To appear in: Iranian Journal of Earth Sciences (Iran J. Earth. Sci.)

E-ISSN: 2228-785X Print ISSN: 2008-8779

Received: 16 August 2024 Revised: 9 December 2024

Accepted: 27 December 2024

DOI: https://doi.org/10.57647/j.ijes.2025.16971

Original Research

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

Akbar Tavakkoli Rad[1], Mohammad Ali Ganajavian[1]*, Reza Farrokhnejad[1], Saeed Saadat[2], Hasan Shadpoor[1]

1- Department of Geology, Shahrud Branch, Islamic Azad University, Shahrud, Iran

2- Department of Petroleum Engineering and Geology, Mashhad Branch, Islamic Azad University, Mashhad, Iran

*Corresponding author: m.ganjavian@gmail.com

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 41.33%. 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.

Keywords: *Nature-Based Tourism, Geo-tourism, Salt Dome, Analytic Hierarchy Process, Semnan*

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 (Yazdi et al. 2013, Yazdi et al. 2024).

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. Arabameri 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 and Shirazy (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). 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^2 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, Shahrood 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).

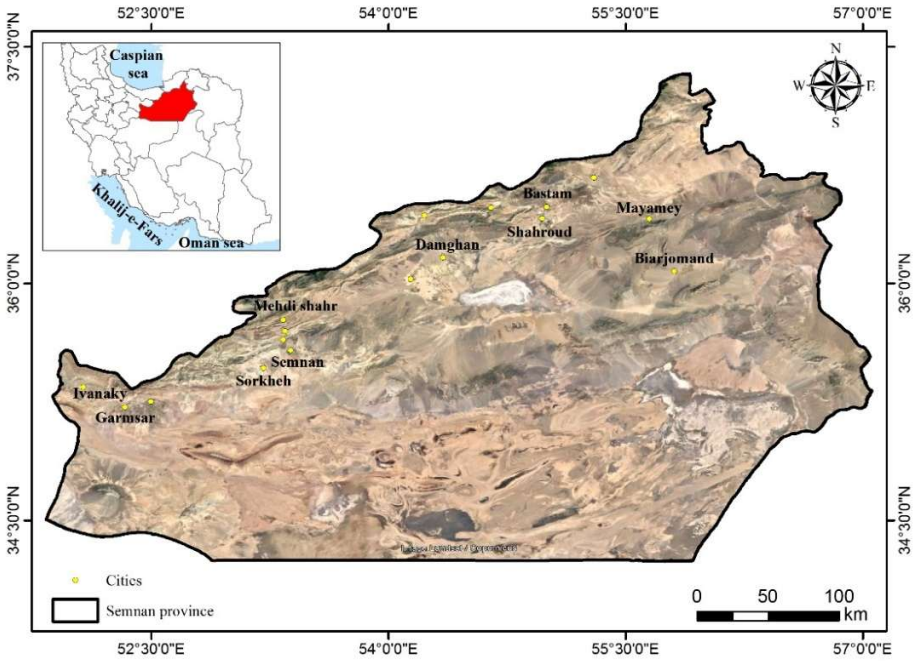

Fig. 1. Geographical location of study area (Satellite image from Google Earth)

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 known 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. 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 1:100000 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.

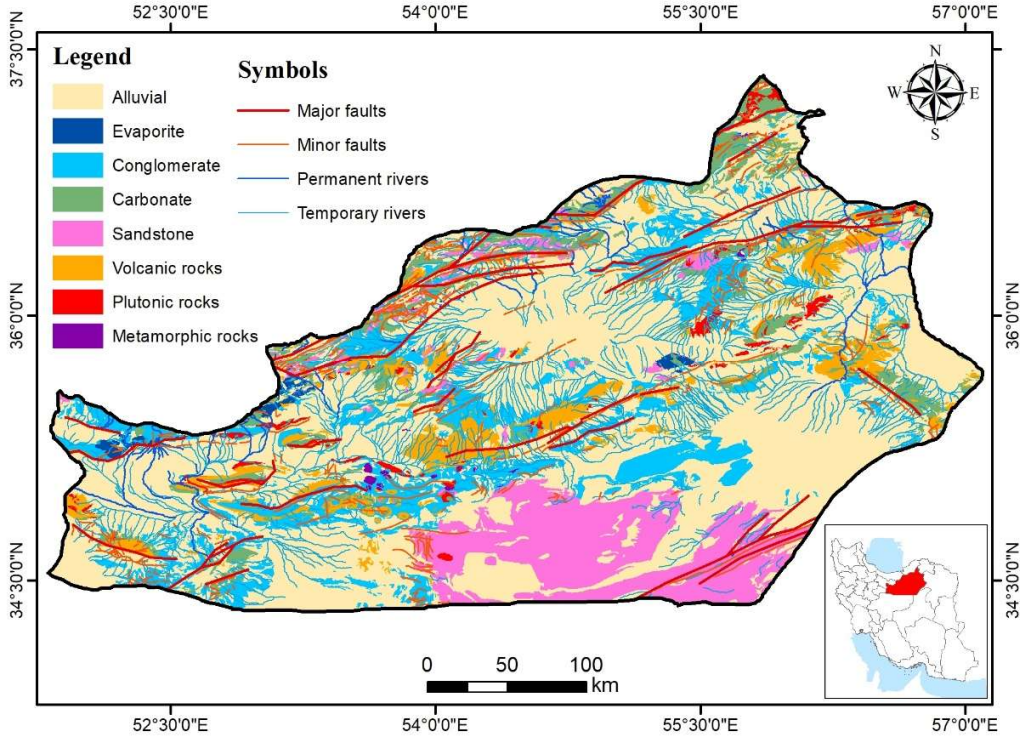

Fig 2. Simplified geological map of Semnan Province (compiled and simplified from 1:100,000 and 1:250,000 geological maps, Geological Survey and Mineral Exploration of Iran)

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.

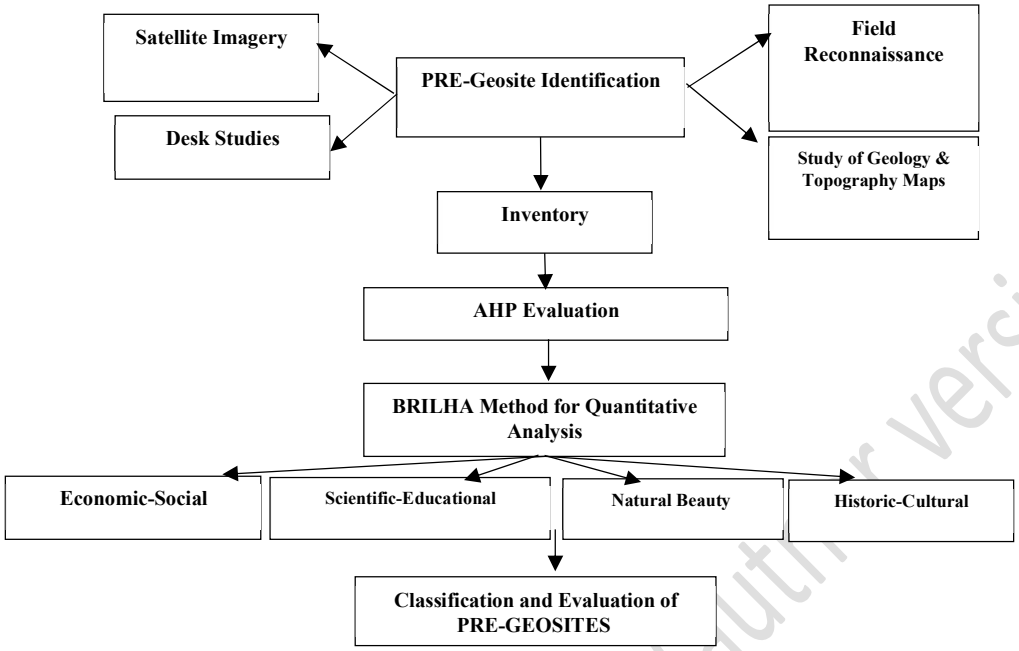

Fig. 3. Flowchart of desk and field stages of study

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 touristy, 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.

Research Plan of Doctoral Dissertation (Ph.D.)
The ID of Geotourism Attractions
Semnan Province (Inventory)

Kavir Darreh(Roya-ye-Kavir)

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): ■Regional □National □Universal
10-Hazards & risk of destruction: Uncontrolled visits by tourists
11-Facilities of/at the accommodation: Residences at the Kavir National Park
12-Reistered as a national heritage? □Yes ■No; If yes:
13-Tourist attractions along the geological feature/phenomenon: Delaazyaan Kavir, Sorkheh Kavir

Prepared by: Akbar Tavakkoli Raad, Feb. 2023

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

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, touristy, 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.

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). The selection was made based on the above four criteria using the AHP (Fig. 5). 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 6 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.

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	Shahroud	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'llemaan 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	Sorkheh	
13	Spa of Sorkheh	53 11 23.1	35 39 27.2	Sorkheh	
14	Desert of Rig-e-Jen (clot of ghost)	53 22 34.1	34 37 48.8	Sorkheh	Iranian so-called Bermuda Triangle
15	Desert of Sorkheh Ravine	53 13 18.7	35 29 42.7	Sorkheh	
16	Oghaab-e-Sangi(Rock/Stone	53 56 11.9	36 06 50.5	Semnan	
17	Mars-like hills	53 51 17.9	36 01 22.6	Damghan	Todarvar Village
18	Toroud Desert(Sand Dunes)	55 00 58.7	35 25 35.4	Shahroud	Conservation area
19	Modjen Haftrang Springs	54 43 03.4	36 32 27.1	Shahroud	
20	Kavir-e- Chaah Jam	55 07 00	35 45 03	Shahroud	
21	Modjen Wtarefall	54 33 06.5	36 28 47.7	Shahroud	
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	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
29	Garmsar Salt Cave	52 09 16.1	35 14 58.6	Garmsar	abandoned section of Koohdash Mine
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	
41	Roozieh Waterfall	53 11 34.1	35 51 55.2	Mahdishahr	
42	Darband Cave in Mehdishahr	53 21 09.5	35 44 56.3	Mahdishahr	One of the biggest calcerous caves in Iran
43	Siaah Darrehin	53 17 37.7	35 44 29	Mahdishahr	Mehdishahr (literally Black Valley)
44	Lezooreh Spring	52 45 32.1	35 30 32.6	Aaradan	
45	Torood Fault	--	--	Shahroud	Scientific-educational tourism
46	Molhedoo Cave	55 58 47.4	35 59 43.7	Shahroud	
47	Chaah Moosaa Copper Mine	54 52 50.2	35 29 04.7	Shahroud	
48	Naam Nik Waterfall	55 40 45.2	37 07 42.6	Mayamey	
49		Mayamey-Shahroud 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 Nevzevaa.			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	Mayamey	
58	Nekaarman Waterfall	54 47 58	36 33 22	Shahroud	Shaahvaar Mount slope
59	Abarsedj Waterfall	54 53 08	36 36 42	Shahroud	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 Salt Cave **	Ejdehaa Mount+Mars-like Hill **		Saleenaa Salt Lake	Salt domes ***	Salt caves **
Semnan		Stone Eagle **	Delaazyaan & 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 Gholi ***		
Shahroud	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	Amiryeh Township (Damghan)	35 28 43.2	52 43 21.8	Baby-in-flowers tradition	Nationally registered as the 1st 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	
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
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	Kaafer Ghal'eh	
16	Mehdishahr	36 02 19.9	53 24 38.5	Molladeh Village	Outstanding touristy
17	Semnan	35 29 44.9	53 24 25.2	Delaaziaan Village	Outstanding touristy village
18	Shahroud	36 00 07.3	56 00 07.3	Ghal'eh Baalaa in Biaardjmand	Outstanding touristy village
19	Shahroud	35 35 33.4	56 46 32.9	Zamaan Aabad in Biaardjmand	
20	Shahroud	35 56 29.4	56 40 54	Reza Aabaad in Biaardjmand	
	Shahroud - Damghan - Semnan	At/along the north of Shahroud, 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
25	Semnan	35 29 44.9	53 24 25.2	Mirak Square(Delaazyaan)	Ancient area
26	Shahroud	--	--	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	

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

No.	Township	Latitude	Longitude	Attraction Type & Its Local Title	Remarks
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	5th Century Hidjri
39	Damghan			Lake of Shaahcheraaghi Dam	Touristy attraction
40	Shahroud			Torood Village	
41	Garmsar	35 14 49.1	52 09 17.8	Boneh Kooh Touristy spot	Outstanding touristy spot
42	Shahroud	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	Shahroud	36 34 47	54 45 50	Farahzaad Touristy spot	Haftrang springs
46	Shahroud	36 28 46	54 38 51	Modjen Touristy Complex	Maasooleh 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/ Attraction	Local Products	Cultural-Religious	Historical	Natural	Remarks
Garmsar	Handicrafts	-Ethnics Museum -Garden-Museum of Science & Industry	-Sangfarsh Road --Ghasr-e-Bahram -The Baghery's-	-Kavir Nationa Park -Behvard(geo-site)	Large reserves of salt and gypsum
Aaradan	Agricultrural products: wheat, cotton, animal husbandry	-Aaradan Mosque -Sultan Abusaed Imam offspring	--Yateri Castle -Ali Aabaad Cistern -Cistern & caravansary of Dehnamak	-Outstanding touristy village of Paadeh -Ghalibafan Village -Lezooreh springs	
Sorkheh	-Kelim & djaadjim -Baskets	-Grand Mosque of Chehelsotoon -Imam Haadi Mosque	-Laasdjerd caravansary -Jahaan Aabaad Castle	-Touristy village of Biabanak	Lasdjed caravansary registered as a national heritage
Mehdishahr & Shahmirzaad	-Orchard produce like walnuts & pomegranate	-Almahdi Mosque - Eel-e-Sangsar Nomads Moseum -Kharand Ancient Area	Ancient structures: -Shir Ghal'eh -Ghal'eh Sheykhi	-Outstanding touristy & international town -Parvar Conservation -Roodbaarak Village & Forrest	
Semnan	-Rug & kelim -Pottery & ceramics -Felt products	-Sultaani Mosque (Imam) -Saroo castles	-Silk Road -Ahovaan Stone Castle -Arg Gate -Old Baazzaar of Semnan	-Sookaan Forrest Park -Khosh Aabrood Valley	World registration of Ahovan caravanserai Large reserves of salt
Damghan	-Pistachio -Kelim & Djaadjim -Felt products	-Taarikhaaneh Mosque -Mehmaandoost Tower	-Dowlat Aabaad Castle -Gerdkooy Castle -Teppeh Hesaar Historic spot	-Cheshmeh Ali -Cheshmeh Gholghol	Pistachio of Damghan is a famous produce
Shahroud	-Pottery -Kelim & djadjim weaving -Needlework	-Shahroud Museum -Sheykh Aliakbar Mosque -The Yaghmaiee's	-Historical Complex of Baayazid Bastami -Sheykh Abolhasan Kharghaani Complex -Old Baazzaar	-Khaartooraan the most famous habitat for leopards -Torood Palm -Khosh Yilaq Conservation	Grapes & vinyards of this city are famous
Mayamey	-Djaadjim -Traditional hand-woven crafts	-Anthropology Museum Grand Mosque	-Mayamey caravansary -Abas Aabad caravansary	-Copse Meadow -Sunflower Meadow -Dasht-e-Shad	Global registration of caravanserais in Miami, Abbas Abad and Miandasht

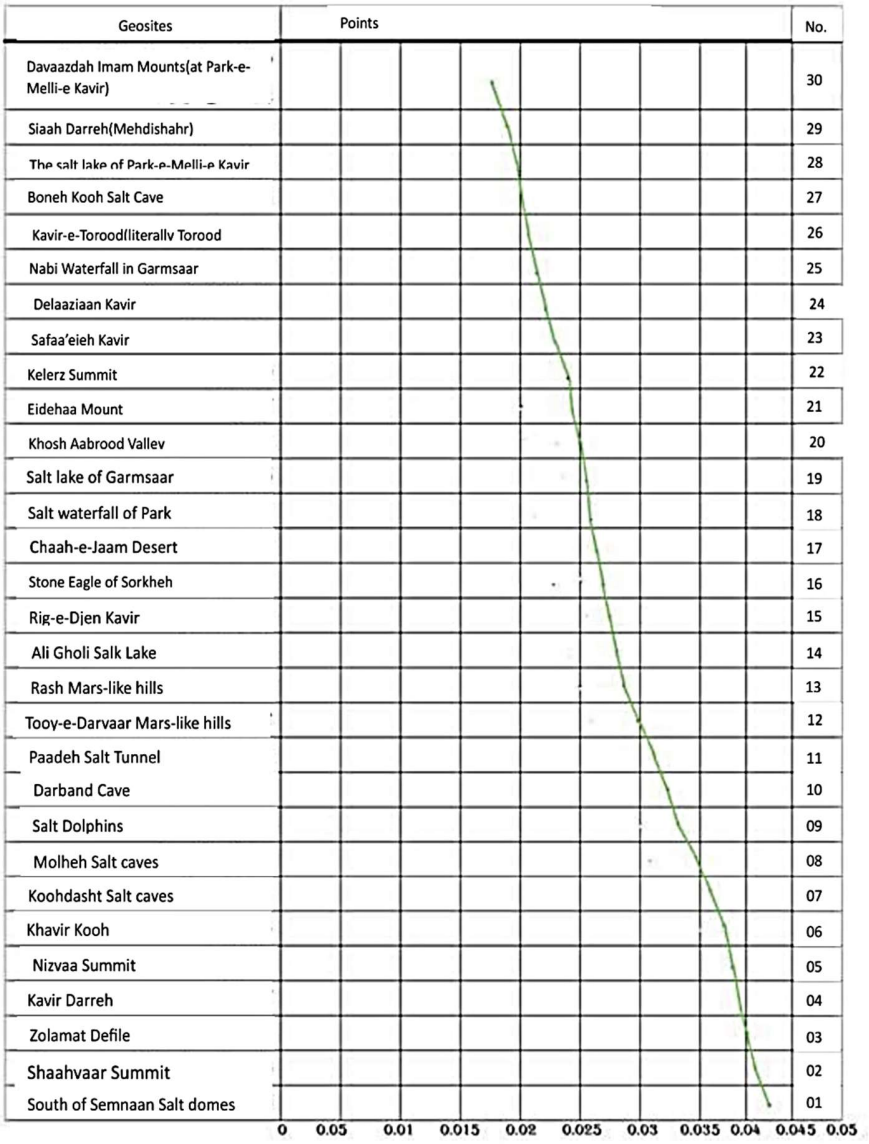

Fig. 5.

Qualitative evaluation and selection of pre-geosites by AHP

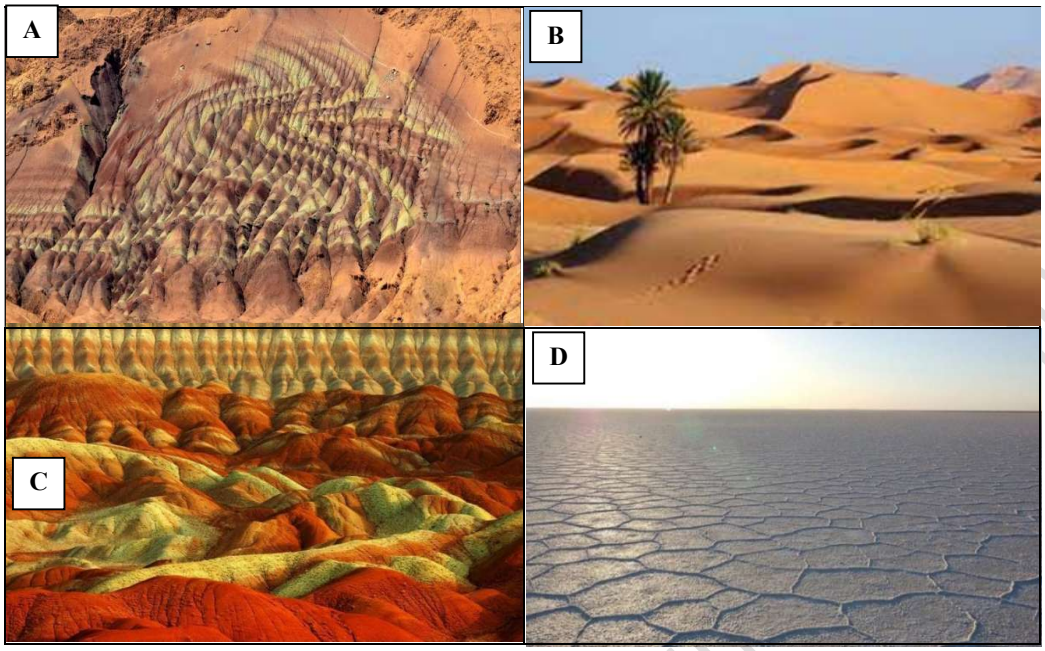

Fig 6. Natural & geological heritage of Semnan Province; A: Dragon Mount-Garmsar; B: Delzyan Kavir-Semnan; C: Mars-Like Hills in Damghan; D: Hadj Ali Gholi Salt Lake-Damghan (Photo from Amri Kazemi 2013)

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. 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 Yilaq 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 (Semnan Natural Resources and Watershed Management 2017)

- 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 Jeme Mosque, Historical Mosque (Damghan)

- The historical sites of Semnan province include: Mirek 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 Braillhe 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, Shiraaz, Mashhad, and Yazd.

References

Aghanabati A (2014) The Geology of Iran, *Geological Survey of Iran (GSI)*, Ministry of Industries and Mines, Tehran, 640 p. (In Farsi)

Amri Kazemi A (2013) Geoheritage Atlas of Iran, *Geological Survey of Iran,* 488 P.

Amri Kazemi A (2018) Geopark and Geo-tourism Capabilities Atlas of Iran: Geological Heritage of Iran, Geological Organization of the country, 460 p.

Amri Kazemi A, Mehrpooya A (2006) Geotourism resources of Iran, *Geotourism* 78-92. 10.1016/B978-0-7506-6215-4.50013-0

Arabameri A, Rzaei K, Yamani M (2018). Evaluation of geotourism capabilities of salt dome landforms in sustainable development of tourism (case study: south of Semnan), *Desert Management* 6(11):1-14.

Brilha J (2016) Inventory and Quantitative Assessment of Geosites and Geodiversity Sites: a Review, The European Association for Conservation of the Geological Heritage, *Geoheritage* 8(2):119-134. http://dx.doi.org/10.1007/s12371-014-0139-3

Dowling RK, Newsome D (2010) Global Geotourism Perspectives, *Management* 32(6):1486-1487. https://doi.org/10.1016/j.tourman.2010.11.006

Ghorbani M (2021) The Geology of Iran: Tectonic, Magmatism and Metamorphism, *Springer Cham,* 453 p. http:// doi.org/10.1007/978-3-030-71109-2

Haami Motlagh H, Badri Kalalloo N, Amri Kazemi A (2021) An introduction to the principles and concepts of geoconservation with a view on Iran, *Javan Emrouz*, 220pp.

Hose TA (1995) Selling the Story of Britain's Stone, *Environmental Interpretation* 10(2): 16-17.

Lashkari H, Riyazi, MH (2016) Analyzing the potential of geotourism development in Semnan Province by using SWOT, *Physical Geography Quarterly* 9(33):37-50.

Lima FF, Brilha JB, Salamuni E (2010) Inventorying geological heritagein large territories: a methodological proposal applied to Brazil, *Geoheritage* 2(3–4):91–99. http://dx.doi.org/10.1007/s12371-014-0139-3

Maqsoodi M, Arab Ameri A (2017) Quantitative assessment of salt geomorphosites in Semnan Province using Brilha and Pralong methods with emphasis on west province geosites, *Journal of natural geographical research* (49)2: 241-258. https://doi.org/10.22059/jphgr.2017.62844

Nekouie Sadry B (2021) The Geo-tourism Industry in the 21st century, The Origin, Principles, and Futuristic Approach, *Apple Academic Press* (CRC), New York, 596 p. https://doi.org/10.1201/9780429292798

Saaty TL (1987) The analytic hierarchy process—what it is and how it is used, *Mathematical modelling* 9(3-5): 161-176. https://doi.org/10.1016/0270-0255(87)90473-8

Salamzadeh A, Ebrahimi P, Soleimani M, Fekete-Farkas M (2021) An AHP approach to identify the barriers of sustainable geo-tourism development in Iran: an economic view, *Geoheritage* 13(3):65. https://doi.org/10.1007/s12371-021-00581-9

Shirazi A, Shirazy A (2020) Introducing Geotourism Attractions in Toroud Village, Semnan Province, IRAN, *International Journal of Science and Engineering Applications*, 9(16), 79-86. https://doi.org/10.7753/ijsea0906.1002

Soltani A, Poodineh S, Raeesi M, Zolfaghari A, Kaboli SH (2023) Frequency Analysis of Cold Waves Occurrence in Semnan Province, Journal of Climate and Ecosystem of Arid and Semi-arid Regions 1(1):167 to 183. https://doi.org/10.22059/jesphys.2017.58916. (in Persian)

Yazdi A, Dabiri R, Mollai H (2024) Protection of Geological Heritage by a New Phenomenon in Earth Sciences: Geoconservation, *Journal of Mining and Environment*, 15(1):365-379. https://doi.org/10.22044/jme.2023.13434.2478

Yazdi A, Emami MH, Jafari HR (2013) IRAN, the center of geo-tourism potentials, *Journal of Basic and Applied Scientific Research* 3 (1): 458-465.

Yazdi A, Arian MA, Rezapour Tabari M (2014) Geological and Geotourism Study of Iran Geology Natural Museum, Hormoz Island, *Open Journal of Ecology* 4(11): 703-714. https://doi.org/10.4236/oje.2014.411060.

Zabihi H, Mohsen A, Isabelle DW, Mohammadreza K, Anuar A, Hasan S (2020) A GIS-based Fuzzy-Analytic Hierarchy Process (FAHP) for ecotourism suitability decision making: A case study of Babol in Iran, *Tourism Management Perspectives* 36(9): 100726. http://dx.doi.org/10.1016/j.tmp.2020.100726

Zakeri A, Naderi R, Poozesh V (2020) An investigation of plant species distribution in Semnan province (Case study: Herbarium of Damghan University), *Journal of Plant Research (Iranian Journal of Biology)* 33(4): 891-913. https://dorl.net/dor/20.1001.1.23832592.1399.33.4.6.2