseline Geodatabase, BGDB, for this problem. Because GIS is potentially a useful tool for the EIA process. This system has the ability to store, analyze, manipulate, and show large sets of multifaceted, geographically linked data and is, therefore, well suited for location-based applications of this nature and complexity [41]. Consequently, BGDB denoted to the collection of background environmental data on the physio-chemical, biological, socio-economic, and cultural settings proposed project area. Therefore, nine feature datasets and one table were derived from these background data saved consistently in the BGDB (Fig. 5). For this study, the baseline data from the Sabalan geothermal project was imported to the BGDB and analyzed in ArcMap.

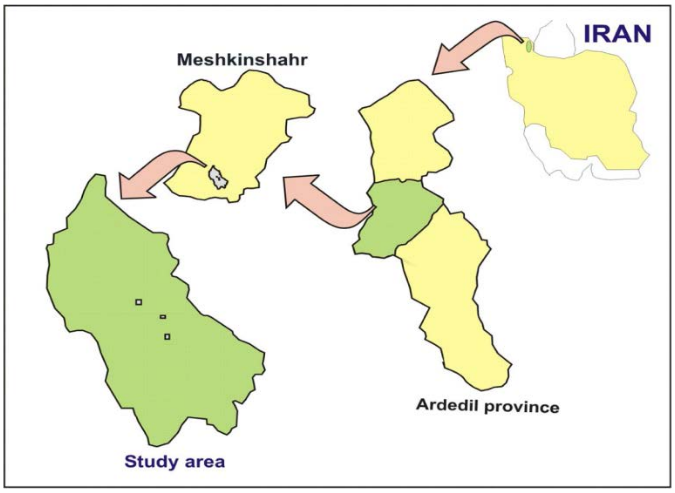


Figure 4. General Location Map of the study area.

6.1. Overview of Sabalan geothermal field

According to the National Energy Act, the project developer should apply for geothermal exploration permit before starting any further survey and exploration drilling and the construction of a power plant. Developers have a priority right to operate the power plant by acquiring exploration permits from the DoE.

In Iran, power plants with a capacity of more than 10 MW EIA studies and EIA report have been investigated. The MoE and SUNA organization were tried to develop the Sabalan geothermal field as the main Iranian geo power plant. The field is located in the northern part of the country in the south of Meshkinshahr.

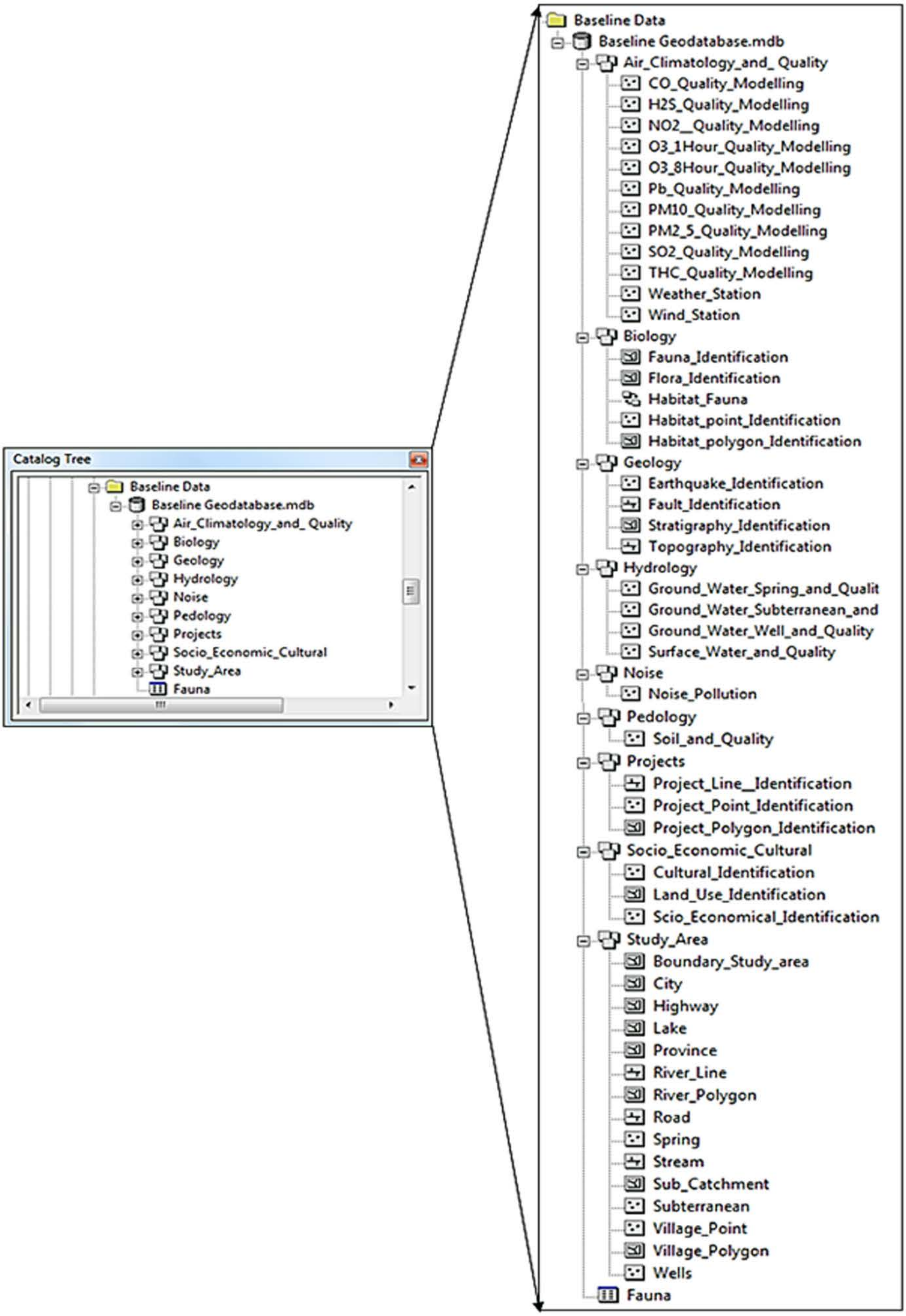


Figure 5. The ArcCatalog tree of the integrated database partially shows the structure of the BGDB, such as feature datasets, feature classes, table, and relationship.

6.2. Baseline geodatabase structure

6.2.1. Geology dataset

This feature dataset includes four feature classes (topography, stratigraphy, fault, and earthquake), which we considered two of them (topography and stratigraphy) based on the data presented by Sabalan geothermal project. This study showed the layers of stratigraphy and topography in the study area before starting the Sabalan geothermal project (see Fig. 6). The Sabalan stratovolcano comprises a wide-spread central mansion built on an eventual tectonic horst of underlying eruptive, effusive, and intrusive volcanoes.

A collapse caldera with 12Km in diameter is formed by enormous amounts of discharged magma, and there is a depression of about 400m; the lava flows were frequently of trachyandesite and dacite with irregular eruptive stages [42].

The primary goals of this exploration survey were to implement exploration of the field to specify any low-resistivity anomalies, which are related to the high-temperature geothermal resources in the underground.

The subsurface geological units were modeled to assess the size and scale of the reservoir to define the location of the first exploration well and to formulate a conceptual model of the hydrology of the geothermal field. Measurement stations' locations were selected by the survey crew to fulfill the exploration objectives of the survey while taking into account the considerations of terrain and site accessibility. The results revealed that large areas with lower resistivity in depth (less than 5 ohms) were located close to the Gheynarje hot springs in Moeil valley, an area close to the Sarein city, and another area called Ghotor prospect close to the Meshkinshahr and Sarein (Ardabil) (Fig. 6).

6.2.2. Climatology and air quality dataset

This feature dataset includes 12 feature classes (wind-station, meteorological-station, CO, NO_2, SO_2, O_3 1Hour, O_3 8Hour, $PM_{2.5}$, PM_{10}, H_2S, Pb, and THC); herein, some factors and attributes of meteorological-stations, wind-station, and SO_2 of air quality based on the data were presented by Sabalan geothermal project. We investigated the temperature, humidity, precipitation, wind patterns of meteorological and wind stations' feature classes, and the SO_2 pollutant of air quality feature class in the study area before starting Sabalan geothermal power plant.

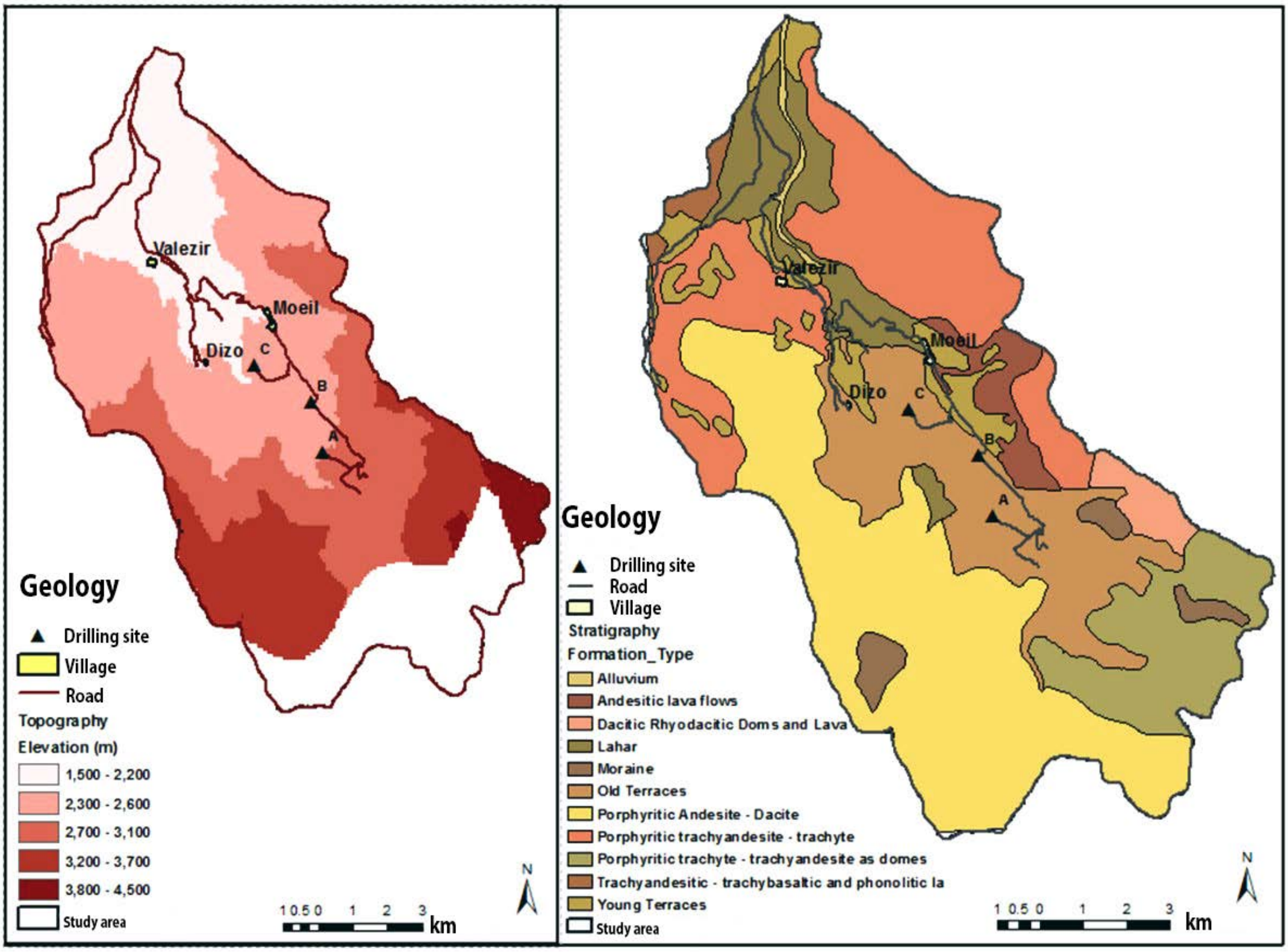


Figure 6. Simplified geological map with the locations of selective wells in the study area.

The variations in temperature in this study area during a year are very high from -35 in January to +35 in June and July [43]. The average temperature from 2000-2003 is shown in Fig. 7. The maximum temperature is +19 °C in August, and the minimum is -5 °C in January.

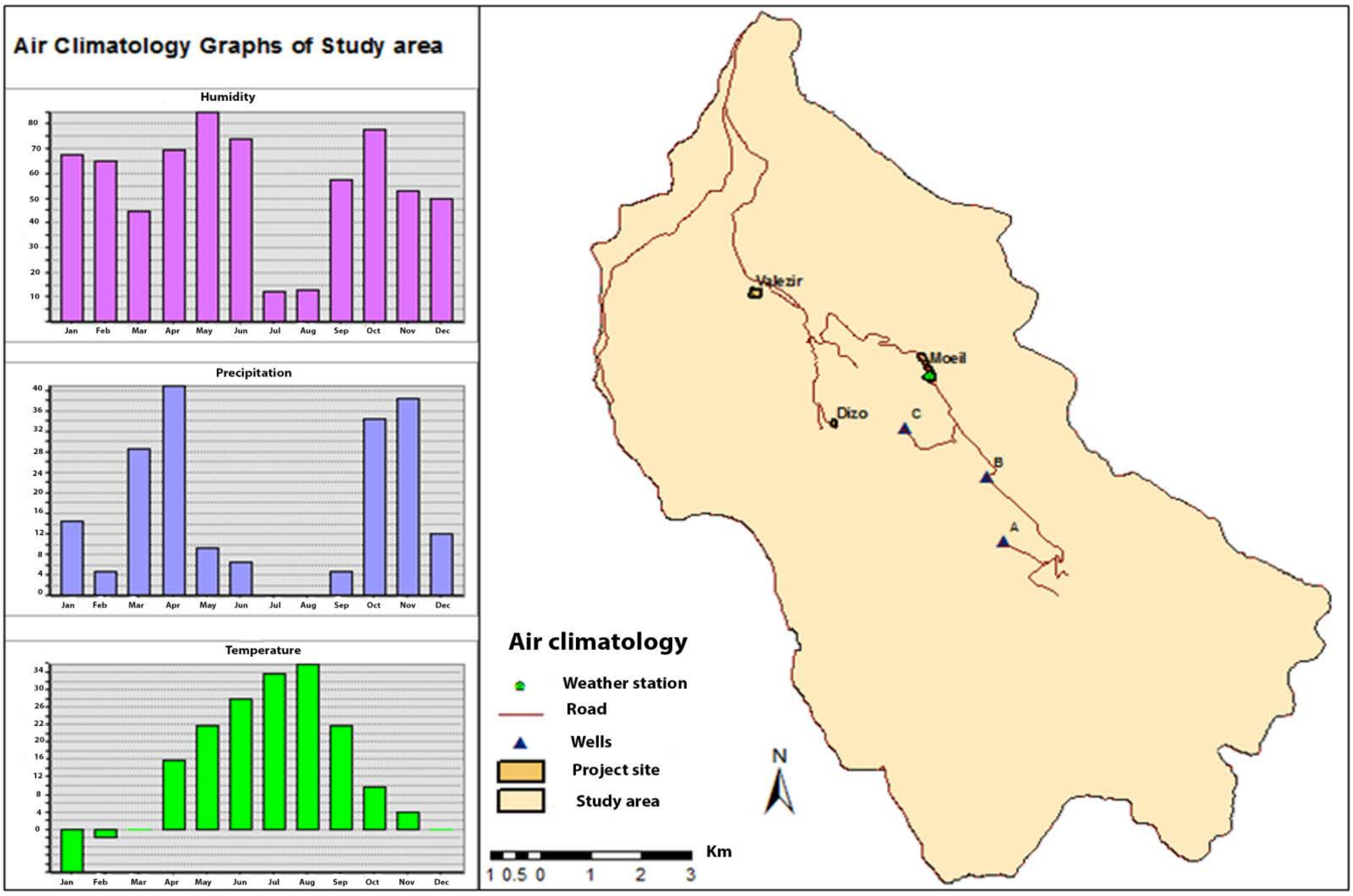


Figure 7. Climatology map with the graphs of the meteorological station in the study area from 2002 to 2003 before geothermal project development.

Humidity is not very high in this area because the elevation is high and the area is located in a very cold climate condition. According to the collected data from a meteorological station located in the study area, annual mean humidity was recorded as 59.5 %.

As shown in Fig. 7, the monthly average humidity revealed that the highest humidity occurred in May (85 %) and the minimum in June and July (13 %).

The major precipitation in the study area is rain that occurs in the autumn and spring season. Most of the snowfall is in the winter. The monthly averages of measured precipitation in the meteorological station installed in the study area for years 2000 to 2003 are shown in Fig. 7. As can be seen, the maximum is in April about 41 mm, and the minimum in June and July is zero.

Wind speed and direction are recorded at the installed station in the study area; collected data have shown that dominant wind directions range from west and southwest in the year 2002.

Maximum soil erosion is reported on the west face slopes; unfortunately, most of the slopes in the study area faced the west wind, and the water erosion force was added to wind erosion forces in same slopes [25].

Northwest Sabalan geothermal area is an unexploited natural land without any industrial activities, and there are no air polluting activities. The concentrations of SO_2 gas in the atmosphere are high. This gas escapes into the atmosphere from geothermal manifestations, and the necessity of its monitoring in the field appears. Therefore, during the EIA project, SO_2 concentrations were monitored in the whole field (132 km^2) where most of the geothermal manifestations were located. The dispersion distribution model of SO_2 gas from the sampling point was interpolated by Kriging method [44-46]; the map is classified into five different classes, as shown in Fig. 8. The results showed that the concentration of the gases was greater in the north-western parts of the field than other parts. Because most of the geothermal manifestations such as hot springs and steaming grounds are located in this part of the study area, the gases are released to the atmosphere from this part. Then, the distribution map of SO_2 concentrations was classified based on the Air Quality Index (AQI) values. It showed that the concentrations of SO_2 were at the acceptable levels of health concern (AirNew 2016), see Fig. 8.

6.2.3. Hydrology dataset

This feature dataset includes four feature classes (surface-water, ground-water-well, ground-water-subterranean, and ground-water-spring) and that we considered two of them (ground-water-spring and surface-water) based on the data presented by Sabalan geothermal project and investigated the existing situation and quality of hot springs and surface water (Khiav river) in the study area before the starting the geothermal project.

There are many hot springs in Sabalan geothermal field with a surface temperature of 25-85 °C that originates from a deep geothermal reservoir related to the Mt. Sabalan. Sampling and data collection for a baseline survey of hot springs' chemical characteristics was carried out for dry and wet seasons in the year 2000-2003. In total, 19 major hot and cold springs were selected. There were no springs exposed in lower elevations.

The Gheynargeh, Copaksu, Malek-su, and Ilando hot springs produce neutral waters with Cl >1500 ppm, SO_4 equal to 442ppm, and have significant concentrations of Mg > 24 ppm. They follow a minimal dilution trend showing mixture with varying amounts of cold groundwater and presents a strong seasonal cyclic flow rate variation. They show very little temperature or chemistry seasonal variation, which is indicative of a larger storage capacity [25].

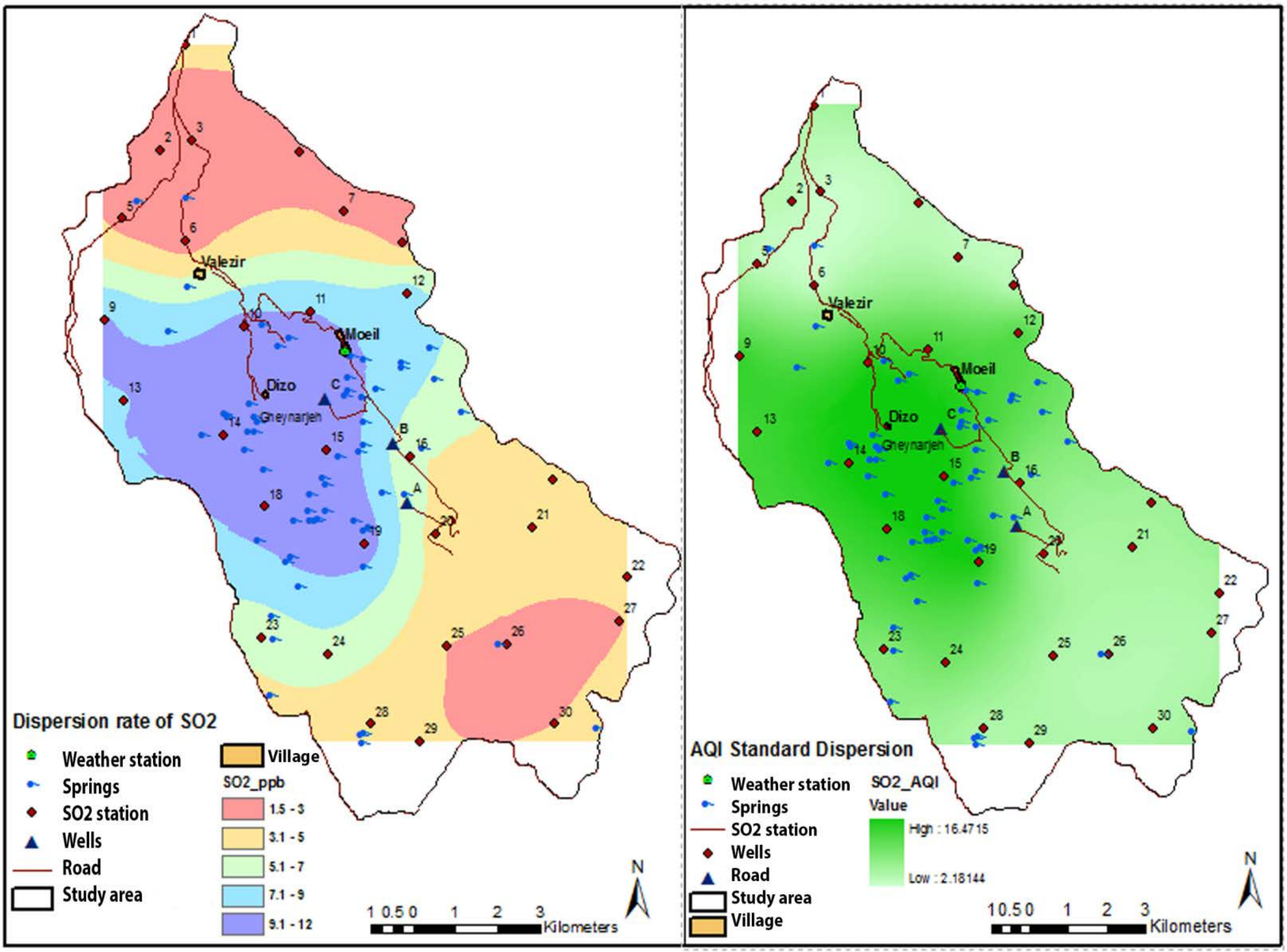


Figure 8. Dispersion and quality maps of SO_2 in the study area in 2002 before developing a geothermal plant.

The pH of Moeil 1, Moeil 2, Aghsu, and Romy springs is acidic. These hot springs are formed by condensation and oxidation of hydrogen sulfide, implying boiling at greater depths. The Romy spring sample contains a significant amount of Cl (119 ppm). The storage behavior of the springs demonstrates that they are feeding with a large perched aquifer that is heated and obtains a high magnesium-neutral Cl-SO_4 composition, which requires magmatic volatiles to be condensed and neutralized within these aquifers. A degassing shallow intrusive and a possible heat source are inferred, which is consistent with the same results derived from the geological studies, see Fig. 9.

Geothermal systems represent a bulky body of hot fluids at the top of the Earth's crust and are described by a particular rock-hydrological situation. Mostly, the system develops by very deep circulation of meteorological water, which usually includes different kinds of precipitation or seawater [47].

Geothermal reservoir characterized by convection of underground water is the most frequent in areas of recent volcanism, tectonics, and quaternary where the thermal gradient is higher with elevated bedrock permeability [26]. The circulating underground water transports heat from the deeper to shallower depths to generate a geothermal system so that the fluid transfer to the surface often includes constituents that may exert adverse effects on surface and groundwater. Hydrological and hydrogeological investigations revealed that the groundwater in the study area flowed from southeast to the northwest and west sides and was correlated with the slope direction of the land. Such groundwaters as several colds and hot springs are finally discharging into the Khiav river.

Khiav river is basically snow-based and spring river. It starts from higher elevations of about 3600 m a.s.l. in Sabalan Mt. After passing several villages and, also, Meshkinshahr city with about 50Km length, it joins Aras river within the Azerbaijan-Iran boundary and goes to the Caspian sea. The river's water not only is used as drinking water for Meshkinshahr city residence, but also flows into several canals for agriculture use. The project is located on the upper part of the river at a higher elevation than the river during the spring and summer. The topography of the area is harsh and mountainous. The average elevation difference between the well sites and the river base is about 300 m.

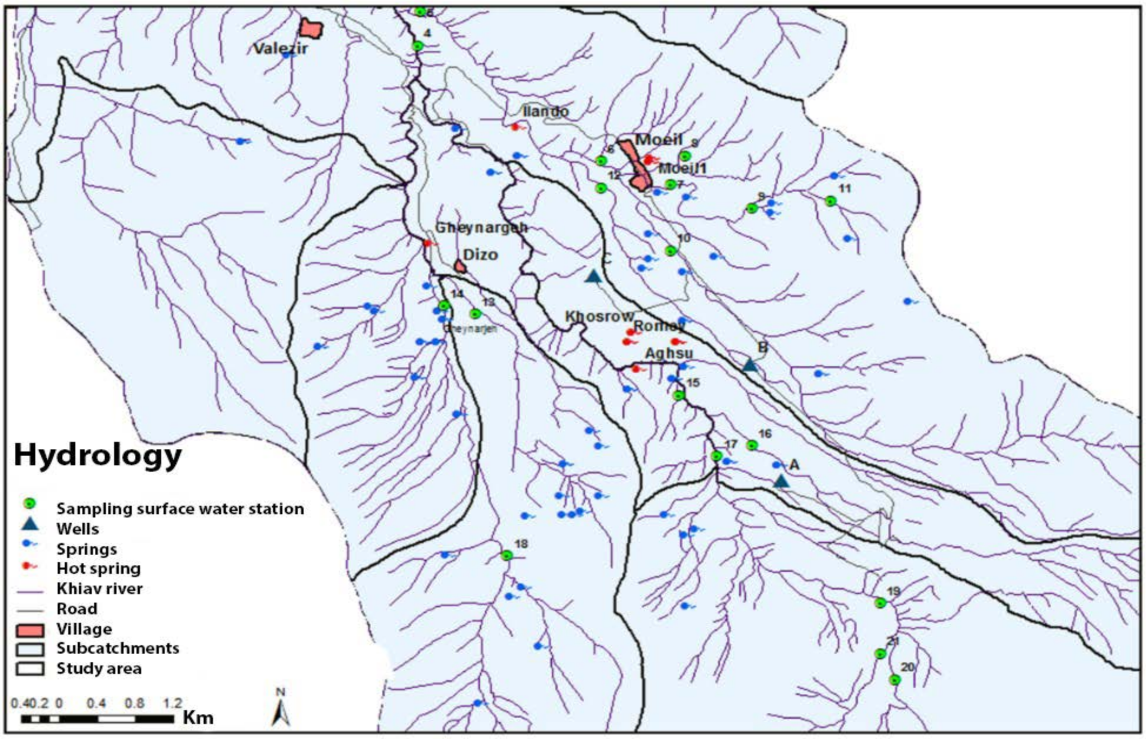


Figure 9. The hot springs of Khiav river basin map and in the study area from 2000 to 2003 before developing a geothermal power plant.

Therefore, for gather river baseline data, 22 sampling points were selected in order to examine the chemical characteristics of river water and spring discharge. The sampling points are those places where different branches of the river meet in different seasons (high and low flow rate). The chemical characteristics measured are TDS, NH_3, SO_4, SiO_2, Ca, Na, Cl, Mg, Cr, K, Co, Zn, Pb, Hg, Ni, Mn, EC, and pH. At first, dispersion distribution of chemical characteristics was interpolated by Inverse Distance Weighting (IDW) method; then, contamination levels were classified according to the standard of the index pollutants of Institute of Standards and Industrial Research of Drinking Water in Iran.

The results of measurements and analysis displayed that a number of toxic chemicals (Hg, Pb, and Cr) were zero or insignificant, and the other toxic and non-toxic chemicals showed significant contamination. For example, contaminated levels of toxic and non-toxic chemicals of Ni and SO_4 are shown in Fig. 10.

The contaminated levels of toxic and non-toxic chemicals might result from the chemical dissolution of the spring together with leaching the soil and sediments of river and spring discharge, as well as agricultural and horticultural activities of Meshkinshar's residents.

6.2.4. Noise dataset

This feature dataset includes one feature class (Noise-pollution), and we investigated the existing status and quality of noise in the study area-based measured data before starting any activities in the project. Noise is the most irritating environmental trouble from the geothermal development projects, mainly during the construction phase and operation phases. In this field, the noise levels were measured using the portable sound level meter. The noise during drilling is specifically high and sometimes exceeds 90 decibels. In a discharging well, the noise level may exceed 120dB; however, practically, by using well-designed silencers, noise can be reduced to about 85dB. Thirty sampling points were selected as noise monitoring stations to clarify the potential noise sources in the project area. The distribution of measured noise intensity in sampling stations was interpolated with Inverse Distance Weighting (IDW) method [48,49] and classified into 6 different classes. The results revealed that the noise levels were well below the safety levels and there was no noise pollution in the study area, see Fig. 11.

Most of the geothermal projects are located in remote lands where the natural noise level is very low and a slight change is detectable. The Meshkinshahr geothermal field is located in an area devoid of human-made industries; thus, the noise level is very low.

6.3. Baseline geodatabase (existing biology environment)

6.3.1. Biology dataset

This feature dataset includes four feature classes (Habitat-point-identification, Habitat-polygon-identification, Flora-identification and Fauna-identification); we considered the feature class of Flora-identification and investigated the existing situation and status Flora and vegetation in the study area based on the data, presented by Sabalan geothermal project before the starting the project.

The vegetation cover density map and vegetation communities' map of the geothermal field are prepared. Results showed that the entire area was covered by vegetation. As shown in Fig. 12, the cover density is 15 % at the elevation above 3200 m with 45 % coverage at an elevation of 2400 m to 3200 m, and it has 30 % coverage in elevation of below 2400 m.

The vegetation density and composition in the rangelands are directly related to the climate conditions and economic situation of the area. Parts of the study area are covered by steppe flora which consists of varied vegetation. The mean annual precipitation in these parts ranges from 200 to 450 mm.

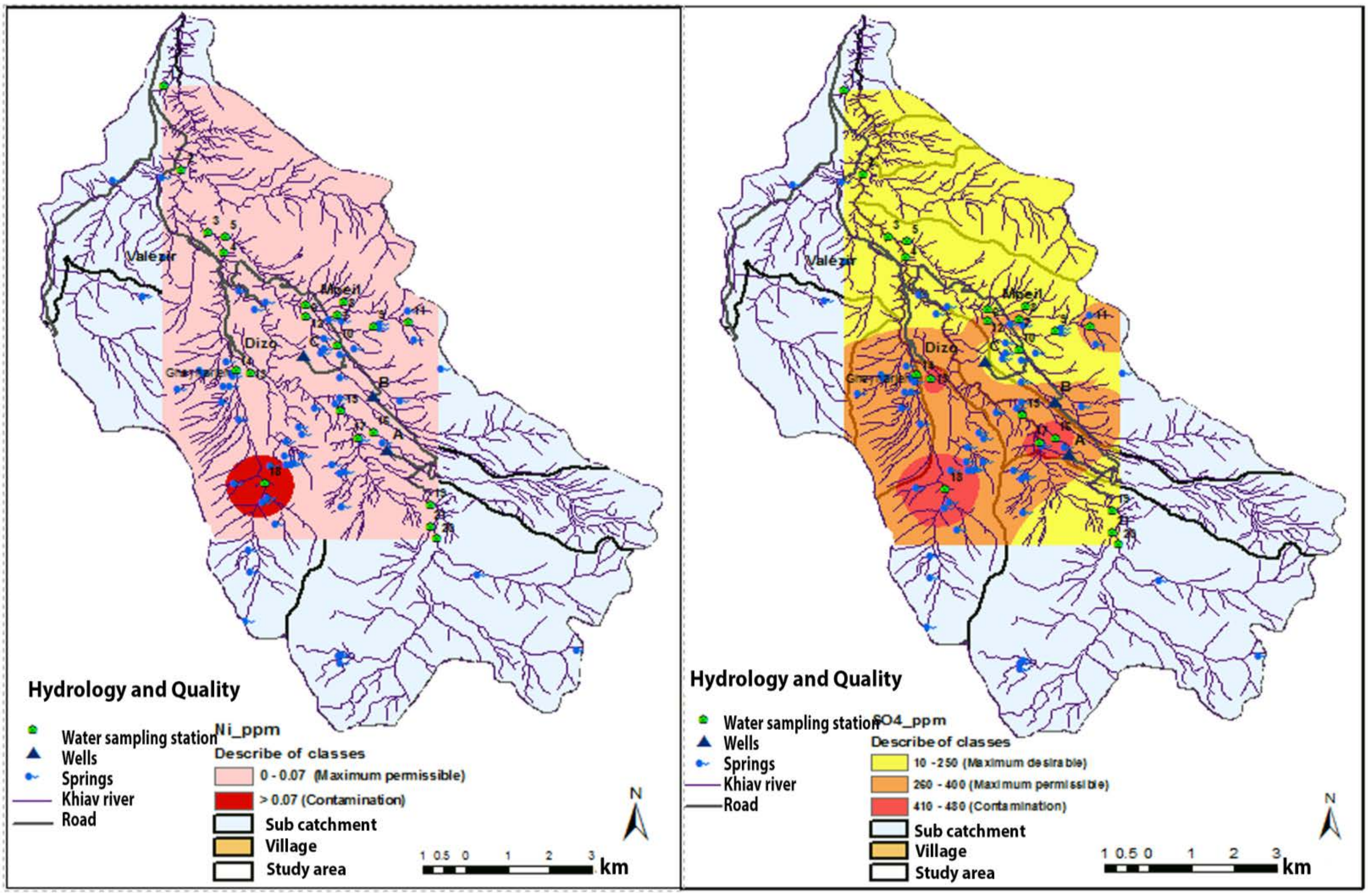


Figure 10. The Khiav river basin map and quality distribution of SO_4 and Ni map in the study area from 2000 to 2003 before developing a geothermal power plant.

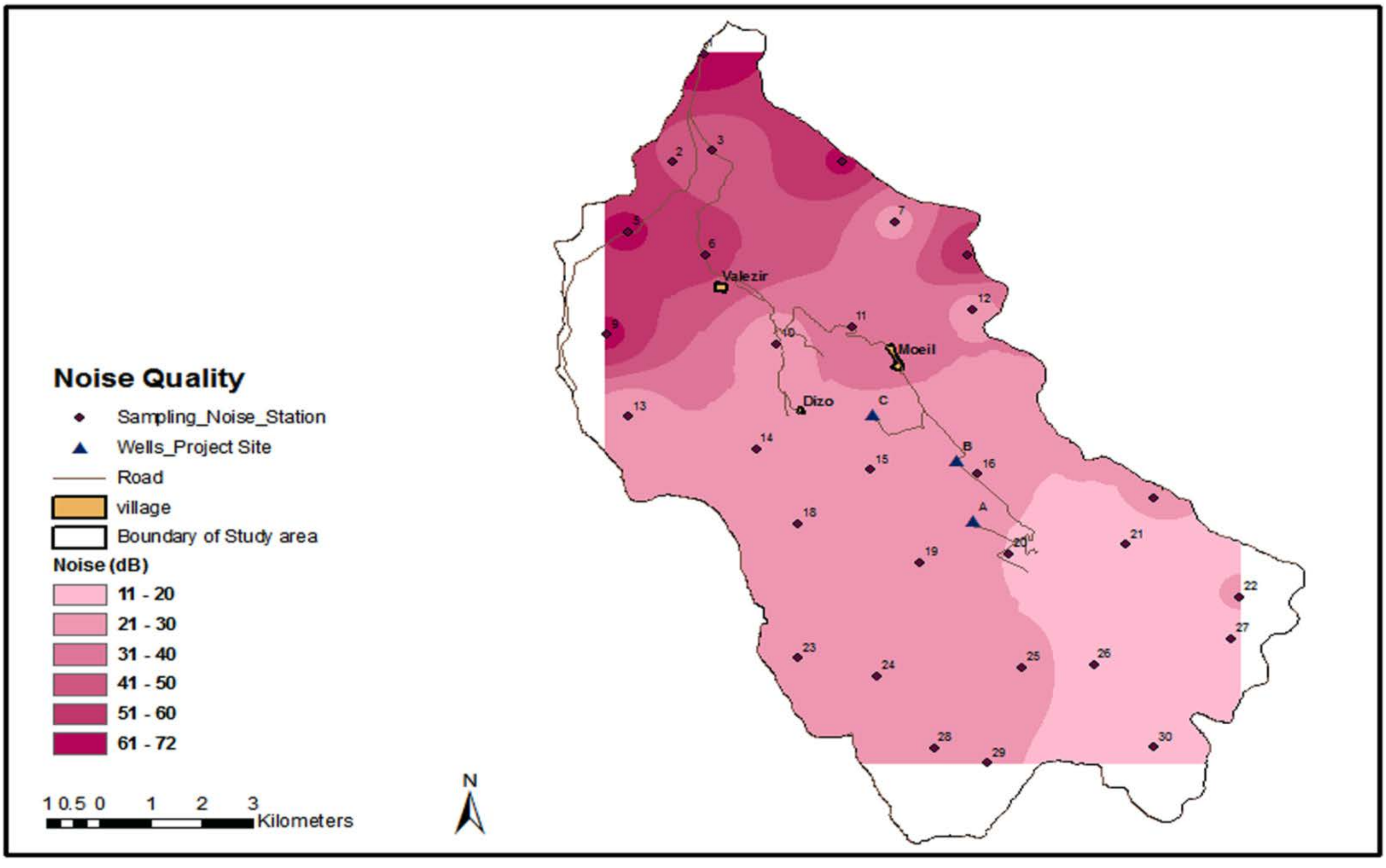


Figure 11. Noise level distribution map in the study area in April 2002 before project drilling.

Aristida plumosa is the main grass, and Artemisia herba-alba is the major shrub. Different types of grasses were common in the past; however, they have been greatly reduced by extensive human activities, farming, and intensive grazing [50].

The results of the vegetation survey indicate that there are almost 369 plant species. Among them, there are 25 endemic species. In total, about 110 species are for animal feeding purposes, 19 species used for medication, 15 species for industrial and chemical applications, and 12 species for human food.

According to the national law of biodiversity protection, 3 different classes of protected plant species exist in the area (conservation classes of one, two and three). There are almost 100 plant species in the area that belong to conservation class one, and it makes the area important for sustainable grazing and careful monitoring. Adonis flammea, Astragalus odoratus, Bellis perennis, and Chenopodium album are the species that belong to Class one. About 12 plant species in the area are in conservation class two, according to the biodiversity conservation law of Iran; plants belonging to this class are classified as endangered and, the utilization and collection of seed and mass are prohibited even for medical or industrial applications. Astragalus mozatfananii, Acantholimon senganense, Bromus tectorum and Cotoneaster nummularioides belong to the conservation class three. These plants are critically endangered and require special care.

According to the vegetation cover study, there are four main vegetation communities in the study area. These vegetation cases are used for grazing and agriculture purposes in the study area. These 4 plant communities include Astragalus-Crisium, Astragalus-Onobrychis-Acantholimon, Astragalus-Onobrychis-Crisium and Festuca-Artemisia. However, according to the vegetation communities' distribution map, the whole study area has a suitable vegetation cover. However, uncontrolled overgrazing has degraded the rangeland [9] (Fig. 12).

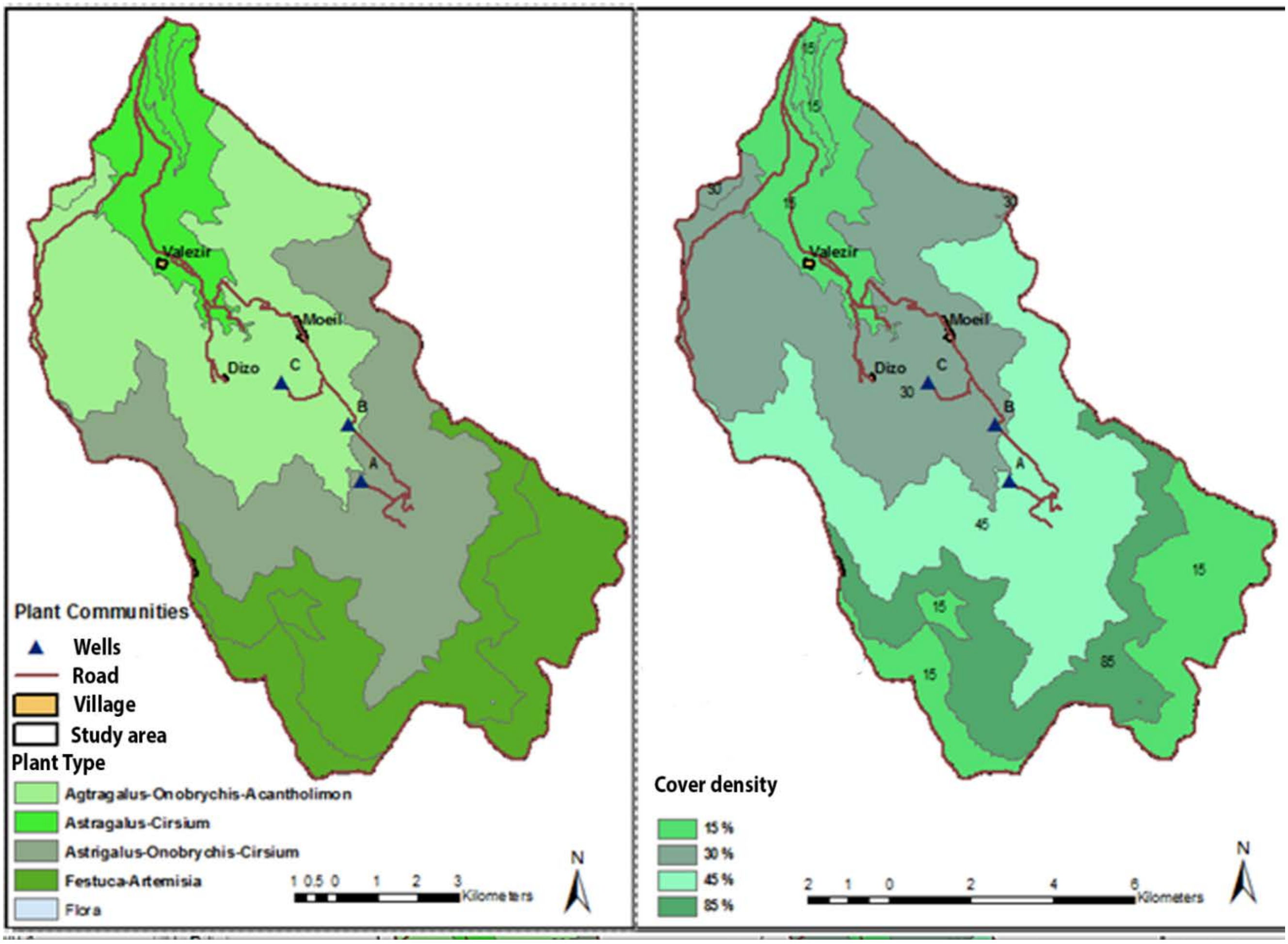


Figure 12. Vegetation cover density map, vegetation communities' maps and database in the study area in 2002.

6.3.2. Fauna table

Sabalan Mt. with an altitude of 4,811 m is one of the most interesting wildlife habitat mountains in Iran. The permanent fauna of the geothermal field was recorded. There are almost 250 species in the study area. Some species such as Mergus albelus, Aaudial chrysaetos, and Phasianus are endangered. Due to the lack of precise data on the scope and polygon of the fauna of the Meshkinshahr field, we used the data of the fauna, according to the fauna's data gathered by the EIA project of Sabalan geothermal power plant before starting executive works. Table of Fauna is shown, and some of the species with their information and specifications are present (Fig. 13).

6.4. Baseline geodatabase (existing socio-economic conditions and cultural environment)

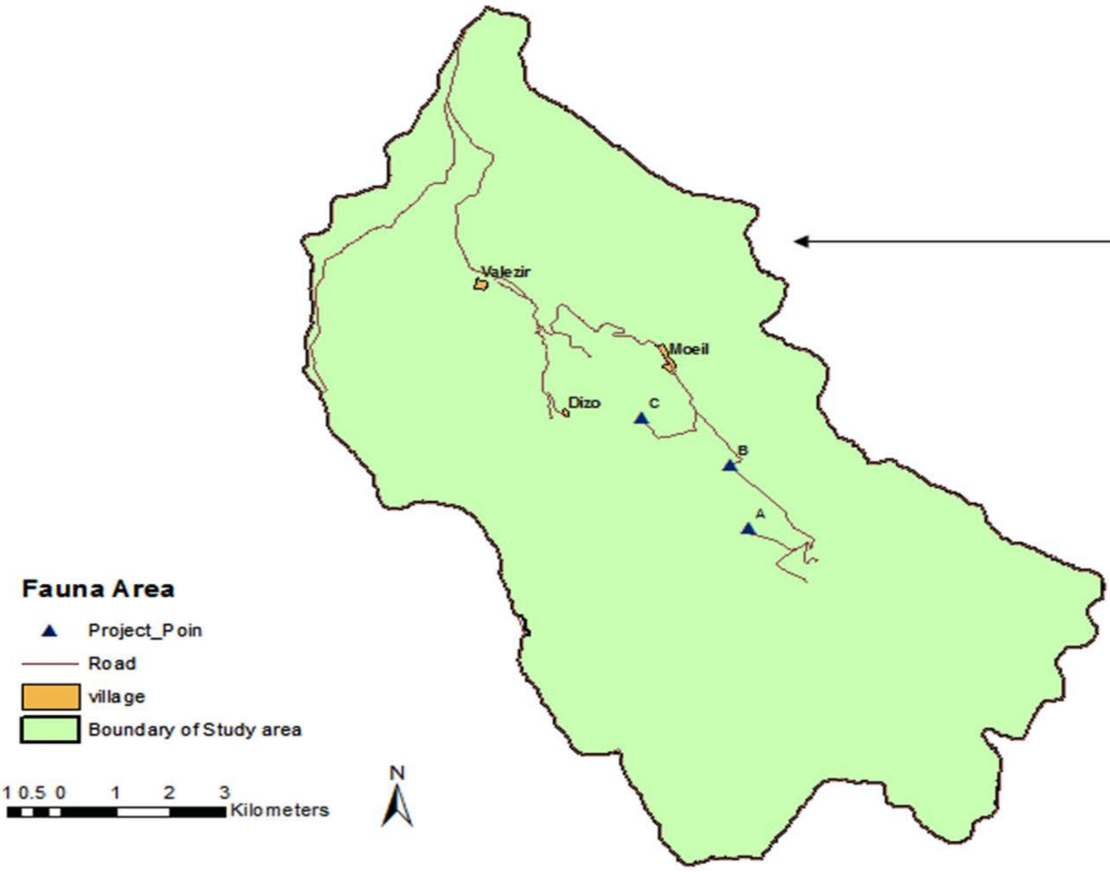
6.4.1. Social-economic and cultural dataset

This feature dataset includes three feature classes (Scio-economical, cultural and land-use), of which we considered only two (Scio-economical and land-use) based on the data presented by Sabalan geothermal project in the study area before starting the project.

Social and economic aspects of the nomadic families and village residents are presented in this feature class. In Iran, the country is divided into 32 provinces by law and each province including some major cities, and every city is divided into several districts; finally, each district comprises several villages. All villages have predefined borders with the surrounding villages, which are presented in this feature class.

The study area consists of three villages. These three small villages are home to a population of almost 2000. The villages are located about 5 Km distance from each other and almost 20 Km from Meshkinshahr city. The first village is Dizo. It is located in the northwestern part of the area. The village named Valezir is located in the north and 50 families living there. The third and highly populated village is the Moeil village, which is located in the southeastern part of the area. The surrounding lands are farmland, and this farmland might extend to several kilometers, and they are parcelled out and belong to each family. There are also meadows and woods used for pasturage. The economy of people living in these villages is highly associated with sheep keeping and insignificant agricultural cropping.

There are almost 200 nomadic families in the study area. They enter the area in May and leave at the end of September every year. Each family has a specific settlement area in the area and common property rights along with other nomadic village communities for grazing the sheep and goats. Their economy mostly depends on sheep (Fig. 14).



Attributes of Fauna

OBJECTID *	Name_Science	Phylum	Habitat_Type	Status_of_Species_IUCN	Name_Area	Type_Area	Time_Record
25	Phasianus	Birds	Mountain - rangeland	endangered	Meshlinshahr	City	2000-2003
24	Aaudial chrysaetos	Birds	Mountain - rangeland	endangered	Meshlinshahr	City	2000-2003
26	Mergus albelus	Birds	Mountain - rangeland	endangered	Meshlinshahr	City	2000-2003
14	Egretta alba	Birds	Mountain - rangeland	<Null>	Meshlinshahr	City	2000-2003
2	Ovis ammon gemelini	Mammals	Mountain - rangeland	<Null>	Meshlinshahr	City	2000-2003
3	Sus scrofa	Mammals	Mountain - rangeland	<Null>	Meshlinshahr	City	2000-2003
4	Erinacecus europaeus	Mammals	Mountain - rangeland	<Null>	Meshlinshahr	City	2000-2003
5	Lepus capensis	Mammals	Mountain - rangeland	<Null>	Meshlinshahr	City	2000-2003
6	Hystrix india	Mammals	Mountain - rangeland	<Null>	Meshlinshahr	City	2000-2003
7	Canis lupus	Mammals	Mountain - rangeland	<Null>	Meshlinshahr	City	2000-2003
8	Canis avreus	Mammals	Mountain - rangeland	<Null>	Meshlinshahr	City	2000-2003
9	Vulpes vulpes	Mammals	Mountain - rangeland	<Null>	Meshlinshahr	City	2000-2003
10	Ursus arctus	Mammals	Mountain - rangeland	<Null>	Meshlinshahr	City	2000-2003
11	Mustela nivalis	Mammals	Mountain - rangeland	<Null>	Meshlinshahr	City	2000-2003
1	Caprea aegagrus	Mammals	Mountain - rangeland	<Null>	Meshlinshahr	City	2000-2003
13	Ardea cinerea	Birds	Mountain - rangeland	<Null>	Meshlinshahr	City	2000-2003
15	Nyctiycorax nyctycorax	Birds	Mountain - rangeland	<Null>	Meshlinshahr	City	2000-2003
16	Ardea purpurea	Birds	Mountain - rangeland	<Null>	Meshlinshahr	City	2000-2003
17	Ardea sp.	Birds	Mountain - rangeland	<Null>	Meshlinshahr	City	2000-2003

Record: 1 Show: All Selected Records (0 out of 26 Selected) Options

Figure 13. Table of Fauna of the study area.

Studies have shown that rangelands are affected by overgrazing by villages' residents and nomadic families' herds (sheep, goat, and cow). The total capacity of the study area (13000 ha) is 7200 sheep equivalent to only 100 days based on Forest, Range and Watershed Management Organization of Iran regulations.

In the landuse map, a feature class of land use is investigated. The area is divided into two major types according to its application: Rangelands and Farmlands. Currently, almost 20 % of the study area is used for cropping and about 80 % for rangeland (Fig. 15).

According to the climate condition in the study area, cultivation is possible only from May to September of each year. The main crops are potato, tomato, onion, cucumber, watermelon, carrot, and another vegetable. Moreover, some parts of the study area are cropped by alfalfa, and farmers use it for their herd during winter. The north and northwest parts of the geothermal field are mainly cultivated.

Rangelands are mainly suitable for grazing or browsing, defined as land where native vegetation is mostly grass. Overgrazing is the main consequence of traditional herding practice, which affects the environment. The effect of domestic herbivores on the land always varies with the density (relative to rainfall and soil fertility). Rangeland has a significant role in the socio-economic life of the habitats and also an effective contribution to soil and water conservation and to non-agricultural and agricultural lifespan. Studies show that the main economic activity of the local families is agricultural activities.

The rangelands are already under severe pressure in the study area. Development of planned geothermal power plants with the total land use of 160 hectares is a great concern of other stakeholders living in the study area. The Iranian Department of Forest, Range and Watershed Management stated that the project would elevate the pressure on rangeland and affect the rangeland biodiversity and quality.

The results of this research indicated that the BGDB responded to the following items in the EIA process:

1. A description of the current status of the study area;
2. Displaying environmental system relationships on the map of the study area;
3. Modeling environmental factors (e.g., air pollutant concentrations) of the study area against which predicted and future changes and effects can be measured;
4. Analysis of the distribution of pollution levels based on determined standards of diffuse sources of pollution (nonpoint sources);
5. Exploring human health risks (relative risks) in terms of where people live (e.g., noise pollution);
6. Making the multipurpose line very flexible in terms of database queries;
7. Easy access to data and information of the study area;
8. Demonstrating sitting opportunities or constraints (inclusive or exclusive) for selecting the optimum options;
9. Possibility to visualize and integrate data and information of the study area;
10. Allowing the user to make queries and obtain relevant information;
11. The ability to update data and change environmental data and resultant impact information.

Therefore, the BGDB can facilitate identifying area and effects, managing the impacts, planning, reporting, decision-making, providing environmentally-friendly project options, and monitoring in the EIA process.

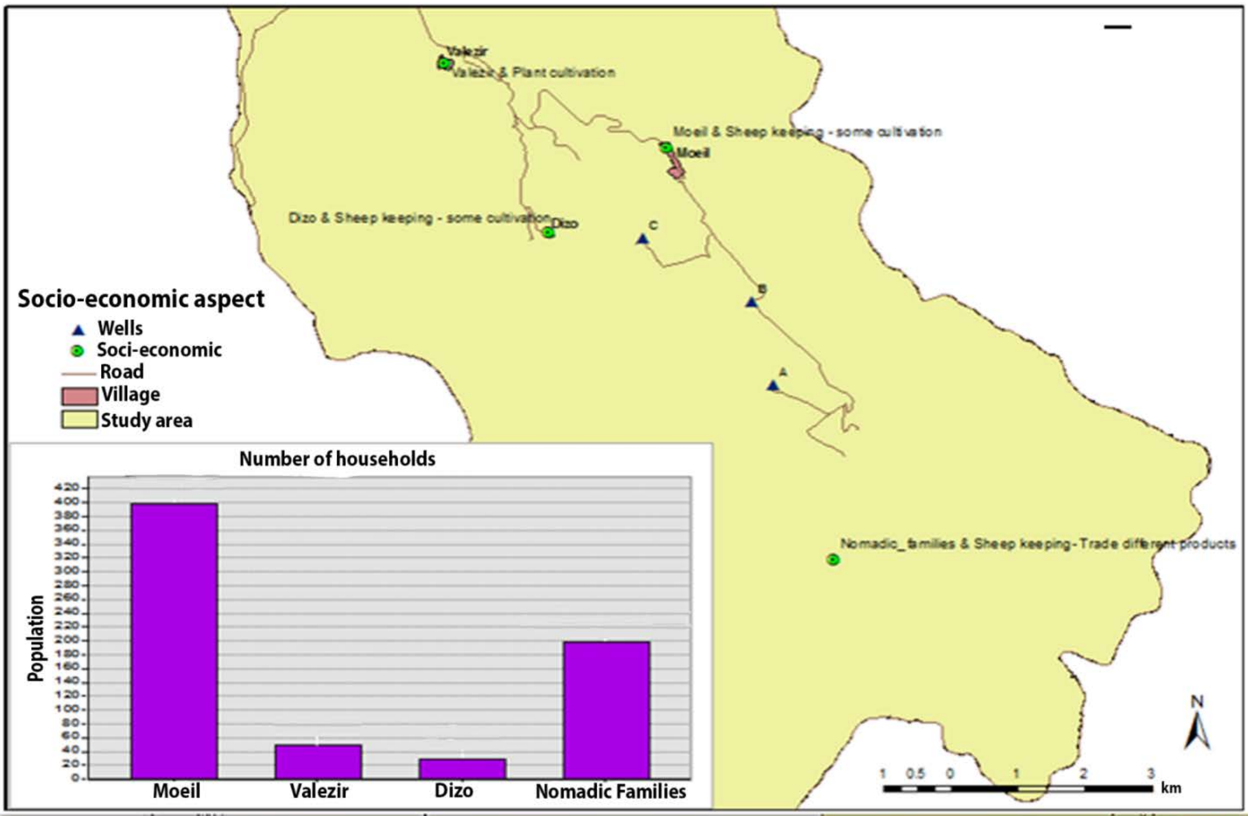
However, the application of the BGDB to EIA studies has been subject to limitations as follows:

a) Data source quality which is defined basically by spatial and spectral resolution of the remotely sensed images to make the digitization process more complex; less reliable results;
b) The digitization process is time-consuming, which increases highly when large areas are digitized on fine scales. However, this effort is justified by the additional detailed information collected during this process;
c) Subjectivity and interpretation of errors and the possibility of user-related errors when using GIS techniques [51];
d) The lack of digital data and related data conversion error and accuracy considerations [36].

It is possible to distinguish the difference between the EIA studies and reports of GIS-based geodatabase for baseline data that could better handle a variety of data (including both location and attribute of particular features) and, also, effectively overcome problems such as high time consumption, costs or human errors; this trend not only shows and produces maps, but also records and analyzes descriptive characteristics of features and retrieves and updates the data and information and supports decisions for spatial planning. Comparatively, the trend prepared in a traditional way without any database versus a set of software packages or programs to generally construct the database showed that the latter performance is virtually their better.

By considering this interpretation, attempts have been made to concentrate on the importance of the baseline data collection by the EIA procedure. We believe that baseline data of the proposed project area could be one of the main reasons to assure the indigenous experts of performing EIA, encourage the local people's participation, and effectively provide useful information for decision-makers in the EIA process [35,40,52]. Hence, BGDB based on ArcGIS for the baseline data stage of the EIA procedure was designed.

Nevertheless, for providing accurate and systematic EIA reports and studies, we require designing another geodatabase such as the rules associated with proposed projects, project activities, effects and impacts of actions, proposed environmentally-friendly options, and mitigation measures, etc. In addition, we need some GIS-group specialists who not only maintain and update the data and information on environmental values, but also perform a proximity analysis and modeling for every proposed project, referred to as the DOE. Accordingly, this process will increase and improve the credibility of EIA reports, the transparency in accountability, and decision-making of planners, managers, and specialists in Iran.



Attributes of Scio_Economical

OBJECTID *	SHAPE *	Number_of_Households	Name_Area	Type_Area	Time_Record	Name_Location	Type_Location	Occupation_Dominant
5	Point Z	200	Meshkinshahr	City	2003	Nomadic_families	Village-rangland	Sheep keeping- Trade different products
3	Point Z	30	Meshkinshahr	City	2003	Dizo	Village	Sheep keeping - some cultivation
1	Point Z	400	Meshkinshahr	City	2003	Moeil	Village	Sheep keeping - some cultivation
2	Point Z	50	Meshkinshahr	City	2003	Valezir	Village	Plant cultivation

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Figure 14. Map and database of the study area in social and economic terms.

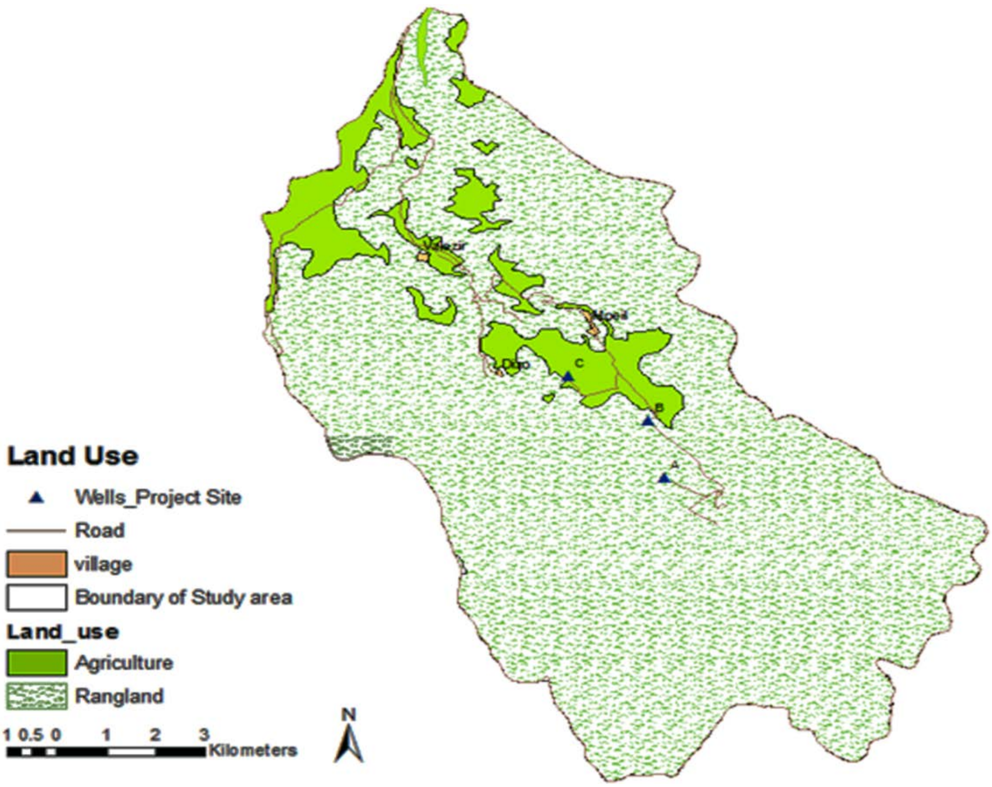

Figure 15. Land-use map and database of the study area.

7. CONCLUSIONS

In most countries, particularly in developing countries, EIA as a legal requirement should be provided before the appraisal of development projects that can significantly affect the environment and guarantee sustainable development. EIA aims to analyze, examine, and assess the planned activities of the proposed project to ensure environmentally sound development. This study highlighted the baseline information (collection of background information on the physical, chemical, biological, social, economic, and cultural environmental data settings of the proposed project area), which is one of the important stages of EIA procedure. On the one hand, it is essential that the baseline information be to be accurate, adequate, reliable, valid, latest, existent, and available; on the other hand, since every stage of the EIA procedure involves many environmental attributes that are spatial in nature, it is imperative to create an appropriate database. Therefore, the Baseline Geodatabase (BGDB) was designed in the form of a GIS-based geodatabase to overcome the mentioned problems. In this respect, the BGDB includes nine feature datasets and one table related to baseline data (projects area, climatology and air quality, hydrology, pedology, general location map of study area, geology, noise, biology, and socio-economic-cultural and fauna table). For example, the BGDB for the Sabalan geothermal power project as a case study was developed.

The results of this research demonstrated that the BGDB could:

a) identify the status of features and the existing environment of the site and surrounding areas of the proposed project in sufficient detail to allow for accurately and adequately assessment of the environmental impacts of the proposed project and to provide a baseline data against which predicted and future changes and effects can be measured;
b) allow integrating a lot of information in a systemic way to produce quantified, georeferenced, and visual outputs, obtain relevant information, and access all relevant data in a convenient and cohesive format for user queries;
c) enhance the capacity of data handling, analysis, and dissemination of the area environmental information by protecting the quality assurance and quality control of data;
d) create robust frameworks for quantitative environmental area analysis and interpretation in the present and future.

In conclusion, the BGDB was designed to achieve these goals, and attempts were made to better use available data on EIA to provide an integrated framework for effectively managing large baseline data in space and time and in a sustainable, durable and efficient manner. As a result, when the application of BGDB to the proposed project studies becomes widespread, it is highly possible to use DOE benefits. Because it will facilitate the EIA process to report and make more accurate and objective decisions on every projects, which are mainly aimed at reducing the environmental impacts on global, regional, and local scales. It also will provide a key source of reference information to access for future environmental management projects and managers in order to optimize and speed up the planning procedures on the current status of the proposed project. We hope that this research serves as an operative step to solve baseline environmental data problems of the EIA studies for environmental specialists, decision-makers, and managers in Iran.

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