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The Changes of YAKHAR Glacier Using Remote Sensing and GIS Technologies

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Abstract This study was an attempt to examine the changes of the YAKHAR Glacier of Damavand Using remote sensing and GIS Technologies. The remote sensing is the best equipment that helps us to find and estimate the area of YAKHAR glacier in the impassable mountainous regions. Moreover, GIS technologies help to design and prepare a map from the region. This study amid to prove this glacier is active and has changed during the recent years. This study was a quantitative survey and the quantitative data was collected with digital topographic map at the scale 1:50000 and 1:25000, Satellite images Landsat TM&ETM+ and IRS P5 (panchromatic). In order to correct those satellite images, the researchers applied geometrical correction and radiometric correction. The quantitative data was analyzed with calculating algorithm changes and plus subtracting from corresponding bands on the satellite images in order to measure Principal Components Analysis (PCA). Moreover, the researchers used Inter band ETM, IRS, and GIS software to indicate the severe chances of glacier via fuzzy logic model. The findings of this study reveal that the area of the YAKHAR glacier is decreasing and its current size is 1/8km. The crucial reasons of the decreasing are the lack of glacier recharge and the heat of smoke emerging from Damavand volcano. Furthermore, the global warning has impact on rising temperatures and melting YAKHAR glacier in this region and also abrupt slope prevents to form the YAKHAR glaciers.

Keywords: *damavand, YAKHAR glacier, remote sensing, GIS*

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1. Introduction

Nowadays water is one of the most influential parameters of social and even political that some experts predict the next conflicts are about water issues. Glacier changes are the key that indicates global climate change. In addition, they are unique sources of fresh water and an important economic factor for hydropower production ([1] cited in Moussavi & etal, 2008:49). Glaciers are made up of fallen snow during many years, and compresses into large, thickened ice masses. Unfortunately, direct measurements of mass are difficult and expensive. Glaciers in Iran are found in five main areas; as can be seen in Figure 1. Two glaciers are located in the Alborz mountain range in the north of Iran (one is in the vicinity of Takhte–Suleiman and the other is on Mount Damavand); the others are found on the Sab Alan Mountains in the northwest Iran, and on the Zardkuh and Oshtorankuh Mountains in the Zagros mountain range of the southwest of Iran.

Remote sensing is as an efficient method so as to gather data about glaciers. The recent Geographic Information Systems (GIS) and Global Positioning Systems (GPS) have created as an effective means to give information about a location. A large number of researchers have taken advantage of remote sensing, GIS and GPS in their studies of glaciers [3].The use of satellite data for updating or generating glacier inventories has been discussed for many years [2]. Furthermore, the combined use of satellite imagery and digital elevation models (DEMs) in a Geographic Information System (GIS) environment is a valuable method of efficient operational data processing ([1] cited in Moussavi & etal, 2008).

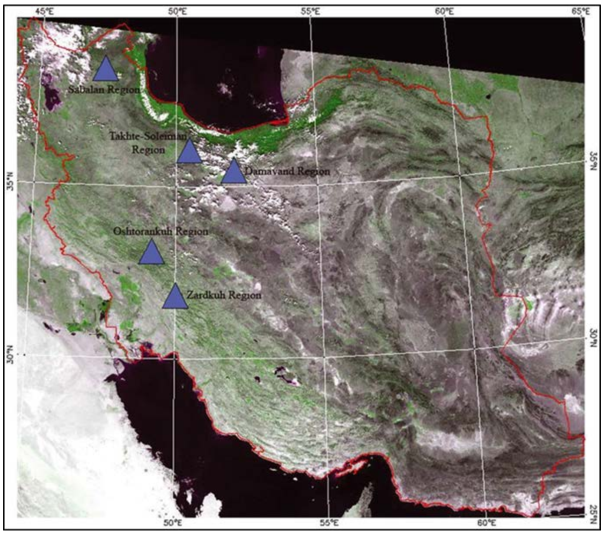

Figure 1. Glacier regions in Iran MODIS (moderate-resolution imaging spectroradiometer) image by [2]

Mount Damavand is a volcano and a strato volcano which is the highest pinnacle in Iran and the Middle East . This pinnacle is located in the middle of the Alborz range, adjacent to *Vararu*, *Sesang*, *Gol-e Zard* and *Mīanrud*. The mountain is located near the southern coast of the Caspian Sea, in Amol City, Mazandaran Province, 66 kilometers (41 miles) northeast of the city of Tehran. Damavand is 5671m altitude. Mount Damavand is the result of volcanic activities at the beginning of the Quaternary geologic time (Pleistocene stage). It simultaneously occurred for Ararat in Turkey and Sahand, Sab Alan and Alvand in Iran. Damavand is actually a non-active volcano. However, its warm mineral springs, absence of extensive glaciers and frequent earthquakes are the evidences of internal activities of this mountain. The following figure shows Damavand Mountain.

According to ([4-9]) the studies on snow, ice, and glaciers in Iran are limited and mostly have done by the above foreign researchers [10]. Zoning of glacier has been done by means of TM Landsat satellite images. [11]. Zoning of glacier changes has been done by means of GIS and ASTER [12]; the study of the retreat of Himalaya glaciers has done by means of remote sensing data from India [13]; Vaziri is the first person who completed study on Iran glaciers. In his book “Exploring Glaciers,” he investigated the mountainous glaciers completely [14]. The study on the Zard Kouh Glacier by means of remote sensing has been done [15]; a new glacier inventory of Iran has been studied [2] however their studies are not completed.

Figure 2. Mount Damavand image by Saeedeh Fakhari, 2015

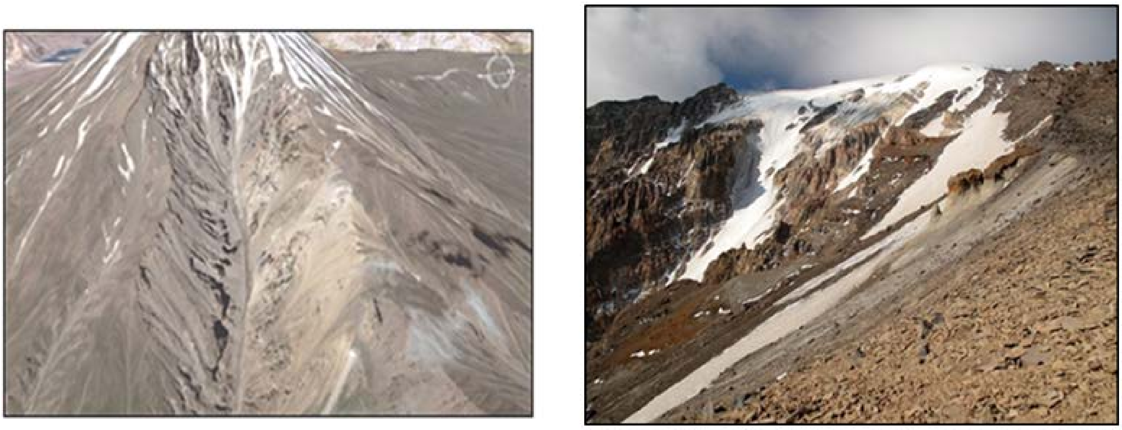

Figure 3. Image of Google Earth from valley of YAKHAR glacier in Mt. Damavand

The most important glaciers of Mt Damavand can be divided in to four glaciers as follows:

1-East and North Eastern Face Glaciers is in the valley of YAKHAR which is the most famous and the largest glacier of Damavand. This glacier can be seen over 3500 meters high. Figure 3 shows this YAKHAR.

2-North Face Glaciers: There are two large glaciers in the north face.

3-South Face Glacier: There is a small glacier in south face of the mountain in KAFAR Valley.

4-West Face Glaciers: There are some small glaciers in the western part.

So the researchers chose Damavand Mountain because it is the highest mountain in Iran and the studies on its glaciers are limited, so the researchers investigated the northern east of glacier.

Hence the matter of this study was the measurement of YAKHAR glacier. One question is going to be addressed to what extent remote sensing can be effective on the measurement of YAKHAR glacier. The purpose of the present study is to achieve a map of the changes of YAKHAR glacier.

2. Methodology

The present study set out to investigate the changes of YAKHAR glacier using remote sensing and GIS technologies. The researchers examined east and north eastern face glaciers are in the valley of YAKHAR which is the most famous and the largest glacier of Damavand. This glacier can be seen over 3500 meters high. Moreover, this glacier has abrupt slope from 40% to 80% and is hanging glacier. This glacier has hanging icicles and their length is more 50m. In addition to this, the height of this glacier is 4500m - 5600 from the surface of the sea. This part will define and justify any single procedural step that was taken throughout three stages of the present study. The purpose of this study is to provide the answer to the following question to what extent remote sensing can be effective on the measurement of the YAKHAR glacier.

The methodology is divided into two parts: the first one is preprocessing and the second one is processing.

2.1. Instruments and Design

In order to examine this study, the researchers applied various procedures such as topographic maps, satellite images, and GIS, PCI Geometrical software, DEM. Moreover, the analysis and interpretation of the data are provided by remote sensing include analysis of different phenomena of the surface of the region which provides the required information, radiometric error, geometrical correction and radiometric correction.

2.2. Data Collection

The researchers collected data and analyze them through different steps as follows:

-Processing data and transforming image format to require the format of the software.

-Field observation is done to provide the control points, Laboratory data, and examine the results.

-Recognition and selection of the suitable control points on images in order to minimize the errors.

-Synthesis images

- Classification of images.
- Illumination the images.
- Providing different photos of the maps and DEM.
- Comparison of the results.

2.3. Preprocessing

Preprocessing consists of the following procedures:

2.3.1. Geometrical Correction

It means to remove the error of the images resulting from errors of earth globosity, refraction and other errors occurred to images. To remove these errors, it is necessary to change the satellite images so that they fit land systems which require land control. These control points can be extracted from topographic maps.

2.3.2. Radiometric Correction

The radiation flow was recorded by the remote sensing system in different bands that is representative of radiation flow. It has been radiated from phenomena on earth such as soil, plant, water, or urban regions. Radiometric error in remote sensing data may be created by the function of the sensing system e.g. certain detectors cannot operate properly or may have not been calibrated well. It is possible that the atmosphere between earth surface and the sensing system may cause some errors. It is necessary to indicate that how many errors can be removed before the next step of the analysis gets started.

There are several methods for the measurement of glacier but the researchers applied combined methods. To carry out this research, the following procedures were taken. The first step was extracting glacier by means of satellite images in order to determine the boundary of the glacier domain through two methods of inter band rate and classification technology.

2.4. Processing

The processing of the methodology is defined in three stages as follows:

2.4.1. Inter Band Methods

Inter band is an effective method in order to recognize the region of glaciers. This method decreases the effects of Topography, shadows, and shows the boundaries of YAKHAR glaciers.

Firstly, the researchers used different combination of bands. Secondly, the ratios of bands 3 to 5 and 4 to 5 were applied regarding a series of thresholds for rebuilding boundary of the domain in this study. Figure 4 shows extracting glacier from IRS image.

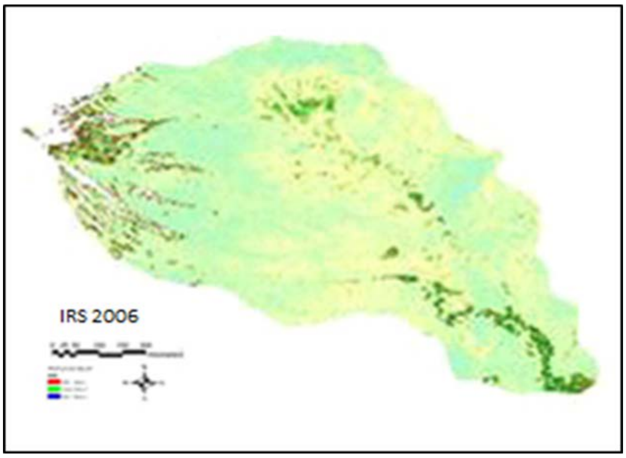

Figure 4. Extracting Glacier from IRS image

2.4.2. Classification Methods

In this method, the researcher used observed and unobserved classification for suitable bands; it is possible to determine the boundary of the glacier domain. The quantitative measurements with the result of ISO DATA classification for bands,1 and 4 provides ETM of glaciers with a good accuracy and observed classification was done with 16 classes and 16 repetition. ISODATA classification is a well-known clustering technique that assigns pixels to a class based on class means. The number of classes is specified over a range and the classification determines the final number. ISO DATA clustering can classify different internal bands. This method is very fast to recognize and classify glaciers that their surface is clear. Therefore, by classification and victor zing (it gives number and coordinate) can access to its boundary and overlapping of the layers. It is possible to achieve the best result using classification technology and GIS. As can be seen in the following Figure 5.

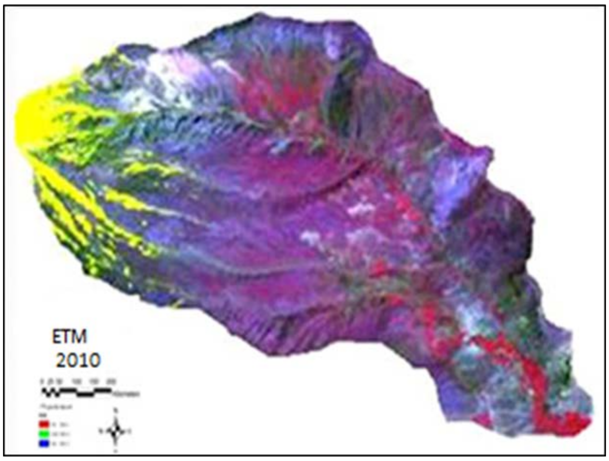

Figure 5. Extracting glacier using ISO DATA classification technique

3. Data Analysis

The research question was formulated to examine to what extant remote sensing can be effective on the measurement of the YAKHAR glacier and detect the effective changes of YAKHAR glacier. Moreover, the change detection consists of the images from different times in order to recognize the regions that have changes in their earth cover. The researchers applied the change detection because it is an important proceeding. This method has an effect on the findings and the analysis of the results significantly. To represent intensify of changes the researchers applied subtraction of the parallel bands on the images of the region. Regarding the image resulted from the main factors, by mains of normal histogram maximum and minimum and average of data of each PCA were estimated and the data was used in fuzzy logic to determine membership. Using fuzzy logic is to assess intensifies of changes and quantity data respectfully presented in Table 1 &Table 2 as well as Figure 6 & Figure 7.

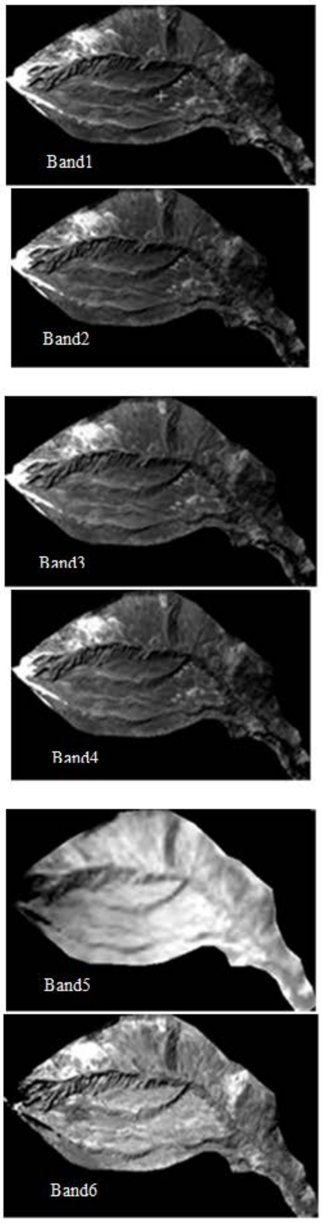

Figure 6. Images resulted from subtraction of bands on ETM and TM images

Table 1. provides statistic information related to main factors

PC	Average	Standard deviation	Maximum	Minimum
Pc1	130	36.8	175	70
Pc2	126	23.15	190	65
Pc3	127	12.2	155	95
Pc4	127	6	145	110
Pc5	126	4	140	115
Pc6	126	4	135	115

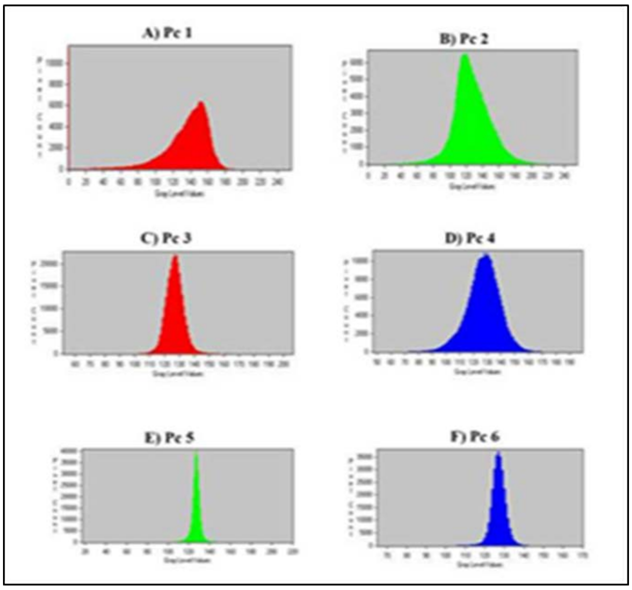

Figure 7. Histograms resulted from analysis of factors

The factors are achieved from the changes of subtraction corresponding bands of images are more than 90 percent in the recent studies. The factors consist of information about changes that can be used as images. So the researchers applied a way to show the information of factors in an image. As a result, the researchers chose fuzzy logic. Membership function was determined from factors regarding to the histograms.

According to the above table, factors two and three resulted from subtraction changes of parallel bands of image in the study. It is covered more than 90% of the total information that can be used as the images of changes. The function of membership in changes was determined according to the histogram of image of different factors. Number 70, 65, 95 represent minimum and 127 shows average. 155,175,190 represent respectively maximum values of membership function regarding to the selected threshold. As can be seen in the flowing table, the researchers display the significant changes in four classes including 0-25, 25-50, 50-75, and 75-100. The changes are shown by a specific color in the resulted map. This color respectively include region with low change intensify to high change intensify. Regions with high change intensify include, riverbed, glacier, mine and foot of the slopes and the regions with low spectral change intensity mainly include slopes covered by lavas. According to Table 2 total area of the studied region changes between 0-100 percent that 52% of the area has significant changes. A part of the region which is located in the domain of 75-100% that shows the maximum changes. According to Figure 8 maximum changes have occurred in the highest regions of the glacier. Area of changes in 1988-2010 was measured by means of TM and ETM.

$$\mu_1 = \begin{cases} 1 \\ \dfrac{(X_i - 130)(130 - 70)}{(X_i - 130)(175 - 130)} & 0 \le X_i \le 70 \\ 1 \end{cases}$$

$$0 \le X_i \le 70$$
$$70 \le X_i \le 130$$
$$130 \le X_i \le 175$$
$$175 \le X_i \le 225$$

$$\mu_2 = \begin{cases} 1 \\ \dfrac{(X_i - 126)(126 - 65)}{(X_i - 126)(190 - 126)} \\ 1 \end{cases}$$

$$0 \le X_i \le 75$$
$$75 \le X_i \le 126$$
$$126 \le X_i \le 190$$
$$190 \le X_i \le 225$$

$$\mu_3 = \begin{cases} 1 \\ \dfrac{(X_i - 127)(127 - 95)}{(X_i - 127)(155 - 127)} \\ 1 \end{cases}$$

$$0 \le X_i \le 95$$
$$95 \le X_i \le 127$$
$$127 \le X_i \le 155$$
$$155 \le X_i \le 225$$

$$\mu_4 = \begin{cases} 1 \\ \dfrac{(X_i - 127)(127 - 110)}{(X_i - 127)(145 - 127)} \\ 1 \end{cases}$$

$$0 \le X_i \le 110$$
$$110 \le X_i \le 127$$
$$127 \le X_i \le 145$$
$$145 \le X_i \le 225$$

Fuzzy logic has 4 roles but the researchers used OR role in order to measure these changes.

$$\text{FCCI} = \text{Max}\left(\mu 1, \mu 2, \mu 3, \mu 4\right)$$

μ1- number value of pixel membership function in factor1
μ2 -number value of pixel membership function in factor2
μ3 -number value of pixel membership function in factor3
μ4 -number value of pixel membership function in factor4

Table 2.The Changes of Area in the River Basin

Classification of changes intensity (%)	Area of changes (km^2)	Area of changes (%)
0-25	5.35	11.5
25-50	8.64	19
50-75	7.92	17.5
75-100	2.23	52
total	45.09	100

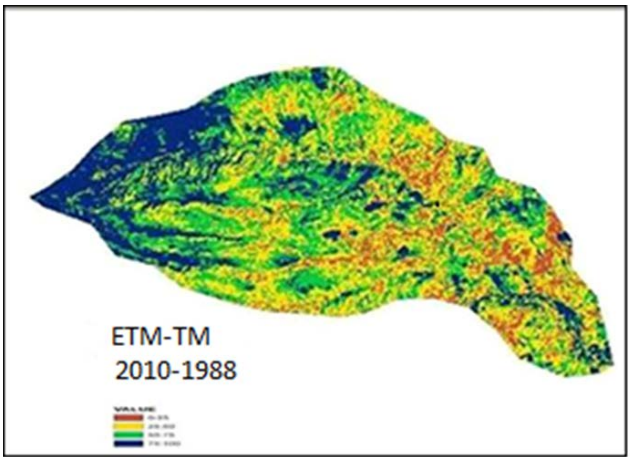

Figure 8. The evaluation of changes in glacier by fuzzy logic

4. Discussion

The study was an attempt to examine the changes of YAKHAR glacier using remote sensing and GIS technologies. Thus, the main objectives of the study are: to investigate the glacier is an active and have a number of changes during recent years due to lack of snow and the recharge of glacier. The pervious study revealed that the size of glacier is deteriorating in the recent years. The findings of this study strongly and positively are the same as the previous studies.

The results of this study showed that these changes are very important. In this study, the researchers estimated the size of glacier is about 1/8 square kilometers by inter band combination, ETM, IRS and GIS software.

Moreover, the glaciers cannot stay in the mountain and move because this place has an abrupt slope. The images of this region show that extreme erosion is emerging from the melting snow. So the YAKHAR valley is changeable and shrinking.

5. Conclusion

Figure 9. Emerging Fumaroles Gas from Damavand Volcano by Saeedeh Fakhari

This study attempts to investigate the changes of YAKHAR glacier using remote sensing and GIS technologies. The findings of the study reveal that first, some factors are more effective on the changes of glacier: 1) lack of snow because the current weather is not appropriate to form and maintain the glaciers. 2) Global warming environment is one of the most important factors to melt glaciers the surface of the earth and also in this region. The temperature is not below zero, so the glaciers are exposures to be melted in the summer. 3) The heating of smoke emerging from Damavand volcano. Emerging fumaroles gas from the eastern of Damavand Volcano. Figure 9.

References

[1] Paul, F. *the new Swiss glacier inventory 2000 – application of remote sensing and GIS*. (PhD thesis, University of Zu¨ rich.) Pe´guy, C.P. 1959. Les glaciers de l'Elbourz. *Bull. Assoc. Ge´ogr. Fr.*, 284-285, (2003), 44-49.

[2] M.S. Moussavi, M.J. Valadan Zoej, M.R Sahebi, Y. Rezaei, *Change Detection Of Mountain Glacier Surface Using Aerial And Satellite Imagery: A Case Study In Iran, Alamchal Glacier*; The International Archives of the Photogrammetry, Remote Sensing; and Spatial Information Sciences. Vol. XXXVII. Part B7. Beijing 2008.49pp.

[3] Gaoa, Jay, Liu, Yansui , *Applications of remote sensing, GIS and GPS in glaciology: a review*, Progress in Physical Geography 25,4 (2001) pp. 520-540 .

[4] Busk, D.L, Climbing *and ski-ing in the Elburz Range, North Persia*, 1931-2. *Alpine J.*, 45(247), .(1933) , 334-341

[5] Bobek, H, *Die Rolle der Eiszeit in Nordwestiran. Z. Gletscherkd.*, 25, (1937), 130-183.

[6] Desio, A, *Appunti geografici e geologici sulla catena dello Zardeh Kuh in Persia. Memorie Geologiche e Geographiche di G. Dainelli*, 4, (1934), 141-167.

[7] Harding, J.G.R. *Cambridge Expedition, 1956, to the Elburz Mountains*, Iran. *Himalayan J.*, 20,. 1957, 112-121.

[8] Schweitzer, G. *Der Kuh-E-Sabalan (Nordwestiran): Beitrage zu r Gletscherkunde und Glacialgeomorphologie* vorderasiatischer Hochgebirge. *Tu¨binger Geogr. Stud.*, 34(3), (1970), 163-178.

[9] Troll, C. *Genecology of the high-mountain regions of Eurasia.* Erdwissensch and ftsliche Forschung der Akademie der Wissenschaften und der Literature, Mainz .Franz Steiner Verlag GMBH, Wiesbaden 1973, 229pp.

[10] Ferrigno, J.G. (1991) Glaciers of the Middle East and Africa. Glaciers of Iran. *In* Williams, R.S., Jr and J.G. Ferrigno, *eds. Satellite image atlas of glaciers of the world*. Denver, CO, United States Geological Survey, G31–G47. (USGS Professional Paper 1386- G-2.).

[11] Frank, P, *Evaluation of Different Methods for Glacier Mapping Using Land sat TM*, University of Zurich, Switzerland, June. (2000) 16 -17.

[12] Siri, Jodha, Singh Khalsa, *Space-Based Mapping of Glacier Changes Using ASTER and GIS Tools Transition on Geosciences and Remote Sensing*, Vol.42.No10, October. 2004.

[13] Anil, V. and Kulkarni, S. S, *Glacial Retreat in Himalaya Using Indian Remote Sensing Satellite Data*, CURRENT SCIENCE, Vol, 92, No 1, 10JANUARY(2007).

[14] Vaziri, F, *Preliminary Exploration of Natural Glaciers. Publications of Iran Organization of Management and Programming.* Tehran, Iran, (2000).

[15] Rezaei, Y. *Investigation on Khersan mountain glacier in Zardkuh Mountains: application of remote sensing and GIS*. (MSc thesis, K.N. Toosi University of Technology.) Tehran, Iran (2004).