

## Research Article

# Investigation of Geological Heritage and Geo-Tourism Capacities of Semnan Province, Iran

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### Abstract

Geology of Semnan province includes 4 different geological structures consisting of limestone, dolomite, siltstone, shale, marl, sandstone, conglomerate and coal bearing sandstone. Other units include ophiolitic, andesitic-basaltic, pyroclastic, tuff and agglomerate complexes and metamorphic rocks. The mentioned geological complex is the source of geomorphological diversity and mineral deposits variety. In this research natural and geological pre-geosites along with complementary attractions are identified throughout Semnan Province, the geological pre-geosites are systematically listed, and the geo-tourism/recreational and educational application of pre-geosites are measured using the latest quantitative assessment method of Brilha. Based on the available data and classification of natural and geological phenomena of Semnan province, regional pre-geosites are 58.33% and national pre-geosites are 31.33%. Analytic Hierarchy Process is later performed using Expert Choice 10.0 software for qualitative and quantitative evaluations of pre-geosites (natural and geological) and complementary (historical-cultural and economic), and the potential of geo-tourism in the Semnan province. The results show that Semnan province has a high potential and capacity in terms of natural attractions and geomorphological diversity and complementary attractions. This province with more than one hundred natural and complementary attractions can be introduced as a "model tourism province". It can be a suitable alternative for tourists and the multitude of travelers in Mazandaran and Gilan provinces. This research shows the importance of paying more attention to the geological features of each region from the point of view of nature tourism and geo-tourism and can be considered as a model for other regions.

**Keyword:** Nature-Based Tourism; Geo-tourism; Salt Dome; Analytic Hierarchy Process; Semnan

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## 1. Introduction

Geological heritage is an inanimate part of nature that illustrates the path of formation and evolution of the earth and uncovers the tourism, scientific and educational

values in each region. Invaluable historical, cultural and economic attractions can complement the geological and natural attractions of each region. Geoconservation's main purpose is the protection of geosites as major units

of geoheritage, and this principle is achieved through the application of specific methods such as indexing geological phenomena, assessment, preservation, valuation, and estimating the importance of each geosite. [Salamzadeh et al. \(2021\)](#) investigated the obstacles to the sustainable development of geo-tourism in Iran using the Analytic Hierarchy Process (AHP). Some 33 generalists in the field of tourism economy were involved to complete questionnaires. A total of 12 factors were investigated. The findings denote those economic and marketing factors are the criteria that have the most and the least impact, respectively. Moreover, the results show that the lack of investment by the State in geo-tourism and the lack of well-grounded staff to guide geo-tourism tourists are the most and least effective sub-criteria, respectively. Lashkari and [Riyazi \(2016\)](#) conducted a Strength, Weakness, Opportunities, and Threats (SWOT) analysis to assess the potential for geotourism development in Semnan Province. Arab Ameri et al. (2018) evaluated the geotourism potential of salt dome landforms in the sustainable development of the area. [Zabihi et al. \(2020\)](#) applied the integration of Geographic Information System (GIS) with Fuzzy Hierarchical Process to determine the suitability of ecotourism sites in Babol town and to evaluate physical, natural, environmental and socio-economic factors. The results denoted that topography, proximity to the nearest stream, ambient temperature and altitude are the most important factors for measuring the suitability index of each area. [Shirazi \(2020\)](#) have studied geotourism attractions in Toroud Village in the southern part of Shahroud City (Semnan province), as the center of decorative and semi-precious stones in Central Iran. The main goal of this research is to identify and introduce geological attractions and evaluate the potential of geo-tourism according to the geological, morphological and structural characteristics of Semnan province. As mentioned, most of previous studies focus on limited subject area (e.g., salt domes, special village), whereas in this research, the potential of geo-tourism in a province-wide scale was considered and evaluated. Accomplishing this goal, will generate job opportunities and foster development, resulting in economic growth, a shift in local attitudes, and improved living standards for communities. Additionally, it will ensure the preservation of the region's geological, natural, cultural, and economic heritage.

## 2. Geo-tourism Background

Geo-tourism in its modern concept as a subsidiary of Nature-Based tourism was first proposed in England in 1995 ([Hose 1995](#)). Geological diversity is an important factor in attracting tourists who favor nature and geology. In recent years, geo-tourism has become one of the most

remarkable sources of income for countries due to its various economic, cultural, social, political and environmental dimensions.

Iran's geomorphic features make it well-suited for geotourism, due to the size and diversity of its landforms. These features include mountains, volcanoes, water formations, islands and other natural factors ([Amri Kazemi and Mehrpooya 2006](#), [Yazdi et al. 2014](#)). Iran is home to 1,500 mountains exceeding 3,000 meters and 600 peaks rising above 4,000 meters. Some of the most notable mountains for geotourism include Mount Damavand, Alamkuh, Sabalan, and Taftan, each offering unique natural and geological attractions. The southern regions of the Zagros Mountains, characterized by large anticlines and calcareous formations, are home to numerous canyons and narrow capes, with some of the most stunning examples found in Fars Province. In western Iran, at the foot of Mount Kabirkuh, the world's largest landslide took place with massive sliding mass covering a distance of 50 km ([Amri Kazemi and Mehrpooya, 2006](#); [Yazdi et al. 2013](#), [Yazdi et al. 2024](#)). There are several landforms related to volcanic or igneous activities. These include lava flows, lava rivers, basaltic columns, craters, and volcanic villages. Hexagonal basalt columns are found in various regions across Iran. The country features several volcanic craters, including a collection of fourteen oval and circular craters found in the Rayen region. Iran is rich in water features, including a variety of lakes, waterfalls, and mineral springs. Additionally, it offers a diverse range of landforms with significant geotourism potential, such as mud volcanoes, salt domes, caves, sinkholes, deserts, and chimney rocks. Semnan Province enjoys numerous salt-related tourism attractions, helping the province emerge as a salt tourism hub in Iran ([Maqsoodi and Arab Ameri 2017](#)).

The terms geo-site and geopark were coined by the Geosciences Department of UNESCO (United Nations Cultural and Social Organization) at the beginning of 2000 ([Dowling and Newsome 2010](#)). This appeared to be the starting point of a big movement in some countries. UNESCO began proposing identification and introduction of locations of geological value worldwide to Geological Surveys. At present, 213 geoparks are found in 48 countries. China ranks first with 41 geoparks; Spain follows in the second place with 11; Japan and France are tied for third with 10 each; Italy and England are tied for fourth with 9 each; Germany ranks fifth with 6; and Greece ranks sixth with 3 geoparks (2024). Upon the call of UNESCO, the Iranian Geological Survey (Geological Survey and Mineral Exploration of Iran) began identification and introduction of geological phenomena ([Amri Kazemi 2018](#), [Nekouie Sadry 2021](#)). A number of three geoparks have consequently been registered

internationally as the Qeshm, Tabas and Aras geoparks. As a result, Iran is the only country in the Middle East with three global geoparks. Considering the vast and diverse landscape of Iran, geoscientists and geology educators will persist in their efforts across the country to identify and promote potential sites as new geoparks.

### 3. Materials and Methods

#### 3.1. Geographical location and natural conditions

The study covers the entire province of Semnan. It coordinates E51°51', to 57° 3' and N34°, 13' to 37°20' (Fig.1). The province is ~96800 km<sup>2</sup> in area and includes 8 cities, 21 townships, 31 villages and 2318 rural districts. It is located on the southern slopes of Alborz highlands and its height decreases northward to southward and terminates in the plain and desert. The most important heights are Shahvar, Khosh Yilaq and Khiashak peak with an altitude of 3000 m, 2802 m, and 2,670 m respectively. The scattered southern mountains of Semnan Province, which consist of hills of the Late Tertiary, have developed plains such as Garmsar, Ivankey, Chaleh Damghan, Mayamey, and the Shahroud alluvial fan (Fig. 1). Semnan's climate is chiefly denoting a hot mediterranean climate. At Semnan, the summers are sweltering, arid,

and clear and the winters are very cold, dry, and mostly clear. Over the course of the year, the temperature typically varies from -0°C to 37°C and is rarely below -5°C or above 40°C. the highest occurrences of cold waves occurred in Semnan City with a fairly long-term duration. Moreover, Shahmirzad, Shahroud and Miamey stations recorded the lowest minimum temperature (<-14 °C) (Soltani et al. 2023). Vegetation types in the study area was most strongly correlated with some soil characteristics such as salinity, texture, available water, lime and gypsum. The most species richness families were Poaceae, Asteraceae, Lamiaceae, respectively. Also, the genus *Bromus*, *Salsola*, *Stachys* and *Prunus* and *Chenopodium* are the largest genera in the region (Zakeri et al. 2020).

#### 3.2. Geology of Semnan province

The area of Semnan province can be divided into several structural-sedimentary units that are as follows: A) The area nown as Alborz, which is a part of the southern slope of Alborz mountains with rough morphology. The oldest rocks in this section are shale and sandstone (Precambrian). Upper Triassic-Jurassic rocks include limestone, dolomite, siltstone, shale and sandstone.

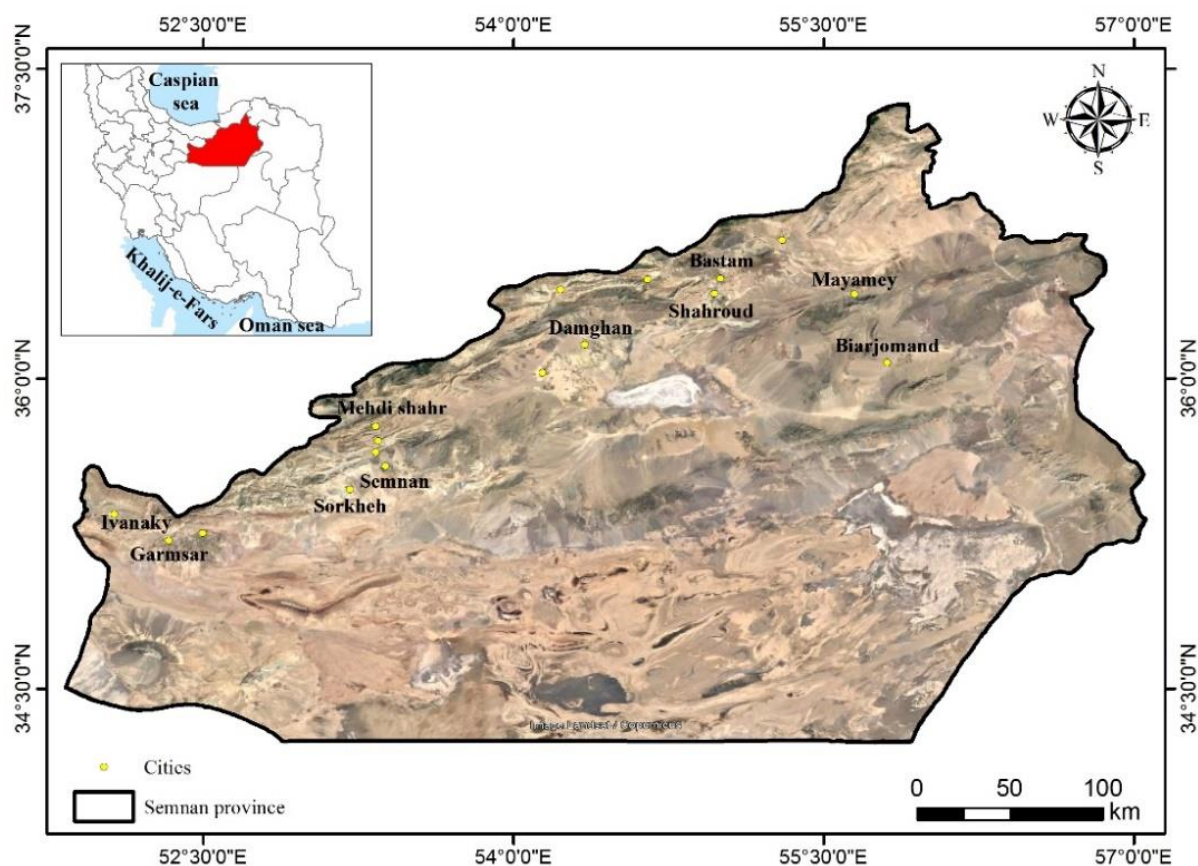
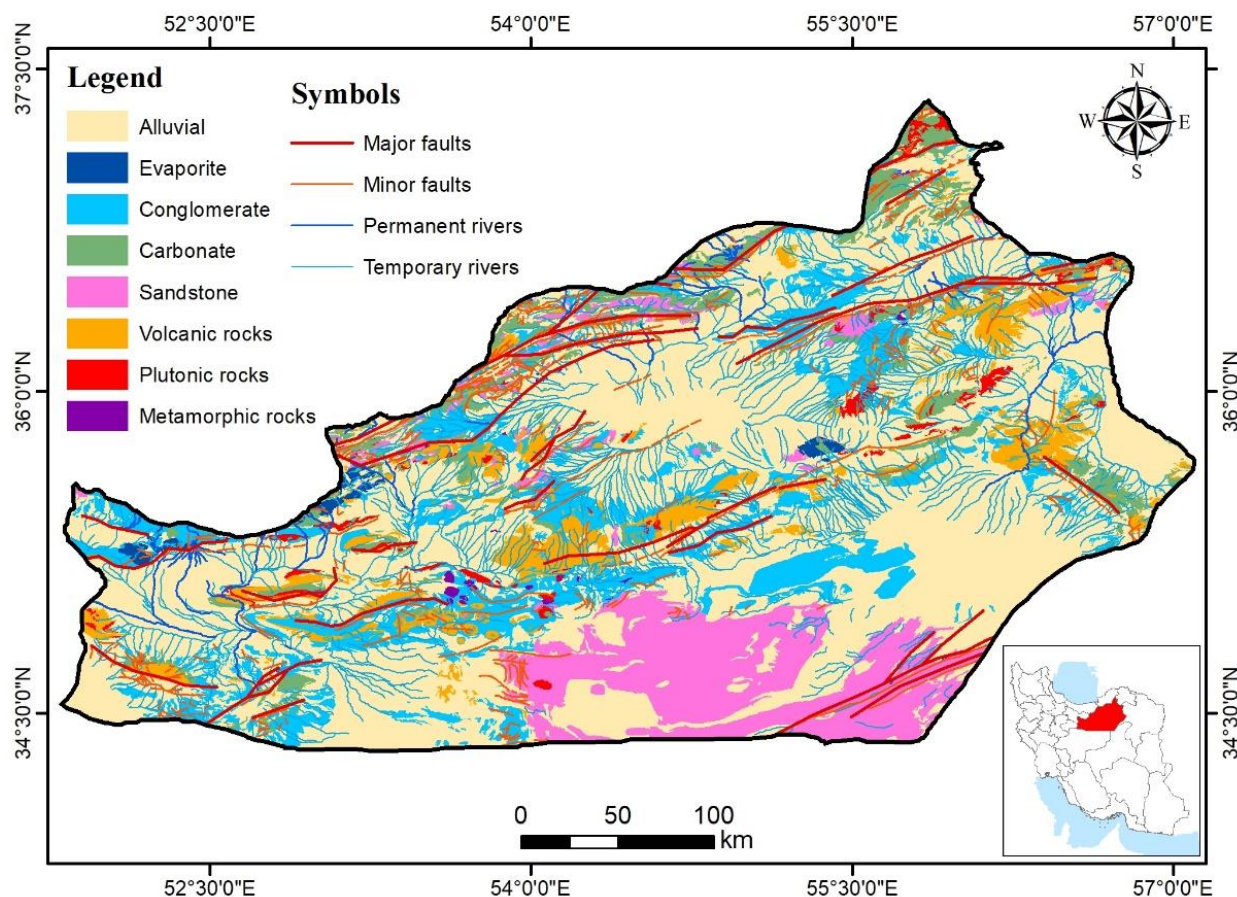


Figure 1. Geographical location of study area (Satellite image from Google Earth)





**Figure 2.** Simplified geological map of Semnan Province (compiled and simplified from 1:100,000 and 1:250,000 geological maps, Geological Survey and Mineral Exploration of Iran)

The volcanic rocks of this group mainly belong to the Ordovician-Devonian period. The Upper Triassic-Middle Jurassic units are mainly shale and coal bearing sandstones, and the Middle Jurassic to Upper Cretaceous units are limestone and marl. Cenozoic units include conglomerate, limestone, pyroclastic and quaternary deposits (Aghanabati 2014, Ghorbani 2021). This area includes large deposits of chalk and salt domes. B) ophiolitic zone (Froumad) in the northeast of the province, which is of interest from the point of view of economic geology in terms of chromite deposits. C) Abbas Abad volcanic rocks, which includes andesite-basalt, explosive lavas of tuff and agglomerate types, and large copper deposits. D) Toroud metamorphic complex (Late Precambrian-Middle Triassic) which extends from the northeast of Toroud to the south of Abbas Abad, in a northeast-southwest trend. Younger rocks are volcanic lava and intrusive bodies of Eocene, Oligocene (Fig. 2). A simplified map from geological maps (scale 1:100,000 and 1:250,000) of Geological Survey and Mineral Exploration of Iran is presented in Figure 2. Astana and Damghan faults are among the most important faults on a regional

scale. Semnan province, with its diverse mineral reserves and exploitation of about 40 types of minerals, has the first rank in terms of gypsum, salt, celestine and zeolite production, the second rank in sodium sulfate production, the third rank in coal and chromite production and it is one of the top three provinces in coal production.

### 3.3. Methods

The implementation of this research includes desk studies and collection of available information, satellite imageries, 1:100,000-scale topographic and geological maps and 1:250,000-scale geological maps (Fig. 3). Field investigations includes visit, identification and inventory of pre-geosites using GPSmap 62s.GARMIN, and then evaluation of these phenomena and ultimately selection of pre-geosites using the AHP and by means of the Expert Choice platform. In the last stage, pre-geosites were quantitatively evaluated using the Brilha approach (2016), and an appropriate range were proposed based on the obtained results and the potential of the research area as a national geopark in the southeast and west to southwest of the province.

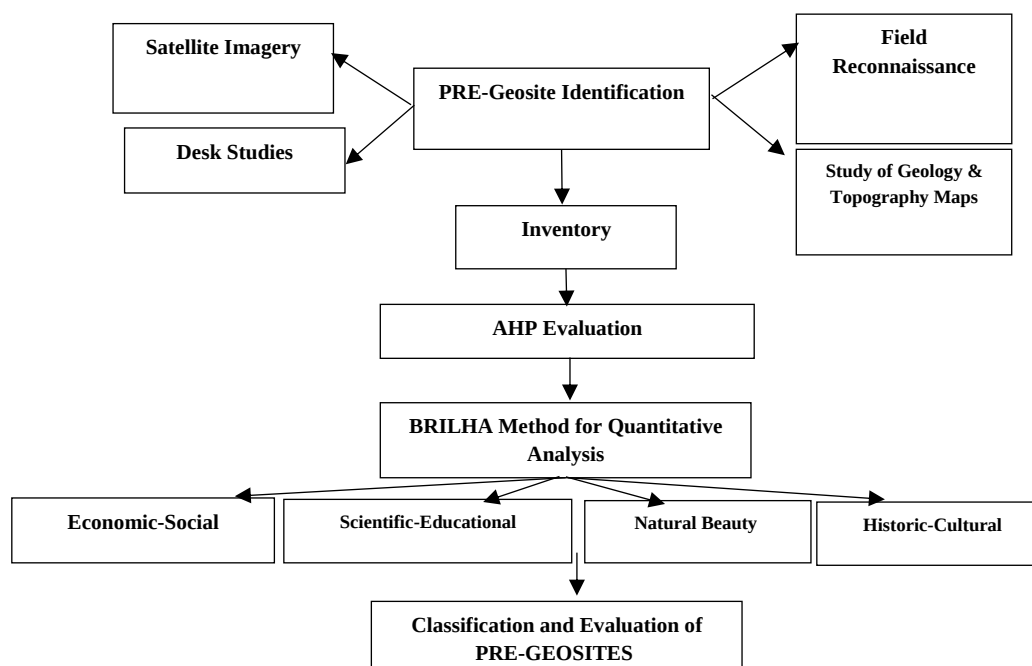


Figure 3. Flowchart of desk and field stages of study

1-The inventory system in each country should be fulfilled on local scale and based on geological, social and cultural characteristics, laws and regulations, and evaluation system. On the other hand, the purpose and scale of the study area in order to undertake the inventory practice is essential (Haami Motlagh et al. 2021). Before starting the inventory, the project objectives need to be unequivocally defined pondering the four following parameters (Lima et al. 2010).

- **Subject:** geological heritage,
- **Value:** pre-geosite usage, which can be touristic, recreational, medical or educational,
- **Scale:** hinges upon the extent of the inventory range (in this study as a geopark in a part of the province),
- **Application (goal):** inventory with the ultimate goal of identification and introduction of geoparks' potential and development of geo-tourism,

2- Inventory of pre-geosites, collection and investigation of the geological information of the region, checking and studying the articles and maps related to the target area and finally preparation of a preliminary list of geosites in the area.

3- Field visits and surveys: Field visits at this stage were undertaken to meet two principal goals: A) Identification and determination of the specifications and features of pre-geosites on the initial list, and B) Identification of new pre-geosites.

Preparation of the final list of geosites with complete specifications of listing can be done in two systematic and scattered ways, which is done in this research. A sample

of the proposed form (listing) of natural attractions and geo-tourism in the research area is presented in Figure 4.

#### 4. Discussion

The evaluation model invented by Brilha in 2016 is one of the most rigorous approaches in the field of quantitative evaluation of potential geosites (pre-geosites), which includes the evaluation of scientific, educational, touristic, and recreational criteria. Each criterion consists of a number of indicators. In this research, three types of practical values (scientific, educational, geotourist-recreational) are considered over field visits for qualitative evaluation of pre-geosites. The inventory of natural and geological attractions of Semnan Province by the authors of this work resulted in the identification of > 100 natural and geological geosites, i.e., spiritual, cultural, historical and economic heritage whose general characteristics include the local name of the phenomenon, and coordinates. Tables 01 and 02 represent the general specifications of the sites, geographic coordinates, and the relative township/location. The qualitative evaluation criteria for the value of the geotourist-recreational potential of the geosite in the study area are as follows:

- 1) Landscape: The proposed site should possess the visual beauty of the geological event.
- 2) Interpretation potential: It should possess the potential to help readily understand the geological phenomenon for ordinary people.
- 3) Accessibility: The proposed geosites should provide the general public with easy access.

| Research Plan of Doctoral Dissertation (Ph.D.)<br>The ID of Geotourism Attractions<br>Semnan Province (Inventory) |                                                                                                                      |
|-------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|
| 1-Geo-site title:                                                                                                 | Kavir-e-Darreh Sorkh                                                                                                 |
| 2-Feature/Phenomenon type:                                                                                        | Geology-Tourist                                                                                                      |
| 3-Local name:                                                                                                     | Roya-ye-Kavir                                                                                                        |
| 4-Township:                                                                                                       | Sorkheh                                                                                                              |
| 5-Proximity to the nearest town:                                                                                  | 10km south of Sorkheh                                                                                                |
| 6-Proximity to the nearest village:                                                                               | 2km from Sorkheh                                                                                                     |
| 7-Approximate coordinates:                                                                                        | N 53° 13' 18.8", E 35° 29' 42.8"                                                                                     |
| Feature/Phenomenon type: Class:                                                                                   | Sedimentary, Sub-class: Erosional                                                                                    |
| 8-Tourist/Empirical/Educational Values:                                                                           | Educational-Tourist                                                                                                  |
| 9-Significance & value of the feature/phenomenon (expert view):                                                   | <input checked="" type="checkbox"/> Regional <input type="checkbox"/> National<br><input type="checkbox"/> Universal |
| 10-Hazards & risk of destruction:                                                                                 | Uncontrolled visits by tourists                                                                                      |
| 11-Facilities of/at the accommodation:                                                                            | Residences at the Kavir National Park                                                                                |
| 12-Registered as a national heritage?                                                                             | <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No; If yes:                                         |
| 13-Tourist attractions along the geological feature/phenomenon:                                                   | Delaazyaan Kavir, Sorkheh Kavir                                                                                      |
| Prepared by: Akbar Tavakkoli Raad, Feb. 2023                                                                      |                                                                                                                      |



Kavir Darreh(Roya-ye-Kavir)

Figure 4. Registration form for geological and geomorphological phenomena in Semnan province

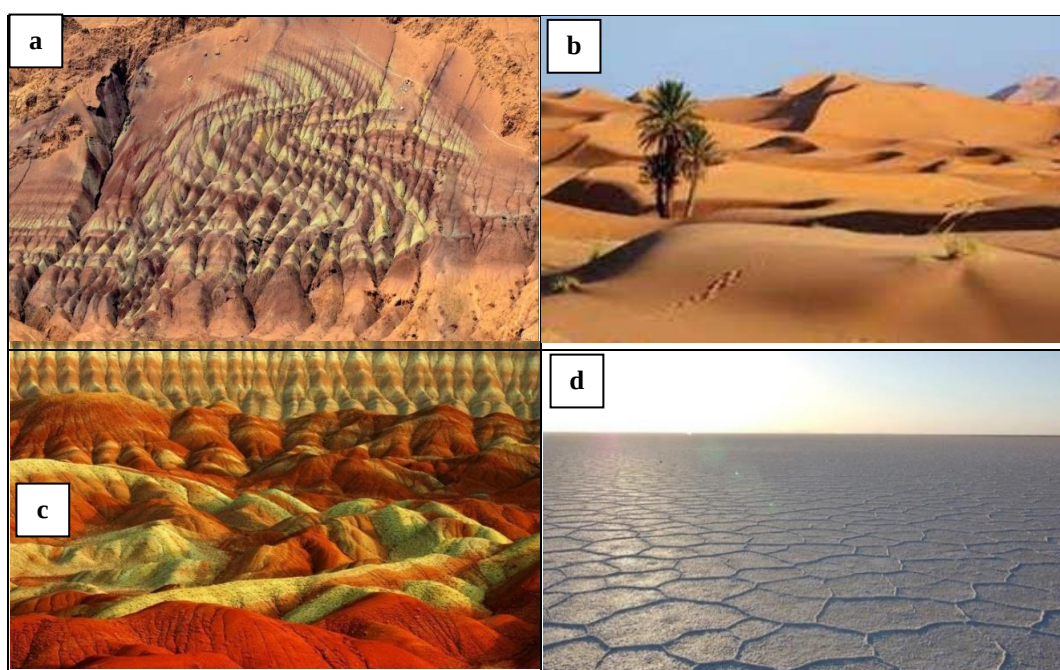


Fig 5. Natural &amp; geological heritage of Semnan Province; a: Dragon Mount-Garmsar; b: Delzyan Kavir-Semnan; c: Mars-Like Hills in Damghan; d: Hadj Ali Gholi Salt Lake-Damghan (Photo from Amri Kazemi 2013)

4) Safety: The proposed site has to be safe for the visitors.

#### 4.1. Pre-geosite selection steps to determine the proposed Geopark

Using the Brailha method, quantitative evaluation of geosites in the province to select natural and geological

attractions as privileged attractions in determining the proposed scope of the National Geopark was undertaken through focusing on the significance of educational usage and the usage of geo-tourism/recreation. 30 pre-geosites received the highest score out of 60 natural and geological pre-geosites (Tables 1 and 2). This number of attractions



became the basis for choosing the geopark area. The natural attractions of the province, e.g. international touristy cities (Mehdishahr and Shahmirzaad) and touristy villages (at least ten), wildlife habitats, Kavir National Park and conservation areas, as well as historical attractions (ancient Silk Road- Sangfarsh Road), cultural-religious attractions (museums and mosques) and economic attractions including: local products and rural handicrafts and the usage of massive resources of evaporate deposits (playa) such as titanium and various nitrates and chlorides in salt deserts each is listed in a separate table (Tables 3 and 4). Figure 5 illustrate images

of the natural and geological heritage of Semnan Province. Given the geographical coordinates of natural and geological attractions which have been investigated, the proposed area is determined and the area is selected as a national geopark.

The development of geo-tourism can bring many benefits to the private sector and local communities, especially villages that are active in tourism. In addition to presenting the basic justifications for the creation of a geopark in this province, the following are the results of this research.

**Table1.** Natural and geological attractions of Semnan Province

| No. | Attraction Type & Its LOCAL Title                               | X                     | Y          | City       | Remarks                                                    |
|-----|-----------------------------------------------------------------|-----------------------|------------|------------|------------------------------------------------------------|
| 1   | Salt domes- south of Semnan                                     | 53 15 25              | 35 08 26.5 | Semnan     |                                                            |
| 2   | Summit & mount of Shahvar                                       | 57 21 54              | 36 25 55   | Shahrour   | The highest in Eastern Alborz, 4000m                       |
| 3   | Padeh Salt Tunnels                                              | 52 32 13.2            | 35 15 10.6 | Aaradan    |                                                            |
| 4   | Paadeh Mars Mounds                                              | 52 32 13.1            | 35 15 10.7 | Aaradan    |                                                            |
| 5   | Nasravaa Watrefall                                              | 54 15 26.6            | 36 32 00   | Damghan    |                                                            |
| 6   | Moa'ilemaan Coloured Hills                                      | 54 32 41.5            | 35 10 25.3 | Damghan    |                                                            |
| 7   | Rashm Mars-like Hills                                           | 54 29 29.6            | 35 17 13.5 | Damghan    |                                                            |
| 8   | Shirband Cave                                                   | 54 19 35.6            | 36 18 30.6 | Damghan    |                                                            |
| 9   | Haadj Ali Gholi Salt Lake                                       | 54 44 26.1            | 35 54 54.7 | Damghan    |                                                            |
| 10  | Pir Khoshtar Waterfall                                          | 54 08 23.3            | 36 22 06.2 | Damghan    |                                                            |
| 11  | Ali Damghan Spring                                              | 54 05 00              | 36 16 39.6 | Damghan    |                                                            |
| 12  | Joveyn Spring(Laasjerd)                                         | 52 53 36.3            | 35 29 25.3 | Sorkkeh    |                                                            |
| 13  | Spa of Sorkkeh                                                  | 53 11 23.1            | 35 39 27.2 | Sorkkeh    |                                                            |
| 14  | Desert of Rig-e-Jen (clot of ghost)                             | 53 22 34.1            | 34 37 48.8 | Sorkkeh    | Iranian so-called Bermuda Triangle                         |
| 15  | Desert of Sorkkeh Ravine                                        | 53 13 18.7            | 35 29 42.7 | Sorkkeh    |                                                            |
| 16  | Oghaab-e-Sangi(Rock/Stone Easel) of the desert of Sorkkeh Mount | 53 56 11.9            | 36 06 50.5 | Semnan     |                                                            |
| 17  | Mars-like hills                                                 | 53 51 17.9            | 36 01 22.6 | Damghan    | Todarvar Village<br>Conservation area                      |
| 18  | Toroud Desert(Sand Dunes)                                       | 55 00 58.7            | 35 25 35.4 | Shahrour   |                                                            |
| 19  | Modjen Haftang Springs                                          | 54 43 03.4            | 36 32 27.1 | Shahrour   |                                                            |
| 20  | Kavir-e- Chaah Jam                                              | 55 07 00              | 35 45 03   | Shahrour   |                                                            |
| 21  | Modjen Wtarefall                                                | 54 33 06.5            | 36 28 47.7 | Shahrour   |                                                            |
| 22  | Semnan spas                                                     | 53 11 23.1            | 35 39 26.8 | Semnan     | Moraad Aab, Goraab, Gholandj                               |
| 23  | Delaaziaan Sulphur Mine                                         | 53 29 40.1            | 35 19 36.6 | Semnan     |                                                            |
| 24  | Melheh Salt Mine                                                | 53 43 28.9            | 35 22 28.6 | Semnan     |                                                            |
| 25  | Salt Waterfall of Kavir National Park                           | 52 26 47.5            | 34 36 37.9 | Garmsar    | In the south of Nakhjir heights                            |
| 26  | Salk Lake of Gramsaar(Saleenaa)                                 | 51 54 33.9            | 34 33 09.3 | Garmsar    |                                                            |
| 27  | Zolamaat Ravine of Garmsar                                      | 52 41 54.8            | 34 24 46.7 | Garmsar    |                                                            |
| 28  | Delaaziaan Kavir                                                | 53 23 10              | 35 17 28   | Semnan     | Spectacular yardangs<br>abandoned section of Koohdash Mine |
| 29  | Garmsar Salt Cave                                               | 52 09 16.1            | 35 14 58.6 | Garmsar    |                                                            |
| 30  | Khosh Aabrood Valley                                            | 52 46 13.5            | 35 24 16.1 | Garmsar    |                                                            |
| 31  | Kelerz Peak                                                     | 52 17 01.2            | 35 20 31.4 | Garmsar    | 2200 m in height                                           |
| 32  | Kavir of Safaaieyeh                                             | 53 03 33.5            | 35 06 39.4 | Garmsar    |                                                            |
| 33  | Salt Cave of Boneh Kooh                                         | 52 09 17.8            | 35 14 49.1 | Garmsar    |                                                            |
| 34  | Ejdehaa/Ranginkamaan Mount(literally Dragon/Rainbow)            | 52 19 59.7            | 35 15 40.3 | Garmsar    | One of the most spectacular geological phenomena           |
| 35  | Koohdasht Salt Mine                                             | 52 04 19.6            | 35 14 25.8 | Garmsar    |                                                            |
| 36  | Opert                                                           | 53 21 02              | 36 02 26.5 | Mahdishahr |                                                            |
| 37  | Opert Spring                                                    | 53 23 27.5            | 36 03 09   | Mahdishahr |                                                            |
|     |                                                                 | 10km north of Damghan |            | Damghan    | Index fault of Deh Maal                                    |
| 39  | Garmsar Fault                                                   | --                    | --         | Garmsar    | Scientific-educational tourism                             |
| 40  | Roozieh Spring                                                  | 53 11 03.8            | 35 51 10.1 | Mahdishahr |                                                            |

**Table1.** Natural and geological attractions of Semnan Province (Continued)

| No. | Attraction Type & Its LOCAL Title   | X                     | Y          | City       | Remarks                                                                        |
|-----|-------------------------------------|-----------------------|------------|------------|--------------------------------------------------------------------------------|
| 41  | Roozieh Waterfall                   | 53 11 34.1            | 35 51 55.2 | Mahdishahr |                                                                                |
| 42  | Darband Cave in Mahdishahr          | 53 21 09.5            | 35 44 56.3 | Mahdishahr | One of the biggest calcerous caves in Iran Mahdishahr (literally Black Valley) |
| 43  | Siaah Darrehin                      | 53 17 37.7            | 35 44 29   | Mahdishahr |                                                                                |
| 44  | Lezooreh Spring                     | 52 45 32.1            | 35 30 32.6 | Aaradan    |                                                                                |
| 45  | Torood Fault                        | --                    | --         | Shahrour   | Scientific-educational tourism                                                 |
| 46  | Molhedoo Cave                       | 55 58 47.4            | 35 59 43.7 | Shahrour   |                                                                                |
| 47  | Chaah Moosaa Copper Mine            | 54 52 50.2            | 35 29 04.7 | Shahrour   |                                                                                |
| 48  | Naam Nik Waterfall                  | 55 40 45.2            | 37 07 42.6 | Mayamey    |                                                                                |
| 49  |                                     | Mayamey-Shahrour road |            | Mayamey    | Over 120km                                                                     |
| 50  |                                     | SE of Semnan          |            | Mayamey    | Scientific-educational tourism                                                 |
| 51  | Angoorestaan & Gholgholi Spring     | 53 49 45.5            | 36 02 17.6 | Damghan    |                                                                                |
| 52  | Siaah Kooh & Davaazdah Emaam Mounts | 52 13 29.6            | 34 41 56.9 | Garmsar    | In Kavir National Park                                                         |
| 53  | Kavir Darreh                        | 53 13 18              | 35 29 42   | Garmsar    | Iranian so-call Grand Canion                                                   |
| 54  | Summit & Mount of Neyzevaa,         |                       |            | Mahdishahr | Alam Kooh of Semnan-3810m                                                      |
| 55  | Ghadamgaah Summit                   | 53 05 32              | 35 53 41   | Mahdishahr | Hiking camp                                                                    |
| 56  | Salt Dolphins(Melheh Namak)         | 53 43 29              | 35 22 28   | Semnan     | In Melheh Salt Mine                                                            |
| 57  | Abbaas Aabaad Copper Mine           | 56 24 12.6            | 36 23 52.4 | Mayamey    |                                                                                |
| 58  | Nekaarman Waterfall                 | 54 47 58              | 36 33 22   | Shahrour   | Shaahvaar Mount slope                                                          |
| 59  | Abarsedj Waterfall                  | 54 53 08              | 36 36 42   | Shahrour   | Aroos-e-Sefidpoosh                                                             |
| 60  | Gol-e-Roodbaar Spring               | 53 41 48.7            | 35 41 48   | Mahdishahr |                                                                                |

**Table 2.** Geodiversity of Semnan Province

| Township                | Springs         | Spectacular Geological Phenomena            | Index Fault                 | Mines/ Quarries            | Waterfalls         | Crvaes                | Mars-Like Hills of Ejdehaa Mount | Deserts & Sand Dunes | Playa & Salt Lakes | Salt Domes                                | Salt Tunnels & Caves    |
|-------------------------|-----------------|---------------------------------------------|-----------------------------|----------------------------|--------------------|-----------------------|----------------------------------|----------------------|--------------------|-------------------------------------------|-------------------------|
| Sorkheh                 | Spas**          | Kavir Darreh***                             |                             |                            |                    |                       |                                  |                      |                    | Salt domes***                             |                         |
| Aaradan                 |                 |                                             |                             |                            |                    |                       |                                  |                      |                    | Salt domes***                             | Heliotherapy tunnels*** |
| Mehdishahr              | Dardjazin Spa** | Geological Fold of the North of Shahmirzaad |                             |                            | Rooziey Waterfall  | Darband Cave***       |                                  |                      |                    |                                           |                         |
| Garmsar                 |                 | Khosh Aabrood Valley, Zolamaat Ravine       | Garmsar Fault**             | Koohdasht Salt Mine        | Nabee Waterfall    | Naft Drreh alt Cave** | Ejdehaa Mount+Mars-like Hill**   |                      | Saleenaa Salt Lake | Salt domes***                             | Salt caves**            |
| Semnan                  |                 | Stone Eagle**                               | Deaazyaan & Attaari fault** | Melheh Salt Mine***        |                    | Aftar Cave**          |                                  | Khooryaan Kavir***   |                    | >40 Salt domes in the south of Semnan**** |                         |
| Damghan                 | Cheshmeh Ali**  | Salt Lake                                   | Deh Mollaa Fault**          | Turquoise Mine of Baaghoo  |                    | Shirband Cave***      | Mars-like Hills***               | Yazdaan Aabaad***    | Haadj Ali Gholj*** |                                           |                         |
| Shahrour                | Taash**         | Shaahvaar heights**                         | Torood Fault**              | Tazareh Coalliery**        | Modjen Waterfall** |                       |                                  | Torood Kavir***      |                    |                                           |                         |
| Mayamey                 |                 | Ghebleh Mount **                            | Mayamey Fault **            | Abbaas Aabaad Copper mines |                    |                       |                                  |                      |                    |                                           |                         |
| Universal Phenomena**** |                 |                                             | National***                 |                            |                    | Local**               |                                  |                      |                    |                                           |                         |



**Table 3.** Complementary attraction of Semnan (historical, cultural, social)

| No. | Township                    | Latitude                                       | Longitude  | Attraction Type & Its Local Title              | Remarks                                                                    |
|-----|-----------------------------|------------------------------------------------|------------|------------------------------------------------|----------------------------------------------------------------------------|
| 1   | Amiriyeh Township (Damghan) | 35 28 43.2                                     | 52 43 21.8 | Baby-in-flowers tradition                      | Nationally registered as the 1 <sup>st</sup> spiritual heritage & courtesy |
| 2   | Semnan                      | 35 43 33                                       | 53 31 32   | Mausoleum of Prophets                          | A reguistered national heritage                                            |
| 3   | Garmsar                     | 34 44 05                                       | 52 07 09.2 | Ghasr-e-Bahraam Caravansary                    | Registered in 1975 as a national heritage                                  |
| 4   | Garmsar                     | 35 02 53.4                                     | 52 19 27.9 | Sangfarsh Road(literally Cobblestone)          |                                                                            |
| 5   | Garmsar                     | 35 15 11.6                                     | 52 44 00   | Dehnamak Village                               | Outstanding touristy spot                                                  |
| 6   | Garmsar                     | 34 44 45.9                                     | 52 09 46.6 | Eyn-Ulrashid Caravansary                       | Nationally registered in 1945                                              |
| 7   | Garmsar                     | 35 14 25.7                                     | 53 03 10.8 | Safaaieyeh Village                             |                                                                            |
| 8   | Mehdishahr                  | 35 53 48.8                                     | 53 15 29.4 | Djaashm Village                                |                                                                            |
| 9   | Mehdishahr                  | 35 39 15.1                                     | 53 20 16.4 | Dardjazin Township                             | The oldest sycamore in Iran                                                |
| 10  | Mehdishahr                  | 35 54 02.1                                     | 53 05 59.7 | Khatir Kooh Village (Djaashm)                  | Outstanding touristy village                                               |
| 11  | Mehdishahr                  | 35 53 41.3                                     | 53 05 32.3 | Kamrood Village                                |                                                                            |
| 12  | Mehdishahr                  | 36 00 16.4                                     | 53 20 00   | Heeko Village                                  | Forrest & mountainous ecosystem                                            |
| 13  | Mehdishahr                  | 36 00 39.1                                     | 53 23 12.2 | Sheli Village                                  | Forrest & mountainous ecosystem                                            |
| 14  | Mehdishahr                  | 35 46 39.6                                     | 53 18 40.9 | Shir Ghal'eh                                   | Ashkaanids Era                                                             |
| 15  | Mehdishahr                  | 35 42 58.2                                     | 53 15 55.3 | Kafer Ghal'eh                                  |                                                                            |
| 16  | Mehdishahr                  | 36 02 19.9                                     | 53 24 38.5 | Molladeh Village                               | Outstanding touristy village                                               |
| 17  | Semnan                      | 35 29 44.9                                     | 53 24 25.2 | Delaaziaan Village                             | Outstanding touristy village                                               |
| 18  | Shahrud                     | 36 00 07.3                                     | 56 00 07.3 | Ghal'eh Baalaa in Biaardjmand                  | Outstanding touristy village                                               |
| 19  | Shahrud                     | 35 35 33.4                                     | 56 46 32.9 | Zamaan Aabad in Biaardjmand                    |                                                                            |
| 20  | Shahrud                     | 35 56 29.4                                     | 56 40 54   | Reza Aabaad in Biaardjmand                     |                                                                            |
|     | Shahrud - Damghan - Semnan  | At/along the north of Shahrud, Damghan, Semnan |            | Silk Road                                      |                                                                            |
| 22  | Mayamey                     | 36 24 35.8                                     | 55 39 11.9 | Shaah Abbaasi Caravansary                      |                                                                            |
| 23  | Mayamey                     | 36 25 55.3                                     | 56 03 35.3 | Shaah Abbaasi Caravansary                      |                                                                            |
| 24  | Mayamey                     | 36 30 57.8                                     | 56 44 59   | Foroomad Village                               | Outstanding touristy village                                               |
| 25  | Semnan                      | 35 29 44.9                                     | 53 24 25.2 | Mirak Square(Delaazyaan)                       | Ancient area                                                               |
| 26  | Shahrud                     | --                                             | --         | Wildlife Conservation of Khaartooraan          | Habitat of Iranian leopard                                                 |
| 27  | Garmsar                     | --                                             | --         | Kavir National Park                            | The biggest desert in Iran                                                 |
| 28  | Garmsar                     | 36 03 31                                       | 53 29 15   | Fenisk & Roodbaarak forests                    |                                                                            |
| 29  | Mehdishahr                  | 35 58 50                                       | 53 29 35.6 | Conservation of Parvar                         |                                                                            |
| 30  | Mayamey                     | Mayamey                                        | 55 45 54.8 | Dasht-e-Shaad Forrest                          |                                                                            |
| 31  | Mayamey                     | Kaalpoosh Touristy Area                        |            | Sunflowers & Copse                             | Ecotourism of Kaalpoosh Village                                            |
| 32  | Damghan                     | 35 54 55                                       | 54 44 26   | Salt lake playa                                | A lucrative economic source                                                |
| 33  | Aaradan                     | 35 15 10.7                                     | 52 32 13   | Paadeh Village, an ancient castle & Salt mines | Outstanding touristy village                                               |
| 34  | Sorkheh                     | 35 29 24.5                                     | 52 53 36   | Gabri's Castle                                 | Nationally registered as a heritage                                        |
| 35  | Sorkheh                     | 35 24 13                                       | 53 04 58   | Laasdjerd Caravansary                          | Nationally registered as a heritage                                        |
| 36  | Sorkheh                     | --                                             | --         | Ancient castles of Sorkheh                     |                                                                            |
| 37  | Semnan                      | 35 43 33                                       | 53 31 32   | Mausoleum of prophets                          |                                                                            |
| 38  | Semnan                      | 35 46 15                                       | 53 43 56.5 | Aahovaan Stone Caravansary                     | 5 <sup>th</sup> Century Hidjri                                             |
| 39  | Damghan                     |                                                |            | Lake of Shaahcheraaghi Dam                     | Touristy attraction                                                        |
| 40  | Shahrud                     |                                                |            | Torood Village                                 |                                                                            |
| 41  | Garmsar                     | 35 14 49.1                                     | 52 09 17.8 | Boneh Kooh Touristy spot                       | Outstanding touristy spot                                                  |
| 42  | Shahrud                     | 36 33 22                                       | 54 47 58   | Negaarman Waterfall                            |                                                                            |
| 43  | Damghan                     | 35 17 14                                       | 54 29 29   | Rashm Village                                  | Outstanding touristy village                                               |
| 44  | Damghan                     | 36 01 22                                       | 53 51 18   | Tooyeh Darvaar Village                         | Outstanding touristy village                                               |
| 45  | Shahrud                     | 36 34 47                                       | 54 45 50   | Farahzaad Touristy spot                        | Hafrang springs                                                            |
| 46  | Shahrud                     | 36 28 46                                       | 54 38 51   | Modjen Touristy Complex                        | Maasoolah in Semnan                                                        |
| 47  | Aaradan                     | 35 28 43.2                                     | 52 43 21.8 | Raameh Baalaa Village                          | Outstanding touristy spot                                                  |
| 48  | Mehdishahr                  | North of Semnan                                |            | Eel-e-Sangsar nomads                           | An invaluable treasure of culture & tourism                                |
| 49  | Damghan                     | Damghan                                        |            | Sasanids Tarikhaaneh Mosque                    | Nationally registered in 1921                                              |
| 50  | Damghan                     | Damghan                                        |            | Tappeh Hesaar Sasanids Palace of               | 7000 years of Iranian civilisation                                         |

**Table 4.** A number of natural, historical, cultural, & economic attraction of the Semnan Province

| Township/<br>Attraction     | Local Products                                                  | Cultural-Religious                                                              | Historical                                                                                               | Natural                                                                                                   | Remarks                                                                                |
|-----------------------------|-----------------------------------------------------------------|---------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|
| Garmsar                     | Handicrafts                                                     | -Ethnics Museum<br>-Garden-Museum<br>of Science &<br>Industry                   | -Sangfarsh Road<br>--Ghasr-e-Bahram<br>-The Baghery's-                                                   | -Kavir Nationa Park<br>-Behvard(geo-site)                                                                 | Large reserves<br>of salt and<br>gypsum                                                |
| Aaradan                     | Agricultural<br>products: wheat,<br>cotton, animal<br>husbandry | -Aaradan Mosque<br>-Sultan Abusaed<br>Imam offspring                            | --Yateri Castle<br>-Ali Aabaad Cistern<br>-Cistern &<br>caravansary of<br>Dehnamak                       | -Outstanding touristy<br>village of Paadeh<br>-Ghalibafan Village<br>-Lezooreh springs                    |                                                                                        |
| Sorkheh                     | -Kelim & djaadjim<br>-Baskets                                   | -Grand Mosque of<br>Chehelsotoon<br>-Imam Haadi<br>Mosque                       | -Laasdjerd<br>caravansary<br>-Jahaan Aabaad<br>Castle                                                    | -Touristy village of<br>Biabanak                                                                          | Lasdjed<br>caravansary<br>registered as a<br>national<br>heritage                      |
| Mehdishahr &<br>Shahmirzaad | -Orchard produce<br>like walnuts &<br>pomegranate               | -Almahdi Mosque<br>- Eel-e-Sangsar<br>Nomads Moseum<br>-Kharand Ancient<br>Area | Ancient structures:<br>-Shir Ghal'eh<br>-Ghal'eh Sheykhi                                                 | -Outstanding touristy<br>& international town<br>-Parvar Conservation<br>-Roodbaarak Village<br>& Forrest |                                                                                        |
| Semnan                      | -Rug & kelim<br>-Pottery & ceramics<br>-Felt products           | -Sultaani Mosque<br>(Imam)<br>-Saroo castles                                    | -Silk Road<br>-Ahovaan Stone<br>Castle<br>-Arg Gate<br>-Old Baazaar of<br>Semnan                         | -Sookaan Forrest Park<br>-Khosh Aabrood<br>Valley                                                         | World<br>registration of<br>Ahovan<br>caravanserai<br>Large reserves<br>of salt        |
| Damghan                     | -Pistachio<br>-Kelim & Djaadjim<br>-Felt products               | -Taarikhaaneh<br>Mosque<br>-Mehmaandoost<br>Tower                               | -Dowlat Aabaad<br>Castle<br>-Gerdkooy Castle<br>-Teppeh Hesaar<br>Historic spot                          | -Cheshmeh Ali<br>-Cheshmeh Gholghol                                                                       | Pistachio of<br>Damghan is a<br>famous<br>produce                                      |
| Shahroud                    | -Pottery<br>-Kelim & djadjim<br>weaving<br>-Needlework          | -Shahroud Museum<br>-Sheykh Aliakbar<br>Mosque<br>-The Yaghmaiee's              | -Historical Complex<br>of Baayazid Bastami<br>-Sheykh Abolhasan<br>Kharghaani<br>Complex<br>-Old Baazaar | -Khaartooran the<br>most famous habitat<br>for leopards<br>-Torood Palm<br>-Khosh Yilaq<br>Conservation   | Grapes &<br>vinyards of<br>this city are<br>famous                                     |
| Mayamey                     | -Djaadjim<br>-Traditional hand-<br>woven crafts                 | -Anthropology<br>Museum<br>Grand Mosque                                         | -Mayamey<br>caravansary<br>-Abas Aabad<br>caravansary                                                    | -Copse Meadow<br>-Sunflower Meadow<br>-Dasht-e-Shad                                                       | Global<br>registration of<br>caravanserais<br>in Miami,<br>Abbas Abad<br>and Miandasht |

The results of the field visits, studies conducted, and the collection of data about the potential and capacities of the geo-tourism of Semnan province confirm the fact that this province, in addition to the mentioned natural and geological attractions, has a significant capacity in the tourism sector including but not limited to:

- Khartoran biosphere reserve with an area of more than one million hectares in the northeast of the province.
- Khosh Yeylaagh Shahroud wildlife sanctuary and Parvar protected area in the northwest of the province.
- Forests and pastures of the province cover more than four million hectares

- Rich economic resources including rural handicrafts, local agricultural products, large mineral deposits such as copper, coal, salt and gypsum and rich sources of evaporative sediments (playa) such as titanium salts, various nitrates and chlorides in the salt lakes of the province

- Mehdi Shahr-Shahmirzad international tourism “model area”

- The number of ten “model tourism villages”

- Global registration of 5 caravanserais in the province

- Numerous cultural and religious attractions: Semnan Jaame'e Mosque(the Great Mosaue), Historical Mosque (Damghan)

- The historical sites of Semnan province include: Mirak ancient hill (Delazian-Semnan), the Paleolithic site of Chah Jam and the historical site of Hesar hill located in the south of Damghan.

- Abandoned salt mines and salt tunnels in many countries of the world are attractive places for medical tourism and an important source of income, e.g. Wieliczka Salt Mine in the southeast of Krakov, Poland. The Polish Tourism Organisation has transformed this old and abandoned mine into a multi-purpose touristic place such as salt therapy suites, a museum, and entertainment halls/venues. With a brief reference made to the subject of salt therapy (heliotherapy) and the usage of tunnels and abandoned salt mines, the significance of paying attention to medical tourism in the west of Semnan Province and the necessity of planning and creating the necessary incentives for investment by private sector sounds quite obvious in this area.

The potentials and advantages of tourism, which were mentioned, leads to introduce Semnan province as a "model tourism province", that can easily replace Mazandaran and Gilan provinces for the multitude of travelers from the capital and neighboring provinces.

## 5. Conclusion

This research was conducted with the aim of identifying, recording, and conducting qualitative (AHP) and quantitative evaluation of potential geosites (pre-geosites) using the Braille method for 40 geological attractions that had received the highest score along with the complementary attractions including natural-historical, cultural-religious and economic attractions (local products). As illustrated, the cities of Semnan, Garmsar, Aaradan, and Sorkheh possess respectively a high and very good potential of salt domes and caves. Amongst the results of this research, in addition to providing justifications for creating a geopark, the following items are recommended:

1. Currently 3 geoparks, Qeshm, Tabas, and Aras have been registered globally, and so far, >31 regions have been identified as potential geoparks, therefore, it is suggested that the Ministry of Cultural Heritage, Tourism and Handicrafts should pay special attention to the nature-oriented tourism sector, which will be achieved by establishing the subsidiary bureau of Department of Geo-tourism.

2. Encouraging the investment by the private sector in order to form specialised geo-tourism agencies and tourism companies by holding geo-tourist guide training courses for geological experts in the centre of the province or cities that have sufficient and appropriate capacity to attract geotourists such as Shahroud and Damghan.

Formation of specialised geo-tourism firms/institutes can be fulfilled via the support and cooperation of the General Department of Cultural Heritage, Tourism and Handicrafts of the province.

3. Easy access to geosites: easy access to geological sites, providing suitable routes and transportation facilities, as well as barrier-free access, all play an important role in attracting tourists with physical disabilities, the elderly and families with children.

4. Efforts shall be made to introduce the capabilities of the province's geo-tourism by taking measures such as:

- Preparation of a comprehensive geo-tourism plan for Semnan Province by the General Department of Cultural Heritage, Tourism and Handicrafts can play an important role in the development of tourism in the province, including Nature-Based Tourism.

- Holding annual or biennial exhibitions of geo-tourism in order to introduce the natural attractions of the province

- Printing brochures and leaflets in order to inform the public of the natural attractions and geological diversity of Semnan Province,

5. Educating and familiarising local communities and villagers with the culture of tourism, encouraging and persuading them to create ecotourism places and creating the necessary conditions to offer local products to tourists.

- Loan payment and supporting the related organisations can play a perceptibly effective role.

6. Ensuring the security of geotourists, particularly international tourists, is one of the most important issues. In this regard, it is proposed to form a special tourism police unit consisting of graduates familiar with environmental and geological issues who intend to serve in the military service under the supervision of the Ministry of Cultural Heritage, Tourism and Handicrafts.

7. Construction of suitable residence in villages and geosites: instead of building multi-star hotels in the centre of the province and in other cities, private and public sector investors should build inns, eco-tourism suites and guest houses in the districts and villages with attractions. This is because wealthy tourists (nature lovers) prefer to stay in cottages by the forest and waterfalls or at salt home hotels rather than to stay in multi-star hotels.

8. Provincial authorities shall pay special attention to medical tourism with a focus on salt therapy

9. The valuable and positive effects of geo-tourism in the socio-economic and cultural fields of the province require that the government officials pay special attention to this sector and in terms of providing the necessary infrastructure for tourism, including communication routes within the province and establishing a regular schedule for local trains and flights from the provincial

capital and Shahroud to the capital and touristy cities of Isfahan, Shiraz, Mashhad, and Yazd.

#### Authors Contribution

All the authors have participated sufficiently in the intellectual content, conception, and design of this work or the analysis and interpretation of the data (when applicable), as well as the writing of the manuscript.

#### Availability of data and materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

#### Conflict of interest

The author states that there is no conflict of interest.

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