Application of AHP -SWOT and geophysical methods to develop a reasonable planning for Zagheh tourist destination considering environmental criteria

SARINA AKBARI , HAMIDREZA RAMAZI
Faculty of Mining Engineering,
Amirkabir University of Technology,
Tehran, IRAN

Abstract: This paper aims to develop geotourism in the Zagheh area, western Iran. There is an expose of a water-filled cave that has a considerable potential in attracting tourists. To investigate the karstic zones and find the path of water the surface geophysical methods of Rs, MLAM and SP were applied in this study. The water flow direction has been well detected by the SP method. The cave related anomalies are appeared at the location of two resistivity sections along P1 and P2 profiles. Besides, a 3-D Rs model was prepared which demonstrated that each karstic area may contain a number of small to large cavities that are linked together like a beehive. Afterwards, an AHP-SWOT model was used to determine the most critical factors for the development of geotourism in the region. The results show that opportunities are the most important factors in the development of geotourism in the study area. So, the region has a high potential for tourism and with the help of suitable planning and proper management, it can become an excellent tourist attraction. This conclusion has been made assuming considering all environmental regulations. Due to the high importance of environmental issues, this research has also been investigated with the assumption of not considering environmental regulations. The results of the AHP-SWOT approach clearly revealed the importance of respecting environmental issues and showed that in this case the threats of investment to turn the Zagheh area into a tourist destination will be much greater than its opportunities. So, the continuation of the project will not be logical.

Keywords: Geotourism development, environment, Karstic zones, geophysics, electrical resistivity, self-potential, Mise-a-la-masse, AHP-SWOT.

Received: March 24, 2022. Revised: October 25, 2022. Accepted: November 19, 2022. Published: January 31, 2023.

1. Introduction

There are many different tourist attractions on our planet, some of which are very old and attract many tourists from all over the world. (Garofano and Govoni., 2012). Since the life quality of residents in tourist areas is directly affected by tourism activities, these tourist attractions are a significant source of income for them. (e.g., Belisle and Hoy., 1980; Sheldon and Var., 1984; Liu et al., 1987; Perdue et al.,1987; Lundberg 1990; Um and Crompton.,1990; Allen et al., 1993; Prentice.,1993; Jurowski et al., 1997; Weaver and Lawton., 2001; Tosun, 2002: Akbari et al.,2020). Therefore, in recent decades, attention has been drawn largely to tourist attractions (Garofano and Govoni., 2012). Geotourism is one of the branches of tourism that, as a leading sector of the tourism industry, relies on the use of environmental potential and is the most fundamental step in identifying ecological and environmental potential. The development of geotourism can directly create countless economic benefits to the indigenous peoples of the country by creating job opportunities. According to the United Nations World Tourism Organization, tourism is the largest active industry in the world. About 153 million people are involved in tourism-related activities around the world. So, tourism is one of the largest employment-generating industries. For every 1 million dollars revenue generated in the industry, 20,000 new jobs are created (Lundberg., 1838). Therefore, paying attention to geotourism and long-term planning for the development of this industry is very important (Perdue et al., 1987; Allen et al.,1993; Akbari et al.,2020). Although tourism growth contributes significantly to the economic development and prosperity of host countries and regions, it always creates significant pressures and disruptions in the host regions. Tourism has social, cultural, economic, and environmental consequences. Because of the complexity and breadth of tourism activities, the resulting effects have many interconnected dimensions that should be considered in tourism effects research (Mason,2020). Most of the natural phenomena which can be considered as a great tourist attraction, happen on the ground surface such as mountains, canyons, islands, beaches, rivers and waterfalls, wildlife and also vegetation (Lobo et al., 2013; Garofano and Govoni.,2012). But geological phenomena often occur underground. Among them, empty underground spaces including caves and cavities are the only phenomena that humans can enter into. Caves make it possible for humans to see and touch the underground world, which was for people like a secret for many years due to the lack of exploration and drilling technology (Garofano and Govoni.,2012). But nowadays, using these technologies, caves and cavities can be discovered and made accessible to become a great tourist attraction, like Ali Sadr cave which is the largest water-filled cave in the world, in Hamadan province, west of Iran. In addition, as mentioned, caves are an important source of revenue, like any other natural tourism attraction. Research shows that about 100 million people in the world earn their income by showing caves and their related activities (transportation, lodging, etc …) (Gillieson.,2009). So, it can be said that caves are of great economic importance, especially in developing countries. (Novas et al., 2017). It should be noted that the development of geotourism in an area also has disadvantages that must be considered. Also, having visual effects is not enough to turn an area into a tourist destination, and other important conditions are involved. In other words, although the prime focus of attracting tourists is to protect tourist resources, efforts should be made to preserve the natural features of the area by determining the necessary rules and regulations to protect the privacy of roads, passages, and rivers, as well as determining the type of land use and construction regulations, and avoiding any kind of damage to it as much as possible. The United Nations study on the impact of tourism on developing countries demonstrates that while the tourism industry brings economic prosperity to host countries and regions and enhances cultural exchanges, it also creates social and environmental issues (Priskin, 2001). Therefore, it is very important to study these conditions and assess the potential of the area for the development of geotourism. Therefore, the detection of caves and cavities and surveying them in various aspects such as depth, dimensions and quantity, Also, examining the conditions of the region and the internal and external factors affecting it for the development of geotourism, as well as considering the resulting benefits and harms especially from environmental aspects are very important. There is a high potential for the development of the geotourism industry in Iran, due to climatic diversity and geomorphology, but the necessary and sufficient measures have not been taken yet. One of the areas that has great potential in the development of geotourism activities, is Lorestan province western Iran. The western region of Iran has different geological formations because it is located in the Zagros Mountains. Calcareous formations usually show up in the Zagros region, which has the potential of forming caves with geotourism capability. There is a naturally formed water-filled cave in Zagheh area, Lorestan province, western Iran. The outcrop of this cave is located at an altitude of 15 meters less than the ground surface and when the water level in this cave rises, it overflows and the entrance of the cave appears when the water level drops. Due to having suitable water resources as well as high potential for attracting tourists. This cave can be used for a detailed examination and Completion of the study plan. According to experts, this cave is even larger than Ali Sadr Cave, so the future of the region can be changed by investing in it. In 2007, preliminary geological and speleological studies were carried out on it, and its entrance was opened in a season when the groundwater level was low. About 75 meters of the cave was navigated with the help of climbers, but they could not go further because they came across a water-filled space or corridor where there were fish and snakes. These fishes and other animals swim in the opposite direction of the water flow and enter the cave. This happens when the water in the pit in front of the cave entrance flows and connects to the river, during the rainy season. For this reason, it was decided to conduct geophysical studies around this cave.

The main aim of this study is to investigate the depth, expansion dimensions, the geometry of this cave, and the presence of other possible cavities, the connection of the corridors and determination of the water path, by geophysical methods and also potential assessment of the area considering social and environmental aspects, for the development of geotourism in the region in order to convert the Zagheh area into a tourist destination.

Geophysical methods are the best tools to detect and delineate caves and cavities. By means of these methods, accurate information about the state of the underground world can be obtained, in such situations where it is not possible to access the underground. These methods have replaced traditional techniques (such as drilling) while saving time and money and, most importantly, without causing environmental damage. (Metwaly and AlFouzan, 2013; Shawkat and Carpenter, 2003; Jardani et al,2007). Geophysical explorations offer a variety of methods for detecting subsurface cavities. The integration of these methods can lead to valuable results in geophysical explorations (Yeboah-Forson et al.,2014; Gan et al., 2017). Simultaneously using multi-geophysical methods can address the weaknesses of each method to obtain more accurate results. Among various geophysical approaches, three different geoelectrical techniques have been applied in this study: (a) electrical resistivity (Rs) which due to the very low conductivity of karstic cavities than surrounding host rock, is the most commonly used method to discover karstic cavities (Metwaly and AlFouzan, 2013); (b) self-potential (SP) upon which the water flow inside the cavities generate a positive SP value which helps to identify the cave location (Vichabian and Morgan, 2002); (c) Mise-a-la-masse (MALM) as a simple and economical geophysical approach.

Subsequently, internal strengths and weaknesses as well as external opportunities and threats were identified using the SWOT model as a supportive decision-making tool that, by defining the strengths and weaknesses as well as the opportunities and threats of a city or organization, examines strategies to strengthen the strengths, address the weaknesses, and seize the opportunities and threats (Dyson., 2004). This study was conducted in two scenarios, one with and the other without regard to environmental regulations, and the results were compared. SWOT analysis is used in combination with an analytical hierarchy process (AHP) as the most widely used MCDM method for assigning meaningful weights to each SWOT factor for determining the most critical factors for the development of geotourism in the region.

2. Study area and Geological setting

Zagheh area is located 40 km east of the capital city of Lorestan province, west of Iran. The best way to access the area is the Khorramabad-Borujerd route, which is located on the Tehran-Ahvaz highway (fig. 1). The area is located in the Hillside and in terms of topography changes are mild and does not have extreme up and downs. The area includes barren lands with a very mild topography. This area is cold and usually snowy in winter, but in the summer, it is hot in the days and mild at nights. There is a naturally formed cave (without human intervention) in the north of this area (Zarrinabad cave) that has an altitude of almost 1850 meters. According to the cavers who navigated 75 meters of the cave, this cave has very large vertical holes and very large halls (Fig. 2). High-intensity water flows out of this cave, especially in rainy seasons and the large pit located at the entrance of it is full of water and the cave entry is completely under water (Fig. 3). In dry seasons, when the water level is at its lowest, the cave entrance is visible. It should be noted that the water level is never below a certain limit.

3. Methodology

Methodologically, at first, environmentally friendly geophysical methods, including Electrical resistivity, Self-potential, and Mise-a-la-mase, were used to identify the expansion of the cave and underground cavities. Then, in order to investigate the potential of the area to develop into a geotourism area from social, environmental, etc. aspects, the hybrid AHP-SWOT method was used.

3.1. Designing of survey lines

The geoelectrical methods applied in this research include Rs, SP, and MALM surveys. Designing of the geophysical surveys, especially resistivity surveys has particular importance and plays a critical role in the accuracy and correctness of the interpretation of data. An inappropriate design can reduce the value of data and, even in some cases, result in misleading. In this study, all measurements were made along several survey lines within 600×550 m^2 areas. Designing of the survey lines was done based on the local geology, the cave outcrop location and topography. All measurements were made along 15 profiles (only 6 profiles were investigated for SP and MALM methods) shown in Figure 4. Each profile has a length of about 550 meters with a measuring point interval of 10 m and the distance between the profiles was set to 30 m.

3.2. Self-potential (SP) and Mise-a-la-masse (MALM) measurements

The basis of the SP method is to measure the naturally occurring electrical potential difference of the earth as a result of the chemical interactions in the earth. In SP surveys, a reference electrode is placed away from the study area where a low SP is expected. Then the mobile electrode M is moved along the profile and the measurements are done on the survey points (Vichabian and Morgan, 2002; Ramazi et al., 2009). Collected data can be used to portray electrical potential distribution or to draw a SP curve. Due to the facility of implementation, high speed and low cost, this method has been widely used by geophysicists. One of the most important utilizations of this method is to detect the water flow direction through the positive SP which is in the orientation of the water flow (Ball et al., 2010).

In this study, we aim at detecting the water-containing cavities using the MALM method. This method is one of the important methods that originally applied for the exploration of conductive deposits that are located within nonconductor rocks (e.g., Schlumberger., 1920; Parasnis., 1967). MALM measurements usually are accomplished using the SP survey lines and survey points. Electrode A is placed in the ore body, and the negative current electrode is placed in a faraway place. One potential electrode is placed at a low SP point. Then by moving the other electrode, potential values are registered (Mary et al, 2018). This method yields very favorable results in combination with other geoelectrical methods such as SP and Rs.

3.3. Electrical resistivity measurements

Among the various geophysical methods, the electrical resistivity method applied in this study is one of the most promising techniques for detecting caves and cavities. The electrical resistivity method is based on measuring the potential difference through the subsurface between two potential electrodes by injecting a direct current into the ground via two current electrodes (Kneisel et al., 2016). This method is employed in order to explore the existence of the karstic cave and other probable subsurface cavities and their geometry, using a CRSP array. There have been many utilizations of electrical resistivity techniques for detection of cave and cavities (see Van Schoor., 2002 and Maillol et al., 1999). This method is a very useful tool in mineral exploration. In addition, it is an appropriate method in hydrology, environmental science and engineering fields (Spies and Ellis., 1995; Barker and Moore., 1998). The resistivity of cavities depends on several factors including the cavity filled with air or water. An air-filled cavity, making it highly resistive and cavities which are partially or completely water-filled have a conductivity ranging from very conductive to relatively resistive, in comparison with the host rock based on the water composition. Freshwater does not have much effect on Electrical resistivity, but saline water dramatically reduces it (Kaufmann et al., 2011). In this case study, cavities are bearing fresh water that has no significant impact on the results.

3.4. Analytical hierarchy process (AHP)

The analytical hierarchy process (AHP) (Saaty, 1980) is one of the most popular MCDM methods by which complex decision-making problems could be solved by dismembering into a system of hierarchies of associated decision elements problems (Ghezelbash and Maghsoudi, 2018b). This is done based on the pairwise comparison of the importance of different criteria and their corresponding sub-criteria (Akbari et al., 2020). Determination of criteria/sub-criteria and calculation of the meaningful weights of them is done using AHP technique and involves following steps (Akbari et al., 2020):

a) Construction of a decision matrix based on the pairwise comparison between the decision factors according to the final objective as:

$$R = (a_{ij})_{m*m} = \begin{bmatrix} 1 & \cdots & r_{1m} \\ \vdots & \ddots & \vdots \\ r_{m1} & \cdots & 1 \end{bmatrix}$$

(1)

b) Assigning meaningful weights to each criterion and its corresponding sub-criteria (or classes) as the following equation:

$$AW = \lambda_{\max} W$$

(2)

3.5. SOWT analysis

The description of internal strengths and weaknesses, as well as external opportunities and threats, is based on a technique known as SWOT analysis (Houben et al., 1999）. This analysis is a common tool used to analyze the internal and external environment simultaneously in order to obtain a systematic approach and support the decision-making situation (Yuksel and Dagdeviren, 2007). The SWOT analysis is conventionally used for an enterprise, but can be applicable for the larger levels for example, at the destination level (Falulkner., 2002). Internal and external factors for the future of an investment are called strategic factors. In SWOT, these factors are divided into four parts called SWOT groups: Strengths, Weaknesses, Opportunities, and Threats. In strategic decisions using the SWOT method, the goal is to select and implement an appropriate strategy based on internal and external factors. In addition, the strategy chosen will be in line with the current and future goals of the decision makers (Kajanusa, et al, 2004).

3.6. The AHP-SOWT analysis

Since SWOT analysis has shortcomings such as low accuracy and lack of quantitative calculation, the hybrid AHP-SWOT method was introduced by Kurttila et al (2000) which can improve and complete SWOT analysis performance. As a result, the quantitative extent of the importance of SWOT factors can be presented by AHP (Jeon and Kim., 2011). To date, the combined AHP-SWOT method has been considered by researchers in many fields, including energy, agriculture, and the machine-tool industry, but not in many cases for the geotourism development (Kaharaman & Demirel., 2007).

In this study, in order to survey the potential for the development of geotourism in Zaghehh area using a hybrid AHP-SWOT method, the following steps have been performed:

1. Identification of internal strengths (S), internal weaknesses (W), external opportunities (O) and external threats (T).
2. Assigning proper weight to criteria and sub-criteria using Analytical hierarchy analysis method.
3. Determining the final weight of the criteria and eventually identifying the most important internal and external factors.

4. Data processing and interpretation

4.1. SP and Mise-a-la-masse method

After initial processing, the SP data, the potential values for all the survey points were plotted and the SP contour map was then generated (Fig. 5). As can be inferred from this map, the SP values increase toward the cave entrance. This issue indicates that the water flows from the peripheries of the cave to the cave entrance in the north of the study area. As a result, the main karstification area (cave entrance) is well revealed. The slow SP variations from the cave surrounding to the cave entrance indicate a monotonic water flow toward the cave entrance. There are some small anomalies in other places that indicate the movement of water to the small fountains that existed at the time of the SP surveys. The leakage of groundwater from seams and small cracks in Limestones has caused these fountains. The result of the SP method clearly shows that the region has sufficient water resources and is well Corresponded to the geology of the study area. However, due to the shallowness of the SP surveys and the impossibility of surveying in different depths, the obtained results just can be used to make a general overview of the area and to adapt it with other methods. It should be noted that the SP surveys were made in April when the water level was high and there were some small fountains in the area.

Recorded Mise-a-la-masse data were processed and the results are presented as a potential contour map shown in Figure 6. When the earth is homogeneous, the equipotential lines resulting from Mise-a-la-masse measurements are converted into circles without any inclination, But despite the anomaly, these equipotential desires towards the anomaly. As can be seen in Figure 6, the trend of equipotential lines resulting from Mise-a-la-masse measurements are from the cave to the southwest of the study area. This could be an indication of the spread of karst toward the southwest of the study area. It is noteworthy that Mise-a-la-masse surveys have also been carried out in the spring as the SP surveys show that there was a high-water level and the cavities were water-filled. Besides, it should be noted that because of the sweetness of water the results of this method were not as useful as expected. However, the result of this method shows the general trend of the main anomaly (the cave) almost correct and does not contradict the Self-Potential map and the results of the electrical resistivity, but unfortunately, it has not been able to reveal smaller cavities and the southern karstic area.

4.2. Apparent resistivity surveys

Raw data obtained from data acquisition were processed. After data processing, electrical resistivity sections along all profiles and the electrical resistivity curves for different length of flow lines (AB), were prepared.

4.2.1 2-D resistivity mapping and imaging

Figure 7 shows the electrical resistivity contour maps along the length of flow lines 50, 90, 130, 150 and 290 m. Resistivity values range from ~700 Ωm to a maximum of ~1200 Ωm are karst associated anomalies. So, the principal anomaly (here, the cave) appeared at the location of the main outcrop of the cave in the north of the study area. With increasing depth, this anomaly is expanded as far as the signature of this anomaly is observed in the length of current line AB=130 meters (Fig. 7c). This suggests the expansion of the depth of the karstic cavities by increasing the depth in this area. As AB increases, there is an increase in the boundary of the carbonate formation (is shown in green) and a decrease in the boundary of the conglomerate formation (is shown in blue) (Fig. 7). Besides, some anomaly signatures are observed in the northwest and south parts of the study area. By increasing the AB, the probability of deep and lateral extension of karstic cavities also increases (maps related to AB=150m and AB=290m (Figs. 7a, d)).

The apparent resistivity pseudo sections along profiles P1, P2, P5, P13 and P15 are shown in Figure 8. The primary profiles (P1 and P2), are designed above the cave entrance (Fig. 4). The footprint of the cave in profiles P1 and P2 is clearly shown by anomalies which are characterized significantly by higher electrical resistivity than its surrounding points and orange-to-red spectrum. Based on the pseudo sections, it can be concluded that the main outcrop of the cave has expanded up to profile p3, while there is no longer any trace of it around profile P5 (Fig. 8c). In this regard, the longitudinal extension of the main cave is probably more than 100 meters. According to the pseudo sections which are generated along the southern profiles (P11, P13 and P15) in the study area, it is observed that there is a possibility of more and more cavities in the northwestern part of these profiles (southwestern of the study area) (Figs. 8d, e). This is more likely at depths of more than 50 meters. This issue is well-matched to the results of electrical resistivity curves for different lengths of flow lines. Besides, carbonate formations have expanded in the southern parts of the area. Thus, the lower part of the pseudo sections are covered by calcareous formations (as shown in green) (Fig. 8). An Increase in resistivity toward the depth is also observed in apparent resistivity pseudo sections. This increase in specific resistivity to the depth indicates the connection between the karstic cavities in the bottom parts. Therefore, some drillings should be done to connect cavities and corridors in the upper parts. The connection between the cavities, corridors and halls in the seasons when the water level is relatively high allows tourists to canoe and visit all over this wonderful cave.

Generally, there is a strong association between the results of apparent resistivity pseudo sections, electrical resistivity contour maps, geological facts and reports provided by cavers and climbers from navigation of the first few meters of the cave. In the study area. According to the obtained results, it is possible that each of the karstic areas contains a number of small and large cavities which are linked together like a beehive.

According to the generated maps and pseudo sections shown in Figure 7 and 8, the main anomalies which are related to the cave, are well-detectable in profiles P1, P2 and P3 with high-levels of resistivity and the cave's footprint disappears in profile P5. The results are well-matched and approve of each other. But in the last profiles, other intensive anomalies are observed which are probably related to the small and large cavities which are linked together like a beehive.

4.2.2 3-D electrical resistivity modeling

Figure 9 shows the trend of electrical resistivity variations from the surface to the depth. As can be seen in this figure, the expansion of the cave is increased to a depth of about 70 meters and then decreased. However, the karstic cavities in the south of the area dramatically increase with increasing depth.

A 3-D electrical resistivity model was generated using Voxler 4 software. This 3-D model was used for precisely indicating the location of the karstic zones, distribution of cavities and their connectivity in the study area. Figures 10 a, b and c illustrate the 3-D electrical resistivity models of the study area from the behind, front and top view, respectively. As shown in Figure 10, the configuration and geometry of the cave in the northern parts as well as the karstic zones in southern and southwestern parts of the study area are well represented. From the front view, the main anomaly, which is the cave in the north of the area, is well simulated (Fig. 10a). From the rear view, as can be seen, there are a number of small and large cavities in the south of the area, which their connections and relations are well visible (Fig. 10b). According to the top view, the connection between the main northern cave and the southern karstic cavities is quite obvious. However, given that the electrical resistivity of the connection point is not very high, this karstic space is probably not hollow. This means that it is not a corridor or cavity and is probably a massive limestone. Therefore, the connection between the cave in the north and the karstic cavities in the south of the area should be done by drilling. Due to the fact that Zagheh area has sufficient water resources and in terms of geomorphology there are no obstacles and restrictions for the development of greenbelts and also due to its proximity to the village and the main road, it has great potential for the development of the geotourism industry. The results also indicate that 3-D modeling of resistivity distribution (Figs. 9, 10) are remarkably coincided with the results of 2-D resistivity mapping (Figs. 7, 8) and imaging (Fig. 8) and also geological facts (outcrop of the cave and cave climbers Report).

4.3. Hybrid AHP-SWOT Process

4.3.1 Identification of internal and external factors influencing the development of geotourism in the region

In order to identify the internal factors affecting the development of ecotourism in the region, library studies and expert opinions have been used. Also using the available information and maps, the situation of the region has been reviewed and finally the strengths and weaknesses of the region have been identified (Table 1). After the identification of strengths and weaknesses of the study area, external factors affecting the development of geotourism in the area were also identified (Table 2).

4.3.2 Assigning significant weights to criteria and sub-criteria

In the first step a hierarchy structure was designed (Fig. 11). In this structure, the final goal of the study is placed at the highest level, the second level includes the two types of strategies. The third level are four strategic criteria that are defined by the SWOT analysis (i.e., criteria). The final level consists of factors that are included in each strategic factor of the previous level (i.e., sub-criteria) (Table 1,2).

In the next step, the pairwise comparison matrix was constructed based on the importance level of selected criteria and sub-criteria and meaningful weights were calculated for them in a pairwise comparison based on expert judgments and using the proposed index by Saaty (1980) (Table 3). Finally, using the AHP method, the weights of each criterion and sub-criterion are obtained . In this section, the criteria are first compared and the results of their pairwise comparison can be seen in Table 4 and Figure 12. According to the obtained results, among the main criteria, the opportunities arising from the development of geotourism in the region have the most value.

The results obtained from the pairwise comparison of sub-criteria related to strengths (S) indicate that among the identified strengths, existence of water resources and absence of geomorphological barriers in the area have the highest score and the quiet environment has the lowest score (Table 5, Fig.13).

Evaluation of the results obtained from the pairwise comparison of sub-criteria related to weaknesses (W) shows that among the identified weaknesses, management weakness and lack of long-term geotourism development planning in the region has the highest score and lack of sports and recreational equipment has the lowest score (Table 6, Fig. 14).

According to the results derived from the pairwise comparison of opportunities (O), directly and indirectly job creation as well as development and improvement of infrastructure has the highest weight and increasing social interaction has the lowest weight (Table 7, Fig. 15).

And finally, as can be seen in the figure 16 And the table 8, increasing land prices and Seasonality of jobs have the highest score and increasing tensions and conflicts have the lowest score among the threats identified in the study area (T).

4.3.3 Determining the final weight of internal and external influencing factors

After comparing the criteria and sub-criteria and determining the weight of each sub-criterion in the relevant group, finally the final weight of each sub-criterion was determined according to the weight of the criterion in which it is located. Table 9 and Figure 17 shows the final weight of criteria and sub-criteria, based on which the most important internal and external factors affecting the development of geotourism in the region have been identified, which are as follows:

1. directly and indirectly job creation (O2) with the total weight of 0.188
2. Development and improvement of infrastructure (O5) with the total weight of 0.155
3. Accessibility to water resources (S2) with the total weight of 0.111
4. Absence of geomorphological barriers (S4) with the total weight of 0.070
5. Proximity to the main road (S1) with the total weight of 0.063

Finally, the impact of each criterion on the development of geotourism in the region is examined. Figure 18 shows that opportunities are the most effective factors in the development of geotourism in the region (51%), while weaknesses have the least impact (6%). Also, Strengths and Threats are in the second and third level with the percentage of 31% and 12% respectively.

It should be noted that the above results were obtained with particular attention paid to the threat criteria and the sub-criterion of environmental damages, taking the following into account.

1) The area's lands are barren, and agricultural lands or vegetation will not be lost if the area is developed as a tourist attraction.
2) Because this area is not the habitat of a specific animal species, it poses no threat to the area.
3) There is no rough topography in the area, so there is no need to demolish, excavate, or embankment the area in order to construct a building and equip the workshop.
4) Adherence to environmental standards in the collection and disposal of sewage and waste to prevent groundwater and environmental pollution.
5) Using wooden boats to avoid polluting the water.
6) Compliance with international standards when drilling and expanding underground holes to prevent pollution transfer to water.

Due to the high importance of preserving the environment and compliance with environmental regulations, this study was again carried out with the assumption of non-compliance with environmental conditions and the existence of agricultural lands and special vegetation in the region. For this purpose, using the AHP method and based on the environmental experts opinion, appropriate weight was assigned to the factors that threaten the environment (in case of non-compliance with environmental standards). The final results were presented in the form of a diagram and compared with the previous results (In this section, because the article is not crowded, all tables and graphs have been avoided, and only final graphs are presented for comparison). (Fig. 19-22). As shown in figure 20 and 21, in this case, environmental damage is identified as the most serious threat to the region, and thus more weight is assigned to other cases such as groundwater pollution and soil pollution and erosion. In this situation, the weight of the main criterion of threat is increased and these sub-criteria are placed in the group of the most important sub-criteria according to the weight of the relevant main criterion (Fig 19, 20 and 22).

5. Discussion and Conclusion

- The result of the SP method was able to validate the existence of an anomaly associated with the cave and also shows the general trend of water movement in the area which flows from the surrounding of the cave to the entrance. The small anomalies observed in the central parts of the map are likely indicating the movement of water toward the small fountains that have existed at the time of the SP observations.
- By using the Mise-a-la-masse method, the cave location was nearly determined. Although the result was not inconsistent with the results of other methods, the results were not as helpful as expected and could not detect smaller cavities. This can be attributed to the sweetness of the water.
- Based on the results of Rs technique, three major anomalies related to the expansion of karst have been delineated in the study area. The main anomalies are probably related to the cave and are located in the areas where profiles P1 and P2 are designed. These anomalies are larger than the other ones in terms of depth and dimensions. Other anomalies extending in the northwest southwest and south of the study area seem to have a less dimensional extent. These cavities seem to be linked like a beehive.
- The 3-D modeling of electrical resistivity confirmed all the results and precisely demonstrated the position of karstic cavities, their distribution and connections in the study area.
- The results derived by electrical resistivity data (e.g., maps, pseudo-sections, and 3-D inverse modeling) are spatially correlated together and also are associated with geological realities.
- Because the cavities are like a beehive and are connected from the bottom. Underground drilling can link cavities, halls and corridors to each other.
- The results of electrical methods show that the dimensions of some holes are very large and reach several tens of meters and the material of them is hard rock. The development and drilling of these cavities to connect them causes the loose rocks that do not have enough mechanical quality and strength to fall and be evacuated. Therefore, the necessary stability is created in the walls and roof of the holes and corridors.
- Due to having favorable climatic conditions, Proximity to the village and the main road, suitable water resources, as well as other features, the area can be converted to a geotourism destination in the future with the aim of entertainment and boating because of containing high-level water after completing the study and drilling plan.
- The results of pairwise comparison of the sub-criteria related to each main factor (SWOT) show that accessibility to water resources, lack of management, directly and indirectly job creation, increasing land prices and Seasonality of jobs are the most important factors related to Strengths, Weaknesses, Opportunities and Threats respectively.
- The calculated final weights of the factors show that among the 24 internal and external factors affecting

the development of geotourism in the study area, directly and indirectly job creation (O2), Development and improvement of infrastructure (O5), Accessibility to water resources (S2) with the total weight, Absence of geomorphological barriers (S4) and Proximity to the main road (S1) are identified as the most effective factors. This is while all environmental standards are observed during the development of the area.

- In a situation where environmental regulations are not followed during the development of the area, including improper disposal of sewage and waste, destruction of vegetation and agricultural land if present, unprincipled construction in the area and the use of metal boats, the results It has changed and the threat criteria and sub-criteria of environmental damage and groundwater pollution will gain the most weight and importance.
- By comparing the results of AHP-SOWT with two different scenarios of compliance with environmental regulations and non-compliance, it is concluded that in the first case opportunities are the most and weaknesses are the least important factors in the development of geotourism in the study area. This means that the region has a high potential for tourism and with the help of suitable planning and proper management, the region can become an excellent tourist attraction. In the second case, it means by not considering the environmental regulations, the weight of the main criterion of threat is greater than the weight of the criterion of opportunity, and it will not have the potential to be developed to a tourist complex from an environmental standpoint, and the project will be declared rejected.

References

Akbari, S., Ramazi, H., Ghezelbash, R., & Maghsoudi, A. (2020). Geoelectrical integrated models for determining the geometry of karstic cavities in the Zarrinabad area, west of Iran: combination of fuzzy logic, CA fractal model and hybrid AHP-TOPSIS procedure. *Carbonates and Evaporites*, *35*, 1-16.

Allen, L. R., Hafer, H. R., Long, P. T., & Perdue, R. R. (1993). Rural residents' attitudes toward recreation and tourism development. Journal of travel research, 31(4), 27-33.

Amini, A., & Ramazi, H. (2017). CRSP, numerical results for an electrical resistivity array to detect underground cavities. Open Geosciences, 9(1), 13-23.Barker, R., & Moore, J. (1998). The application of time-lapse electrical tomography in groundwater studies. The Leading Edge, 17(10), 1454-1458.

Belisle, F. J., & Hoy, D. R. (1980). The perceived impact of tourism by residents a case study in Santa Marta, Colombia. Annals of tourism research, 7(1), 83-101.

Dyson, R. G. (2004). Strategic development and SWOT analysis at the University of Warwick. *European journal of operational research*, *152*(3), 631-640.

Faulkner, B. (2002). Rejuvenating a maturing tourist destination: The case of the Gold Coast. *Current Issues in Tourism*, *5*(6), 472-520.

Gan, F., Han, K., Lan, F., Chen, Y., & Zhang, W. (2017). Multi-geophysical approaches to detect karst channels underground—A case study in Mengzi of Yunnan Province, China. Journal of Applied Geophysics, 136, 91-98.

Garofano, M., & Govoni, D. (2012). Underground geotourism: a historic and economic overview of show caves and show mines in Italy. Geoheritage, 4(1-2), 79-92.

Ghezelbash R, Maghsoudi A (2018b) A hybrid AHP-VIKOR approach for prospectivity modeling of porphyry Cu deposits in the Varzaghan District, NW Iran. ARAB J GEOSCI 11(11), 275

Gillieson, D. (1996). Caves. Processes, development and management: Cambridge, Massachusetts: Blackwell Publishers.

Hazreek, Z. A. M., Nizam, Z. M., Aziman, M., Dan, M. M., Shaylinda, M. Z. N., Faizal, T. B. M., ... & Ashraf, M. I. M. (2018, April). Mapping on Slope Seepage Problem using Electrical Resistivity Imaging (ERI). In Journal of Physics: Conference Series (Vol. 995, No. 1, p. 012091). IOP Publishing.

Houben, G., Lenie, K., & Vanhoof, K. (1999). A knowledge-based SWOT-analysis system as an instrument for strategic planning in small and medium sized enterprises. *Decision support systems*, *26*(2), 125-135.

Jardani, A., Revil, A., Santos, F., Fauchard, C., & Dupont, J. P. (2007). Detection of preferential infiltration pathways in sinkholes using joint inversion of self-potential and EM-34 conductivity data. Geophysical Prospecting, 55(5), 749-760.

Jeon, Y., & Kim, J. (2011). An application of SWOT-AHP to develop a strategic planning for a tourist destination.

Jurowski, C., Uysal, M., & Williams, D. R. (1997). A theoretical analysis of host community resident reactions to tourism. Journal of travel research, 36(2), 3-11.

Jurowski, C., Uysal, M., & Williams, D. R. (1997). A theoretical analysis of host community resident reactions to tourism. Journal of travel research, 36(2), 3-11.

Kahraman, C., Demirel, N., & Demirel, T. (2007). Prioritization of e-Government strategies using a SWOT-AHP analysis: The case of Turkey. *European Journal of Information Systems, 16*(3), 284-298.

Kajanusa M. J. Kangas and M. Kurttilac (2004), "The Use of Value Focused Thinking and the A'WOT Hybrid Method in Tourism Management", Tourism Management, (25), 499-506.

Kneisel, C., Emmert, A., & Kästl, J. (2014). Application of 3D electrical resistivity imaging for mapping frozen ground conditions exemplified by three case studies. Geomorphology, 210, 71-82.

Kurttila, M., Pesonen, M., Kangas, J., & Kajanus, M. (2000). Utilizing the analytic hierarchy process (AHP) in SWOT analysis: A hybrid method and its application to a forestcertification case. Forest Policy and Economics, 1(1), 41-52.

Liu, J. C., Sheldon, P. J., & Var, T. (1987). Resident perception of the environmental impacts of tourism. Annals of Tourism Research, 14(1), 17-37.

Lobo, H. A. S., Trajano, E., de Alcântara Marinho, M., Bichuette, M. E., Scaleante, J. A. B., Scaleante, O. A. F., ... & Laterza, F. V. (2013). Projection of tourist scenarios onto fragility maps: Framework for determination of provisional tourist carrying capacity in a Brazilian show cave. Tourism Management, 35, 234-243.

Loke, M. H., & Barker, R. D. (1996). Rapid least-squares inversion of apparent resistivity pseudosections by a quasi-Newton method 1. Geophysical prospecting, 44(1), 131-152.

Loke, M. H., Acworth, I., & Dahlin, T. (2001). A comparison of smooth and blocky inversion methods in 2-D electrical imaging surveys. ASEG Extended Abstracts, 2001(1), 1-4.

Lundberg D E (1990) The tourist business (6th ed.). New York: Van Nostrand Reinhold.

Maillol, J. M., Seguin, M. K., Gupta, O. P., Akhauri, H. M., & Sen, N. (1999). Electrical resistivity tomography survey for delineating uncharted mine galleries in West Bengal, India. Geophysical prospecting, 47(2), 103-116.

Mason, P. (2020). Tourism impacts, planning and management. Routledge.

Metwaly, M., & AlFouzan, F. (2013). Application of 2-D geoelectrical resistivity tomography for subsurface cavity detection in the eastern part of Saudi Arabia. Geoscience Frontiers, 4(4), 469-476.

Novas, N., Gázquez, J. A., MacLennan, J., García, R. M., Fernández-Ros, M., & Manzano-Agugliaro, F. (2017). A real-time underground environment monitoring system for sustainable tourism of caves. Journal of cleaner production, 142, 2707-2721.

Parasnis, D. S. (1967). Three‐dimensional electric mise‐a‐la‐masse survey of an irregular lead‐zinc‐copper deposit in central Sweden. Geophysical Prospecting, 15(3), 407-437.

Perdue, R. R., Long, P. T., & Allen, L. (1987). Rural resident tourism perceptions and attitudes. Annals of Tourism Research, 14(3), 420-429.

Prentice, R. (1993). Community-driven tourism planning and residents' preferences. Tourism Management, 14(3), 218-227.

Priskin, J. (2001). Assessment of natural resources for nature-based tourism:: the case of the Central Coast Region of Western Australia. Tourism management, 22(6), 637-648.

Ramazi, H. R. (2005). Combined resistivity sounding and profiling and its application in mineral exploration and site investigation. Tehran (in persian).

Ramazi, H., & Jalali, M. (2015). Contribution of geophysical inversion theory and geostatistical simulation to determine geoelectrical anomalies. Studia Geophysica et Geodaetica, 59(1), 97-112.

Ramazi, H., & Mostafaie, K. (2013). Application of integrated geoelectrical methods in Marand (Iran) manganese deposit exploration. Arabian Journal of Geosciences, 6(8), 2961-2970.

Ramazi, H., Nejad, M. R. H., & Firoozi, A. A. (2009). Application of integrated geoelectrical methods in Khenadarreh (Arak, Iran) graphite deposit exploration. Journal of the Geological Society of India, 74(2), 260-266.

Saaty T L (1980) Analytic hierarchy process. John Wiley & Sons, Ltd.

Schlumberger, C. (1920). Etude sur la prospection electrique du sous-sol. Gauthier-Villars.

Shawkat A, Carpenter P. 2003. Geophysical response of filled sinkholes, soil pipes and associated bedrock fractures in thinly mantled karst, east-central Illinois. Environmental Geology 44: 705–716.

Sheldon, P. J., & Var, T. (1984). Resident attitudes to tourism in North Wales. Tourism management, 5(1), 40-47.

Spies, B. R., & Ellis, R. G. (1995). Cross-borehole resistivity tomography of a pilot-scale, in-situ vitrification test. Geophysics, 60(3), 886-898.

Tosun, C. (2002). Host perceptions of impacts: A comparative tourism study. Annals of tourism research, 29(1), 231-253.

Um, S., & Crompton, J. L. (1990). Attitude determinants in tourism destination choice. Annals of tourism research, 17(3), 432-448.

Van Schoor, M. (2002). Detection of sinkholes using 2D electrical resistivity imaging. Journal of Applied Geophysics, 50(4), 393-399.

Vichabian, Y., & Morgan, F. D. (2002). Self-potentials in cave detection. The Leading Edge, 21(9), 866-871.

Weaver, D. B., & Lawton, L. J. (2001). Resident perceptions in the urban–rural fringe. Annals of tourism research, 28(2), 439-458.

Yeboah-Forson, A., Comas, X., & Whitman, D. (2014). Integration of electrical resistivity imaging and ground penetrating radar to investigate solution features in the Biscayne Aquifer. Journal of hydrology, 515, 129-138.

Yüksel, İ., & Dagdeviren, M. (2007). Using the analytic network process (ANP) in a SWOT analysis–A case study for a textile firm. *Information sciences*, *177*(16), 3364-3382.

Table captions:

Table 1. Internal factors affecting ecotourism development in the study area.

Table 2. External factors affecting ecotourism development in the study area.

Table 3. Ratio scales in AHP method (from Saaty, 1980).

Table 4. Pairwise comparison among main criteria of the study area and their calculated weights based on AHP method.

Table 5. Pairwise comparison among sub-criteria related to the strengths (S) of the study area and their calculated weights based on AHP method.

Table 6. Pairwise comparison among sub-criteria related to the weaknesses (W) of the study area and their calculated weights based on AHP method.

Table 7. Pairwise comparison among sub-criteria related to the opportunities (O) of the study area and their calculated weights based on AHP method.

Table 8. Pairwise comparison among sub-criteria related to the Threats (T) of the study area and their calculated weights based on AHP method.

Table 9. Final weights of sub-criteria related to the study area.

Table 1. Internal factors affecting ecotourism development in the study area.

weaknesses		Strengths	
lack of management	W1	barrenness of the lands in the region	S1
Weak planning in the development of geotourism in the region	W2	Existence of water resources	S2
The unknownness of the area	W3	Absence of specific plant and animal species in the region	S3
Lack of accommodation and welfare facilities	W4	Absence of geomorphological barriers	S4
Lack of about 15 kilometers proper access road (side road)	W5	quiet environment	S5
Lack of entertainment and sports equipment	W6	Proximity to Eyvashan dam	S6

Table 2. External factors affecting ecotourism development in the study area.

Threats		Opportunities	
increasing land prices	T1	making the study area prominent at the regional level	O1
Seasonality of jobs	T2	directly and indirectly job creation	O2
Environmental damages	T3	Increasing social interaction	O3
Soil pollution and erosion	T4	Providing accommodation and welfare facilities	O4
Groundwater pollution	T5	Development and improvement of infrastructure	O5
increasing tensions and conflicts	T6	More attention to the environment	O6

Table 3. Ratio scales in AHP method (from Saaty, 1980).

Intensity of importance	***Definition***
1	Equal importance or preference
2	Equal to moderate importance or preference
3	Moderate importance or preference
4	Moderate to strong importance or preference
5	Strong importance or preference
6	Strong to very strong importance or preference
7	Very strong importance or preference
8	Very to extremely strong importance or preference
9	Extreme importance or preference

Table 4. Pairwise comparison among main criteria of the study area and their calculated weights based on AHP method.

Factors	Strengths	weaknesses	Opportunities	Threats	Weight
Strengths	1	5	0.5	3	0.301
weaknesses	0.2	1	0.166	0.333	0.062
Opportunities	2	6	1	5	0.509
Threats	0.333	3	0/2	1	0.127

Table 5. Pairwise comparison among sub-criteria related to the strengths (S) of the study area and their calculated weights based on AHP method.

Strengths	S1	S2	S3	S4	S5	S6	Weight
S1	1	0.333	4	1	6	3	**0.210**
S2	3	1	4	2	8	3	**0.370**
S3	0.25	0.25	1	0.166	3	1	**0.074**
S4	1	0.5	6	1	7	2	**0.232**
S5	0.166	0.125	0.333	0.142	1	0.5	**0.035**
S6	0.333	0.333	1	0.5	2	1	**0.087**

Table 6. Pairwise comparison among sub-criteria related to the weaknesses (W) of the study area and their calculated weights based on AHP method.

weaknesses	W1	W2	W3	W4	W5	W6	Weight
W1	1	2	3	5	3	6	**0.347**
W2	0.5	1	4	4	3	6	**0.276**
W3	0.333	0.25	1	2	0.25	3	**0.093**
W4	0.25	0.25	0.5	1	0.25	2	**0.063**
W5	0.333	0.333	4	4	1	4	**0.179**
W6	0.166	0.166	0.333	0.5	0.25	1	**0.040**

Table 7. Pairwise comparison among sub-criteria related to the opportunities (O) of the study area and their calculated weights based on AHP method.

Opportunities	**O1**	**O2**	**O3**	**O4**	**O5**	**O6**	**Weight**
O1	1	0.333	4	0.5	0.2	0.333	**0.084**
O2	3	1	8	4	2	5	**0.370**
O3	0.25	0.125	1	0.333	0.2	0.5	**0.038**
O4	2	0.25	3	1	0.25	2	**0.111**
O5	5	0.5	5	4	1	6	**0.304**
O6	3	0.2	2	0.5	0.166	1	**0.090**

Table 8. Pairwise comparison among sub-criteria related to the threats (T) of the study area and their calculated weights based on AHP method.

Threats	T1	T2	T3	T4	T5	T6	Weight
T1	1	2	3	5	3	6	**0.366**
T2	0.5	1	3	4	3	6	**0.279**
T3	0.333	0.333	1	2	1	4	**0.126**
T4	0.2	0.25	0.5	1	0.5	2	**0.069**
T5	0.2	0.333	1	2	1	4	**0.117**
T6	0.166	0.166	0.25	0.5	0.25	1	**0.040**

Table 9. Final weights of sub-criteria related to the study area.

Weight of sub-criteria	Sub-criteria	Weight of criteria	Criteria
0.063	S1	0.301	**Strengths**
0.111	S2		
0.022	S3		
0.070	S4		
0.011	S5		
0.026	S6		
0.022	W1	0.062	**Weaknesses**
0.017	W2		
0.006	W3		
0.004	W4		
0.011	W5		
0.002	W6		
0.043	O1	0.509	**Opportunities**
0.188	O2		
0.019	O3		
0.056	O4		
0.155	O5		
0.046	O6		
0.044	T1	0.12	**Threats**
0.033	T2		
0.015	T3		
0.008	T4		
0.014	T5		
0.005	T6		

Figure captions:

Fig. 1. The location and the geological map of the study area in Lorestan province.

Fig. 2. Pictures taken by cavers from inside the cave and its large corridors and halls.

Fig. 3. The cave entrance at the rainy season which is completely underwater.

Fig. 4. Geoelectrical survey lines layout and topographic curves of the study area.

Fig. 5. Self-potential variations contour map of Zagheh area.

Fig. 6. Equipotential lines resulted from Mise-a-la-masse measurements in Zagheh area.

Fig. 7. Electrical resistivity contour maps along (a): AB=50, (b): AB=90 (c): AB=130, (d): AB=150 and (e): AB=290.

Fig. 8. Apparent resistivity pseudo sections along profiles (a): P1, (b): p2, (c): p5, (d): p13 and (a): p15.

Fig. 9. The trend of electrical resistivity variations from surface to depth.

Fig. 10. The 3-D electrical resistivity model of the Zagheh area from the (a): rear view, (b): from the front view and (c): top view.

Fig. 11. Hierarchical structure for ecotourism development in the study area.

Fig. 12. pairwise comparison results of criteria.

Fig. 13. pairwise comparison results of sub-criteria related to the strengths (S) of the study area.

Fig. 14. pairwise comparison results of sub-criteria related to the weaknesses (W) of the study area.

Fig. 15. pairwise comparison results of sub-criteria related to the opportunities (O) of the study area.

Fig. 16. pairwise comparison results of sub-criteria related to the threats (T) of the study area.

Fig. 17. Comparison of final weights of sub-criteria in the study area.

Fig. 18. The impact of each main criterion on the geotourism development in the study area based on final weights of sub-criteria.

Fig. 19. pairwise comparison results of criteria assuming that environmental standards are not considered.

Fig. 20. pairwise comparison results of sub-criteria related to the threats (T) of the study area assuming that environmental standards are not considered.

Fig. 21. Comparison of final weights of sub-criteria in the study area assuming that environmental standards are not considered.

Fig. 22. The impact of each main criterion on the geotourism development in the study area based on final weights of sub-criteria assuming that environmental standards are not considered.

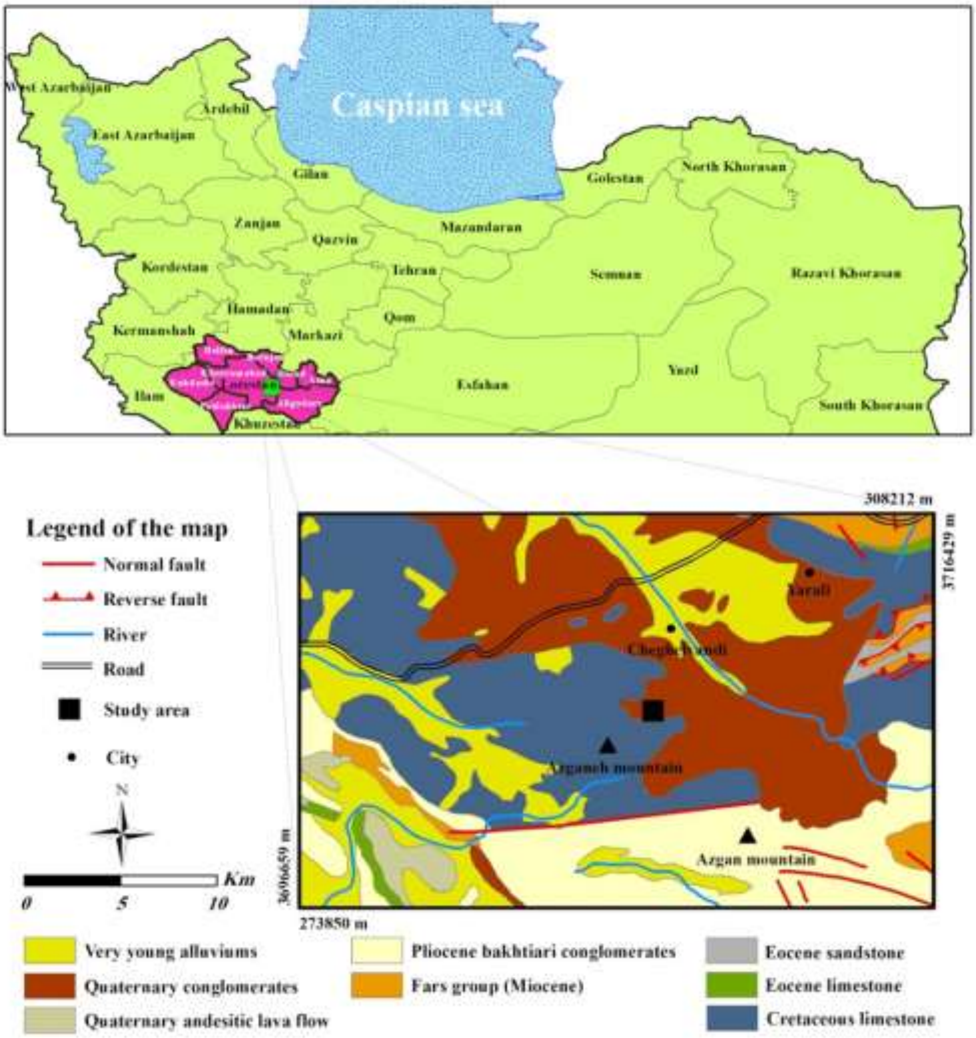
Caspian sea
West Azarbaijan
Ardebil
East Azarbaijan
Gilan
Golestan
North Khorasan
Zanjan
Qazvin
Mazandaran
Kordestan
Tehran
Semnan
Razavi Khorasan
Hamadan
Qom
Kermanshah
Markazi
Lorestan
Esfahan
Yazd
Ilam
South Khorasan
Khuzestan
Legend of the map
Normal fault
Reverse fault
River
Road
Study area
City
N
Km
0
5
10
308212 m
3716429 m
3696659 m
273850 m
Yarali
Argaueh mountain
Azgan mountain
Very young alluviums
Quaternary conglomerates
Quaternary andesitic lava flow
Pliocene bakhtiari conglomerates
Fars group (Miocene)
Eocene sandstone
Eocene limestone
Cretaceous limestone

Fig. 1

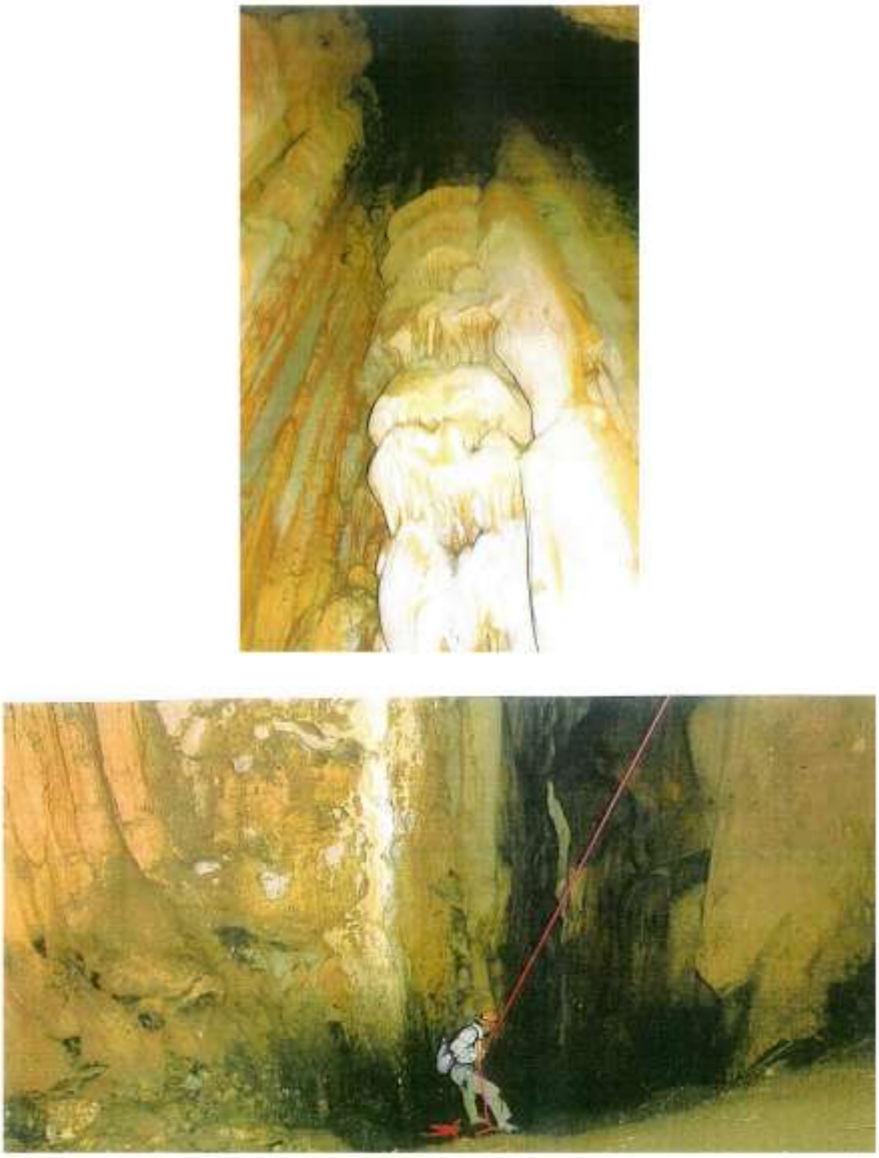

Fig. 2

Fig. 3

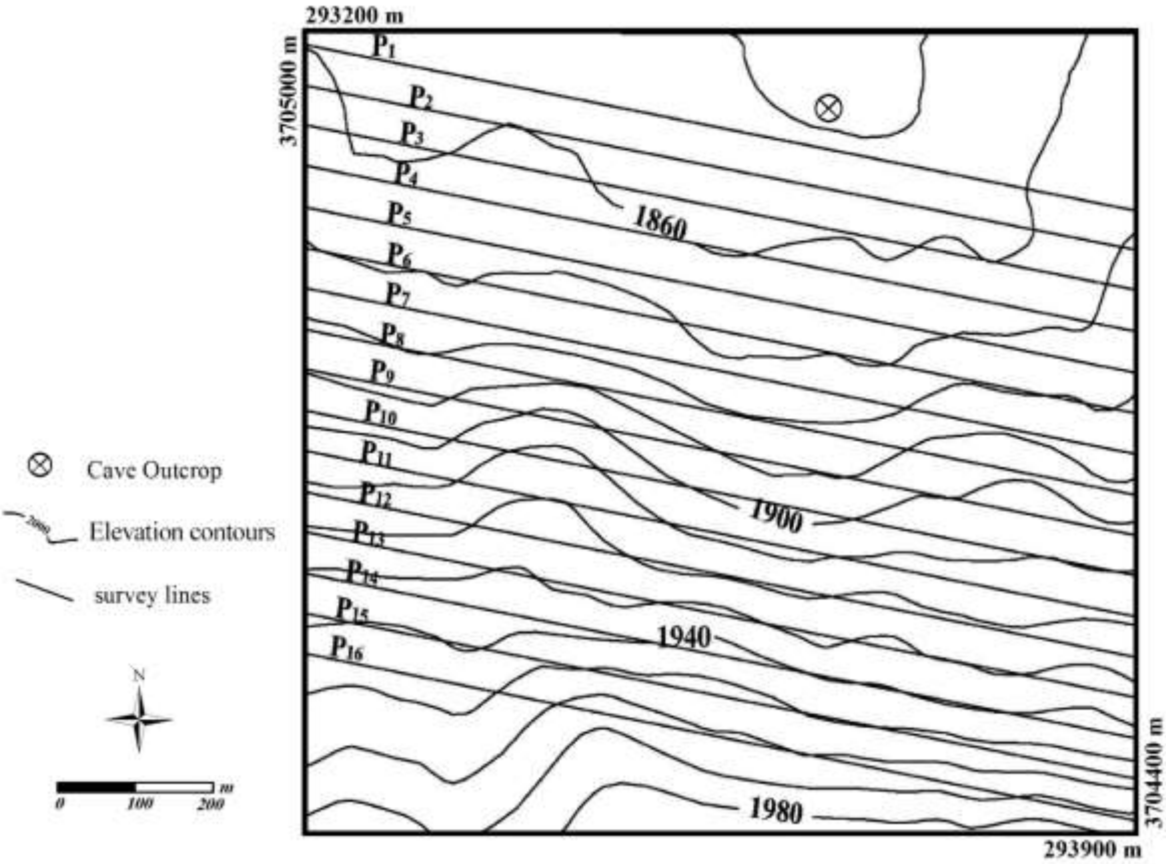
293200 m
3705000 m
P1
P2
P3
P4
P5
P6
P7
P8
P9
P10
P11
P12
P13
P14
P15
P16
1860
1900
1940
1980
3704400 m
293900 m
Cave Outcrop
Elevation contours
survey lines
N
0
100
200
m

Fig. 4

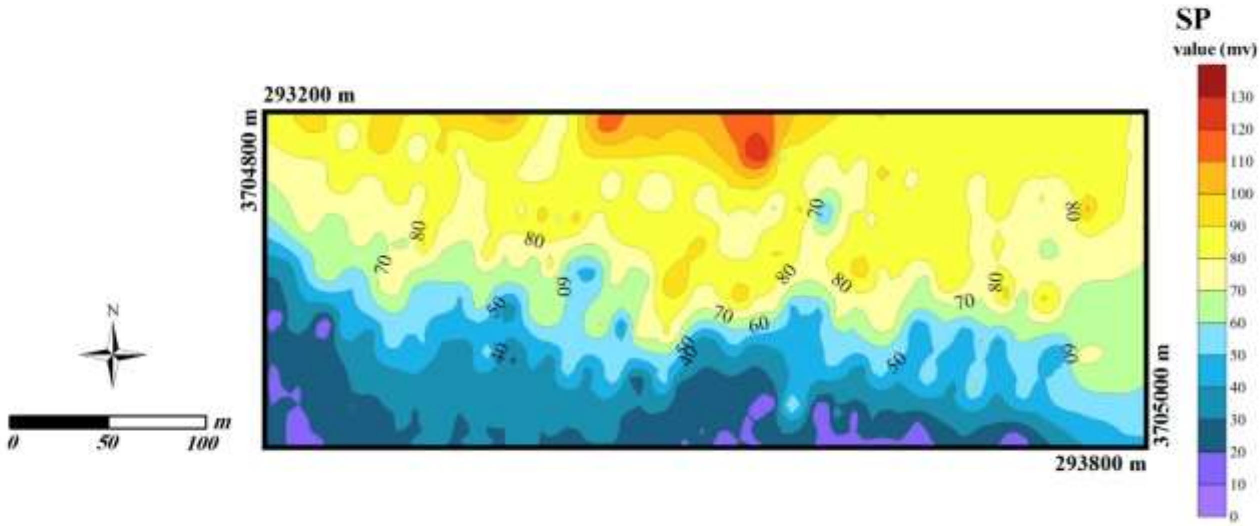

Fig. 5

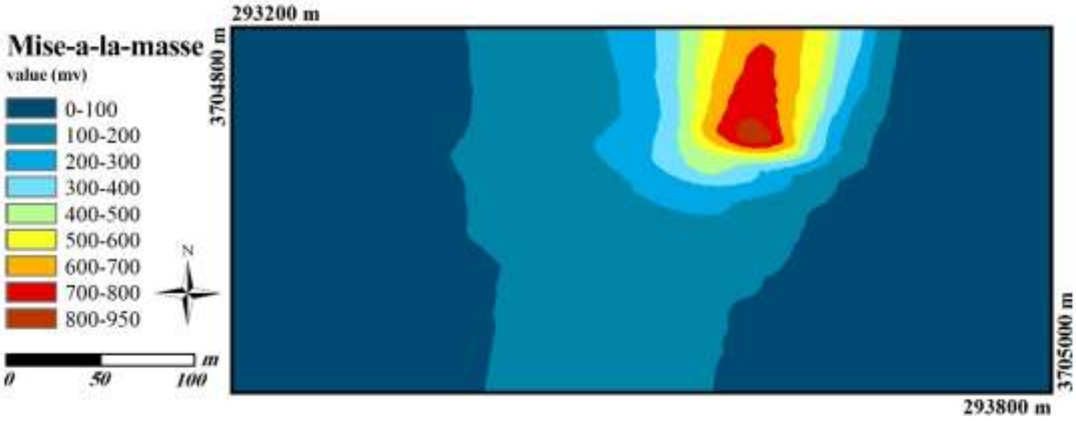
293200 m
Mise-a-la-masse
value (mv)
0-100
100-200
200-300
300-400
400-500
500-600
600-700
700-800
800-950
N
m
0
50
100
3704800 m
3705000 m
293800 m

Fig. 6

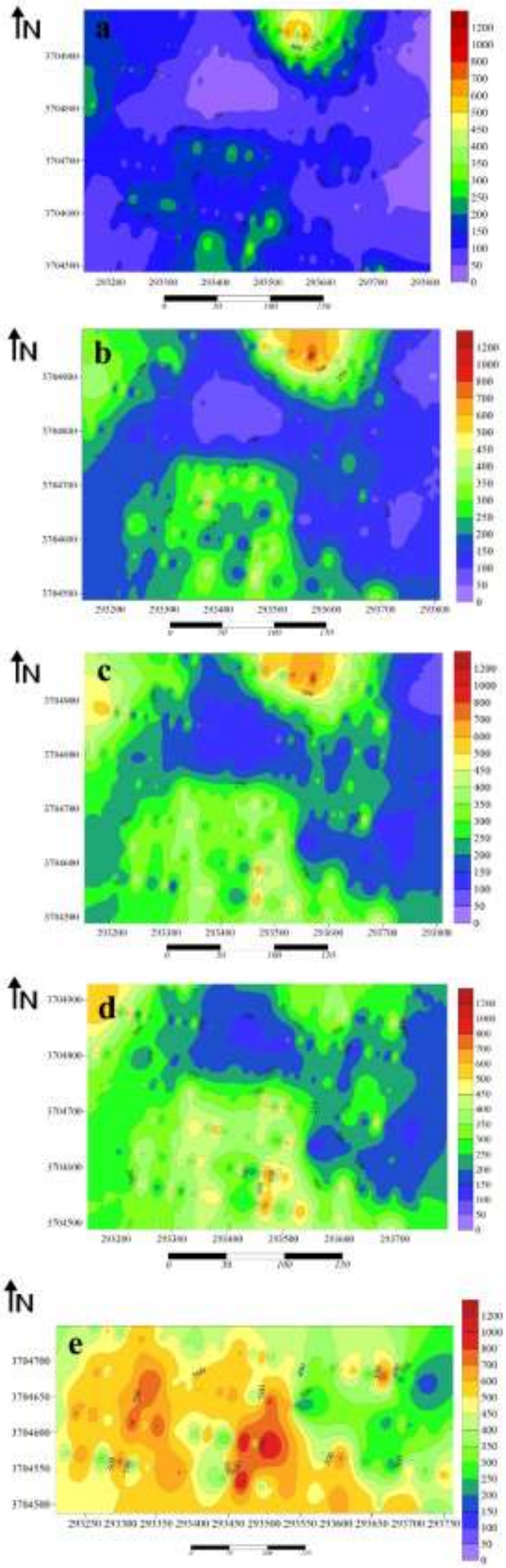
N
a
b
c
d
e
1200
1000
800
700
600
500
450
400
350
300
250
200
150
100
50
0

Fig. 7

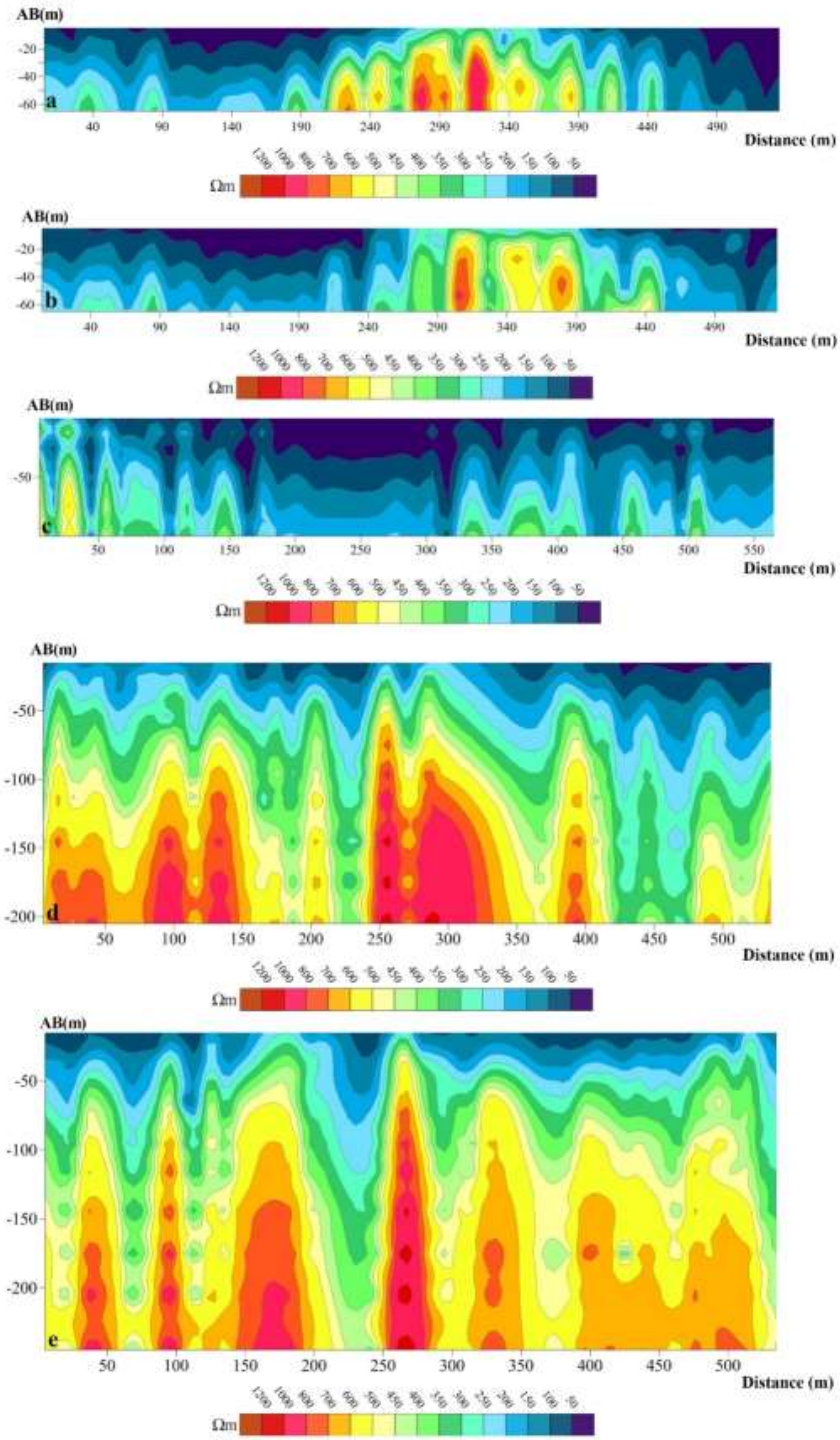

Fig. 8

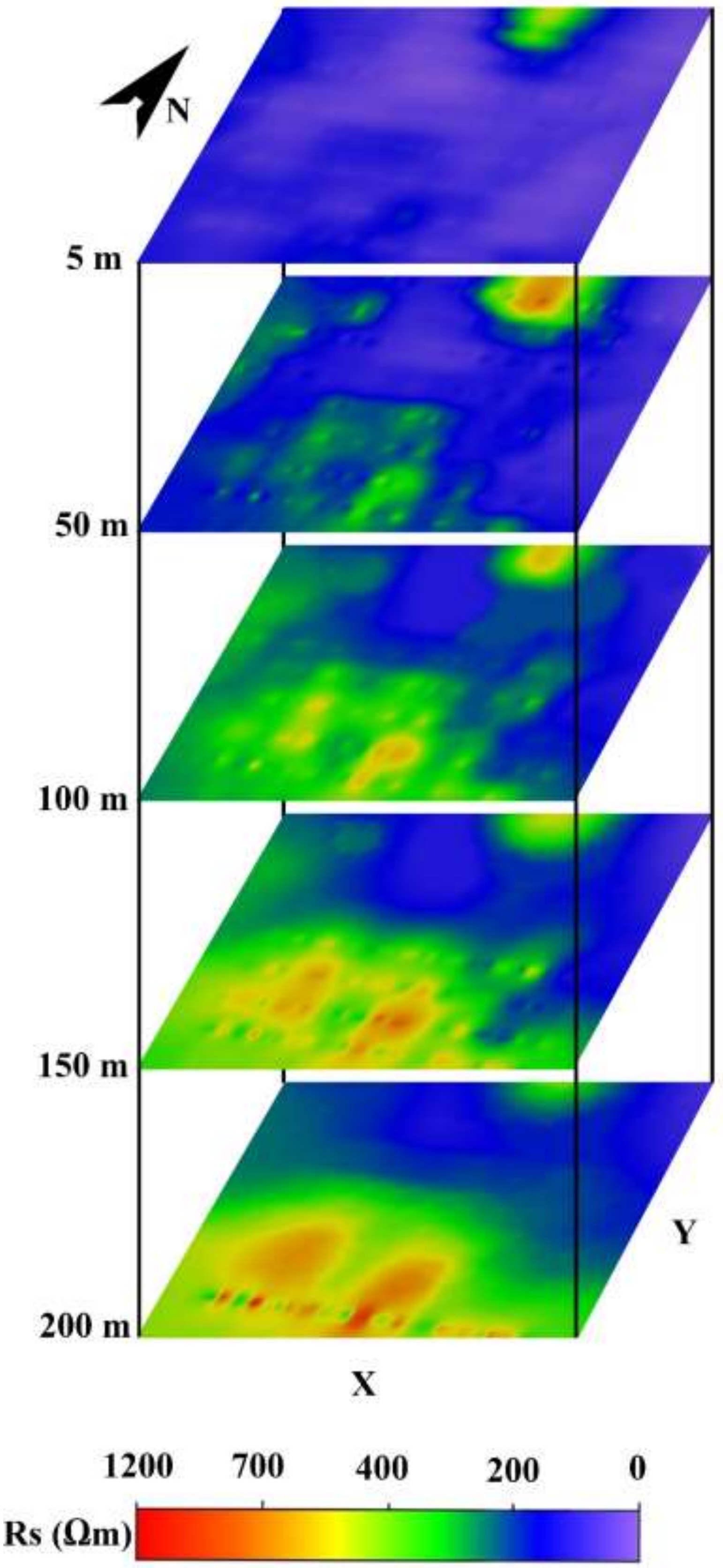

Fig. 9

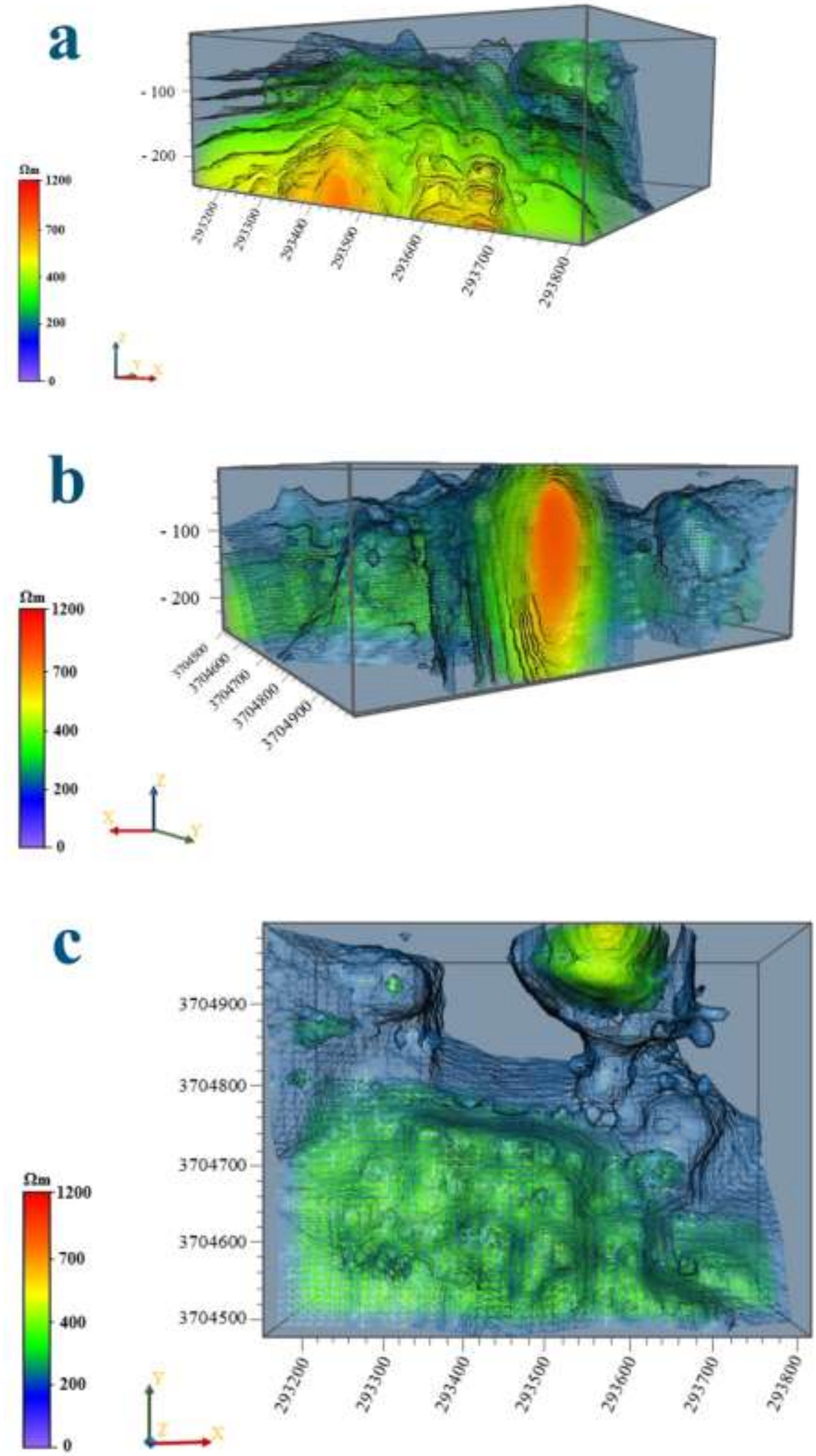
a
- 100
- 200
Ωm
1200
700
400
200
0
293200
293300
293400
293500
293600
293700
293800
b
- 100
- 200
Ωm
1200
700
400
200
0
3704500
3704600
3704700
3704800
3704900
c
3704900
3704800
3704700
3704600
3704500
Ωm
1200
700
400
200
0
293200
293300
293400
293500
293600
293700
293800

Fig. 10

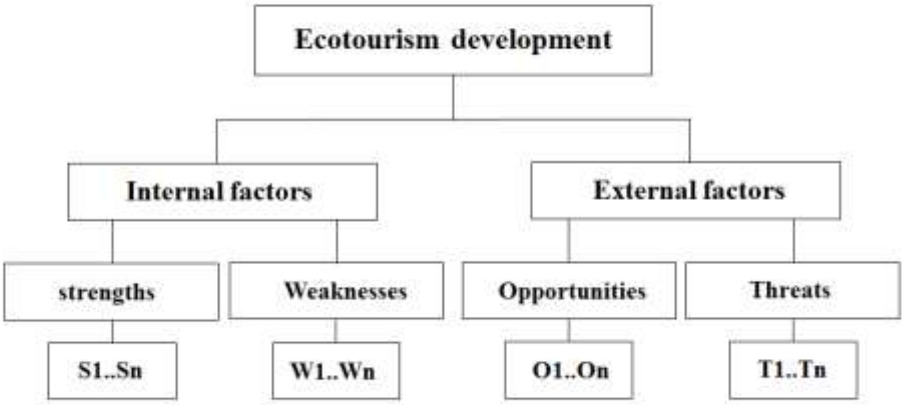
Ecotourism development
Internal factors
External factors
strengths
Weaknesses
Opportunities
Threats
S1..Sn
W1..Wn
O1..On
T1..Tn

Fig. 11

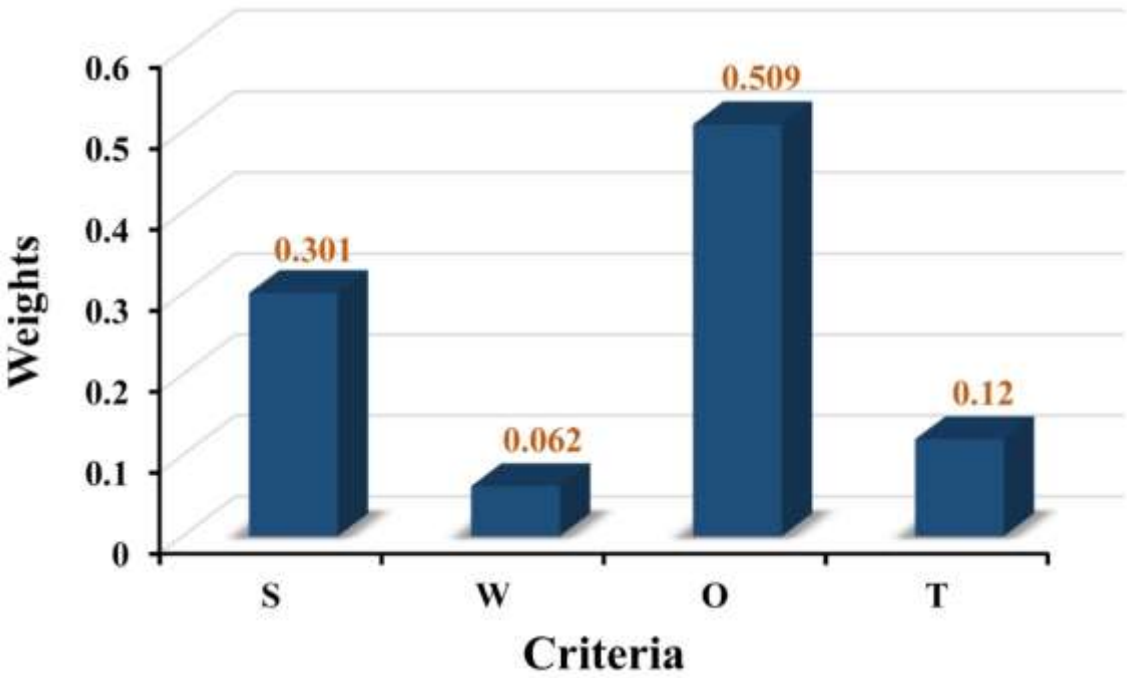

Fig. 12

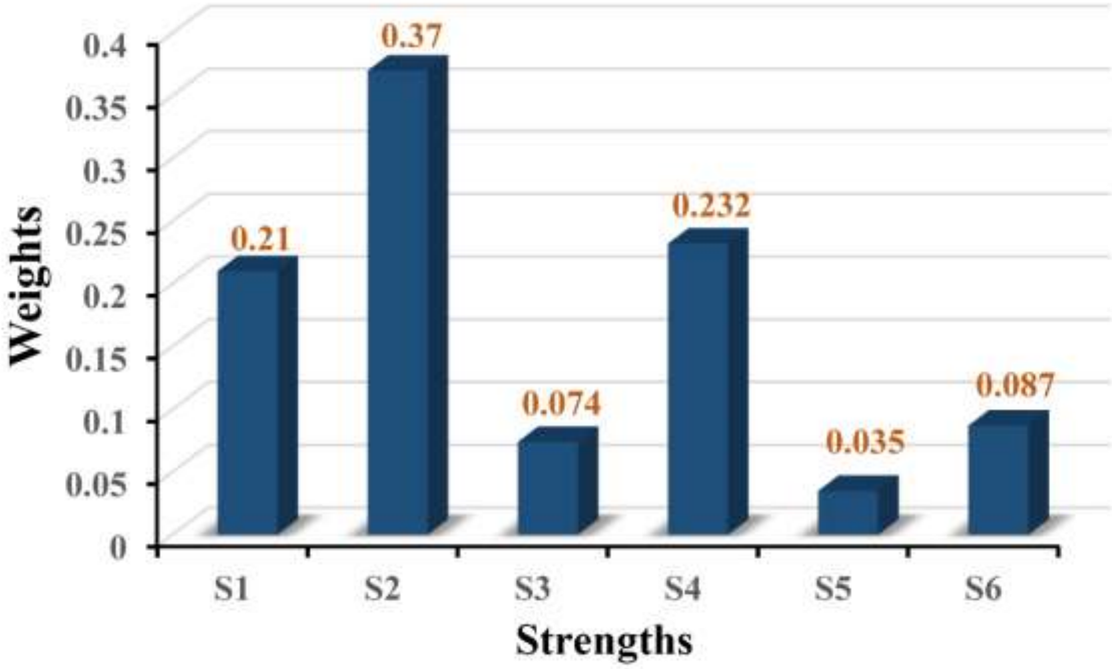
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Weights
0.21
0.37
0.074
0.232
0.035
0.087
S1
S2
S3
S4
S5
S6
Strengths

Fig. 13

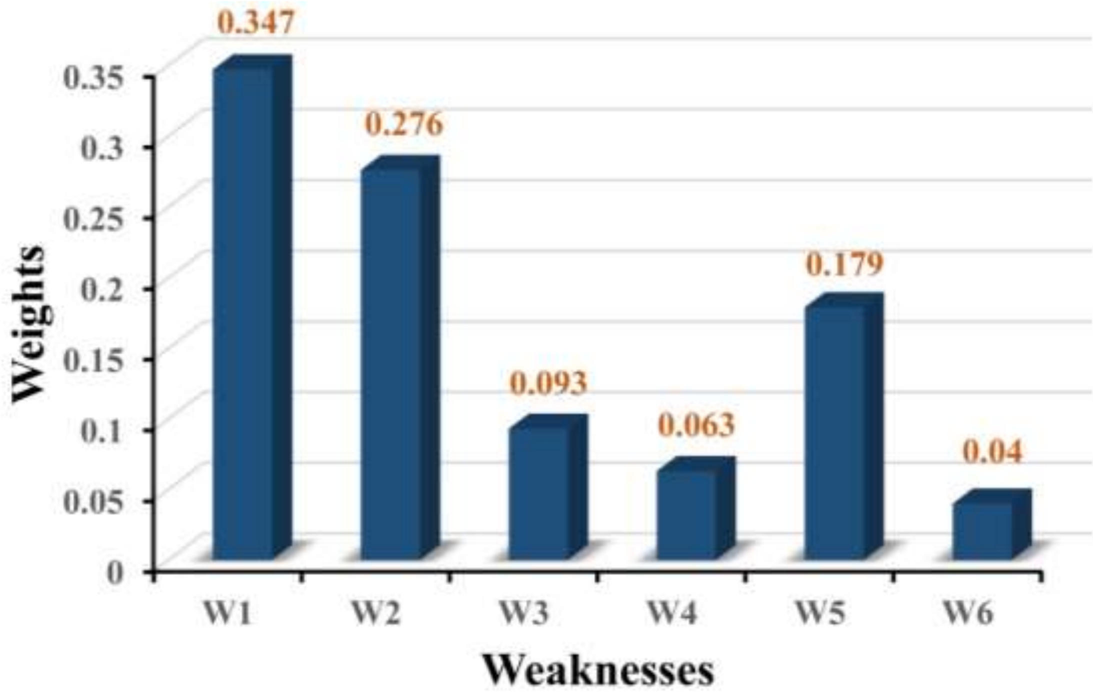
0.347
0.276
0.093
0.063
0.179
0.04
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Weights
W1
W2
W3
W4
W5
W6
Weaknesses

Fig. 14

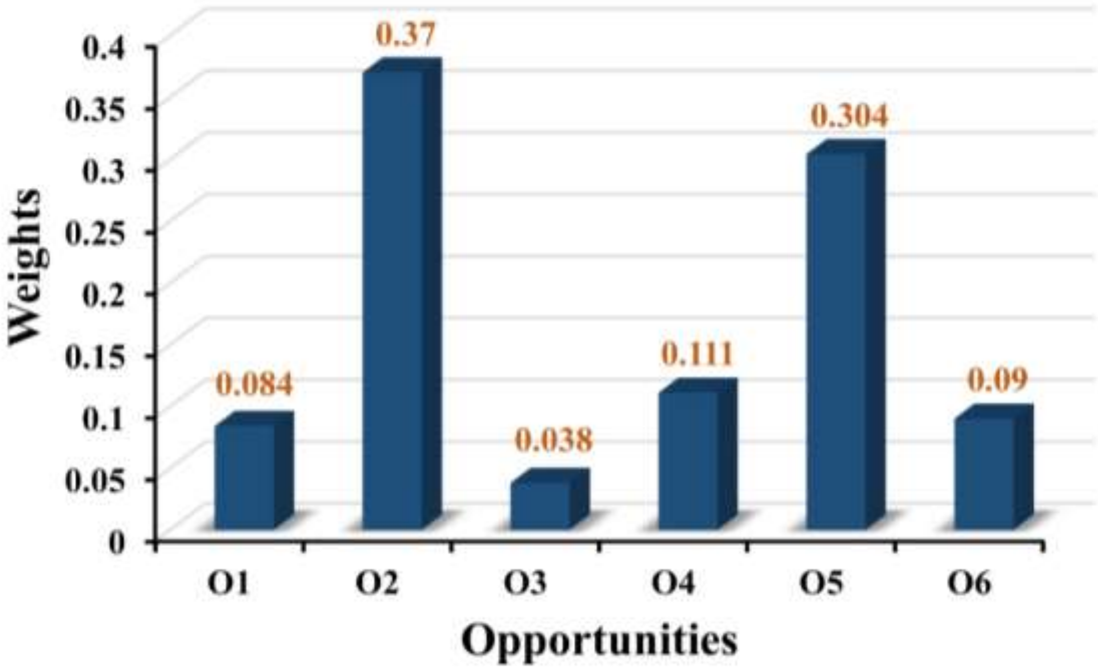
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Weights
0.084
0.37
0.038
0.111
0.304
0.09
O1
O2
O3
O4
O5
O6
Opportunities

Fig. 15

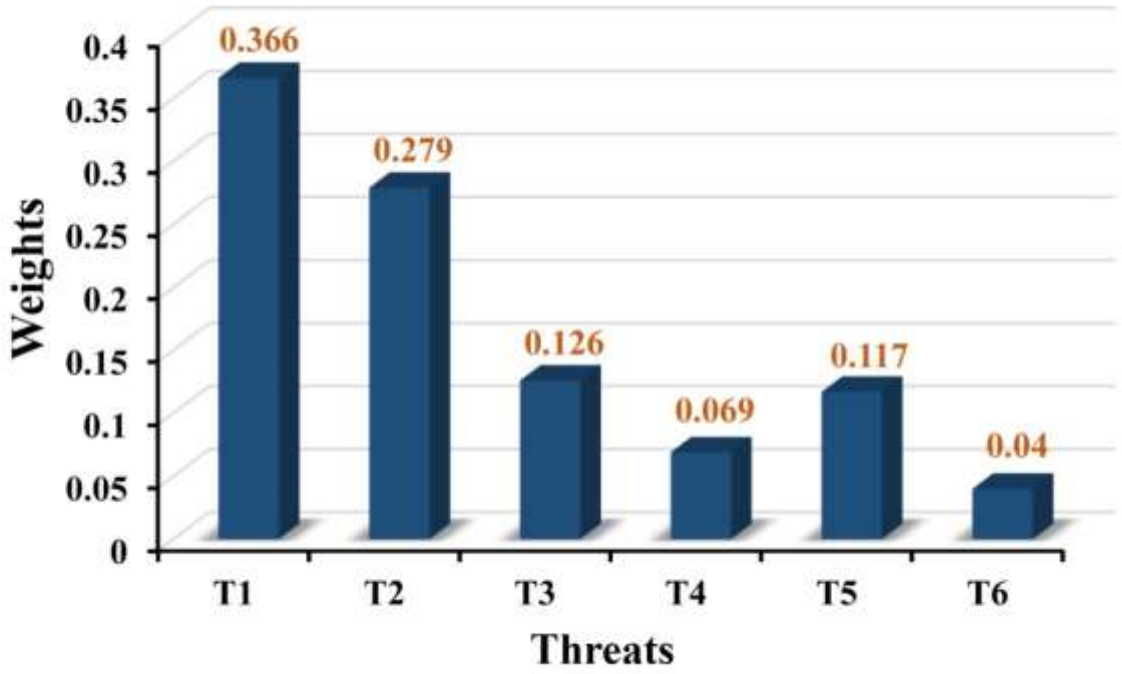
0.366
0.279
0.126
0.069
0.117
0.04
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Weights
T1
T2
T3
T4
T5
T6
Threats

Fig. 16

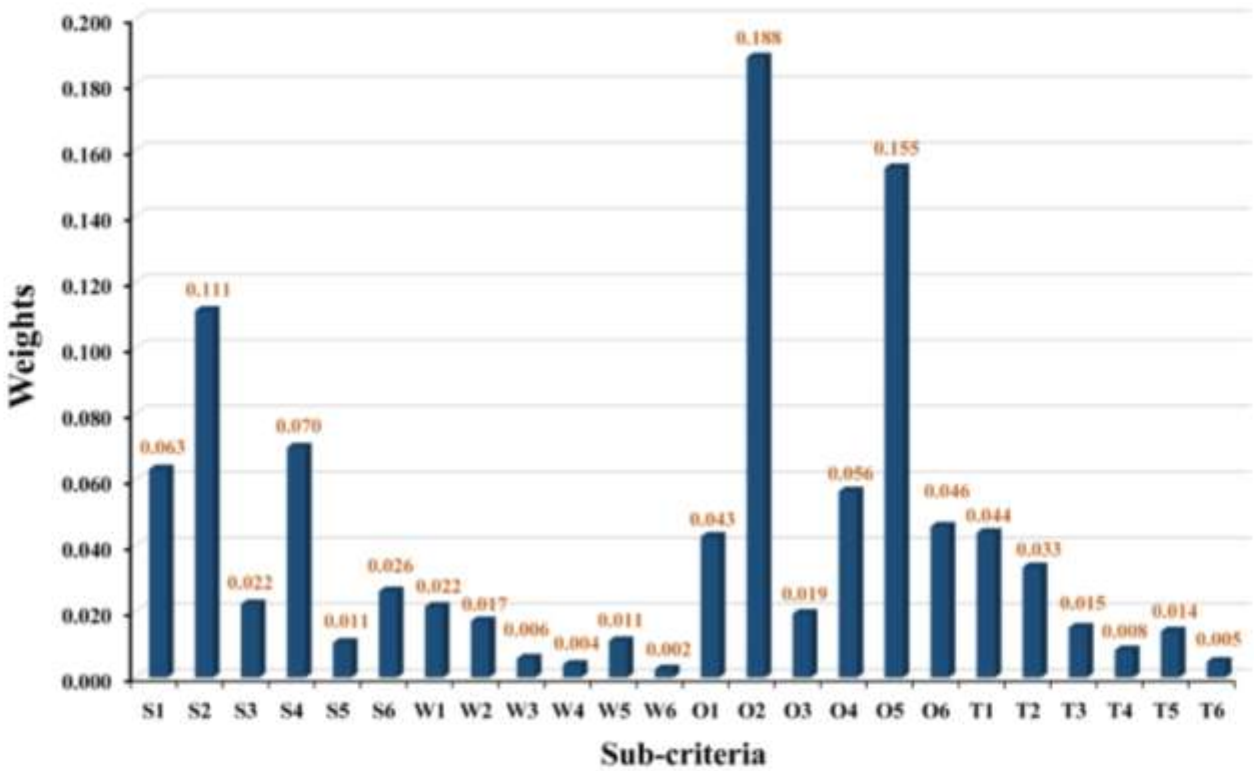
0.200
0.180
0.160
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
Weights
0.063
0.111
0.022
0.070
0.011
0.026
0.022
0.017
0.006
0.004
0.011
0.002
0.043
0.188
0.019
0.056
0.155
0.046
0.044
0.033
0.015
0.008
0.014
0.005
S1 S2 S3 S4 S5 S6 W1 W2 W3 W4 W5 W6 O1 O2 O3 O4 O5 O6 T1 T2 T3 T4 T5 T6
Sub-criteria

Fig. 17

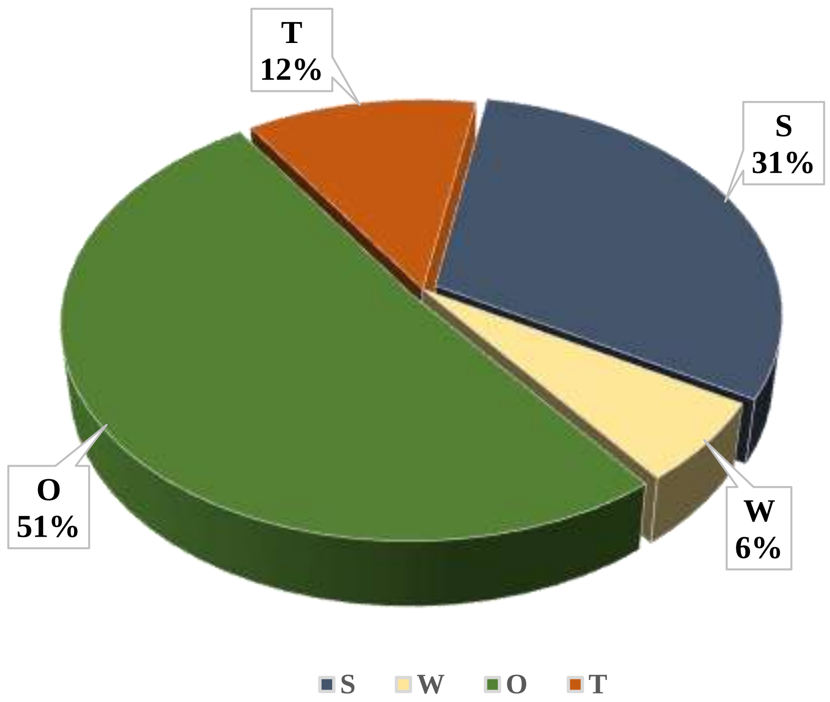

Fig. 18

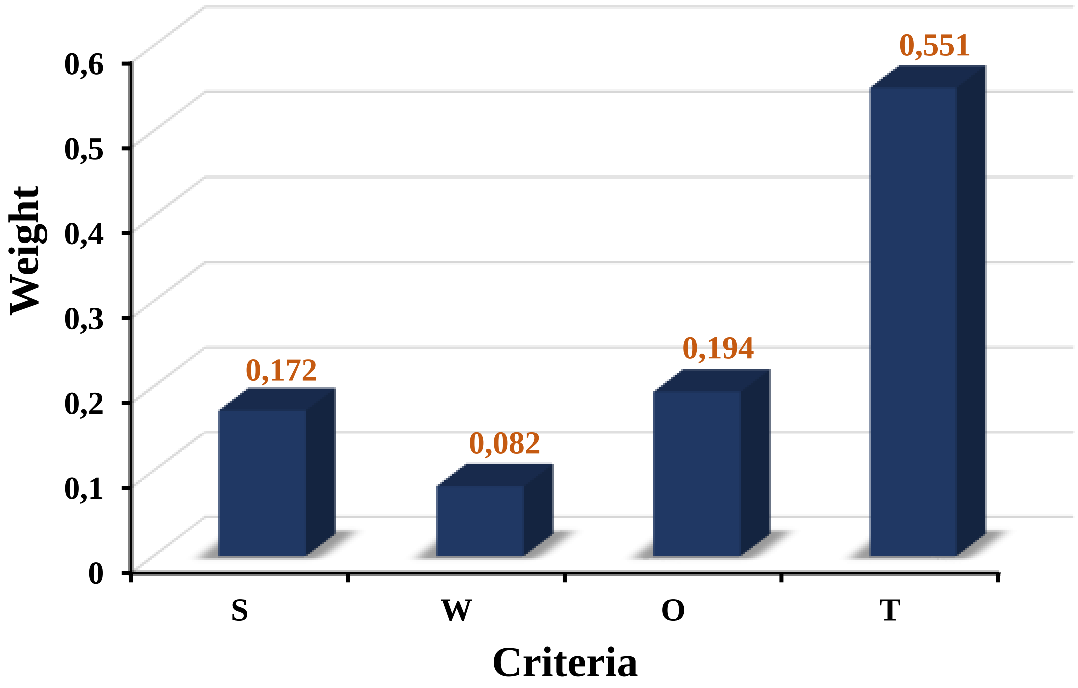

Fig. 19

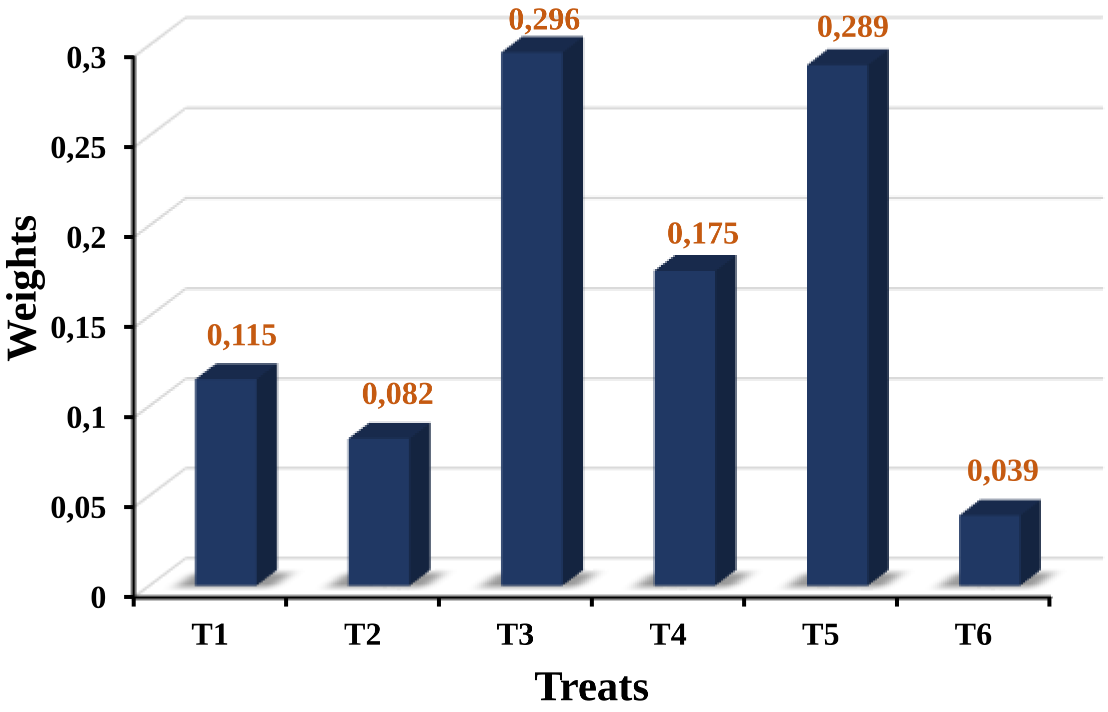
Weights
0,3
0,25
0,2
0,15
0,1
0,05
0
0,115
0,082
0,296
0,175
0,289
0,039
T1
T2
T3
T4
T5
T6
Treats

Fig. 20

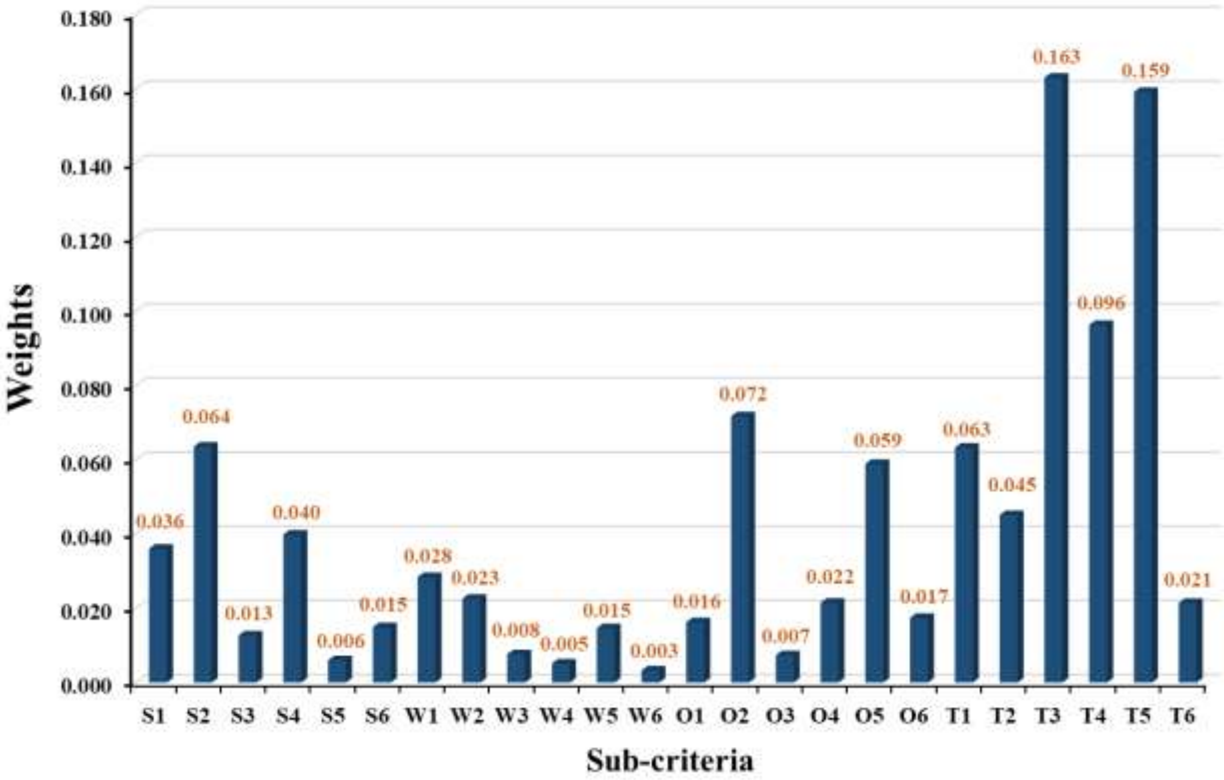
Weights
0.180
0.160
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
0.036
0.064
0.013
0.040
0.006
0.015
0.028
0.023
0.008
0.005
0.015
0.003
0.016
0.072
0.007
0.022
0.059
0.017
0.063
0.045
0.163
0.096
0.159
0.021
S1 S2 S3 S4 S5 S6 W1 W2 W3 W4 W5 W6 O1 O2 O3 O4 O5 O6 T1 T2 T3 T4 T5 T6
Sub-criteria

Fig. 21

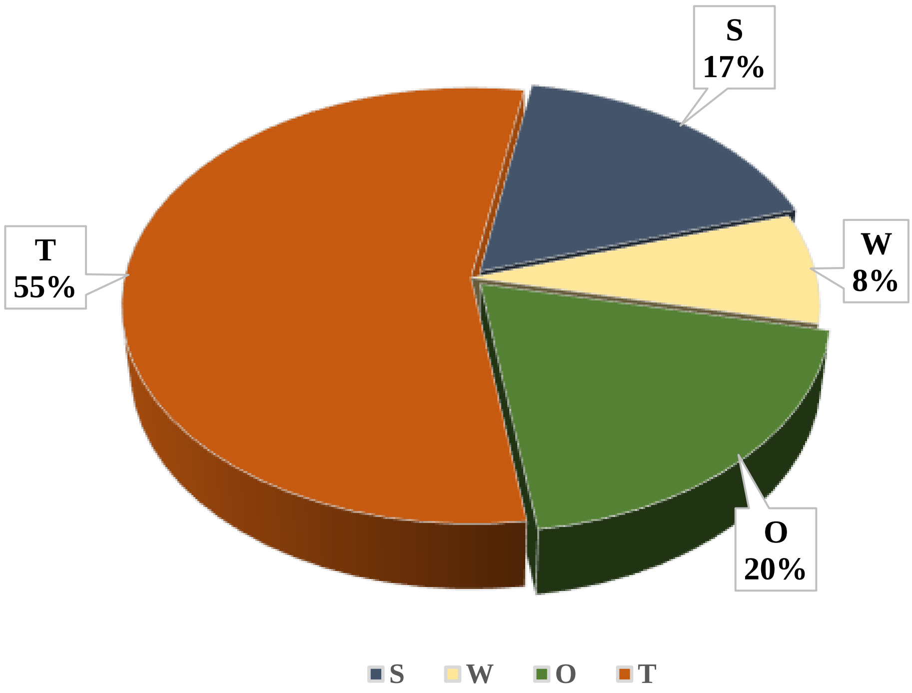

Fig. 22