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ORIGINAL ARTICLE

DETECTION OF CHANGES OF WEST-DENA PROTECTED AREA GLACIERS AFFECTED BY CLIMATE VARIABLES IN PAST PERIODS

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Abstract:

In this Article the probable effects of climate change on glaciers in West-Dena protected area during the past periods has been studied. West-Dena protected area is located in North-East Kohkilouyeh and Boyr Ahmad province and a long zagroos mountain chain.

Dena the highest mountain of Zagroos mountain chain includes a vast part of fauna and flora in this geographical limitation and has always been regarded as one of the richest diversity zones in the country. This survey has studied the changes of snow coverage in Dena glaciers by using NDSI index in 3 decades (1980-2010). By processing and interpreting satellite pictures during the above-mentioned years, we conclude that from 1987 up to 2010 the protected area has experienced major climate changes that in turn, have had remarkable impacts on glaciers and ecosystem of West-Dena protected area.

KEYWORDS:

Climate Change, Protected Area, NDSI Index.

1. INTRODUCTION:

Today, the estimates on the snow and glacier covered surface is a basic activity in managing the water resources. Specially, the management is necessary in the regions where the snowfall plays an important role in the downpours. Modeling the specificities of snow and ice from hydro-climatic viewpoint has an important role in managing the snow receiving areas, controlling of flooding and land erosion, predicting droughts and providing water. The glaciers are the huge resources for pure water but universally, the amount of these resources will be reduced within few decades with the increase in the earth temperature. The side effects of the reduction in glaciers are negative on the environmental, eco-hydrological and micro climatic phenomena.

The studies on the changes in the glaciers in the recent decades are a very valuable thing in the investigation of the process of change in the glaciers' levels and it will be quite helpful in the studies related to environment. In the mountainous areas, especially in the cold seasons, the snow downpour is known as the most climatic element. Water from melted snow cover surface can have opposite and relevant effects in downpour-receiving areas, and it also affects other hydrologic parameters such as flow of surface waters, method of feeding the underground water, happening of flood and vegetation surface.

In the study limit, the life of land and water ecosystems is under influence of the extant water resources and the very glacier of Dena. This glacier has an important role in providing water for the areas

down the mountain. In the years that glacier level reduces, the vegetation surfaces of the region will be affected accordingly. Therefore, the scholar has attempted at signifying the snow level in the Dena glacier in this research. Using water ,reserved in Dena glacier, can be a significant help to the environment at the lower region to this glacier during the dry hydrological periods .This glacier, in the recent decades ,as a result of change in the climates, has lost a good deal of its natural water reservoir. As the protected areas are among the important regions from the viewpoint of biodiversity, the topic of the current study has been chosen to be the investigation of the probable effects of climatic changes in the last decades.

2. The Research Methodology

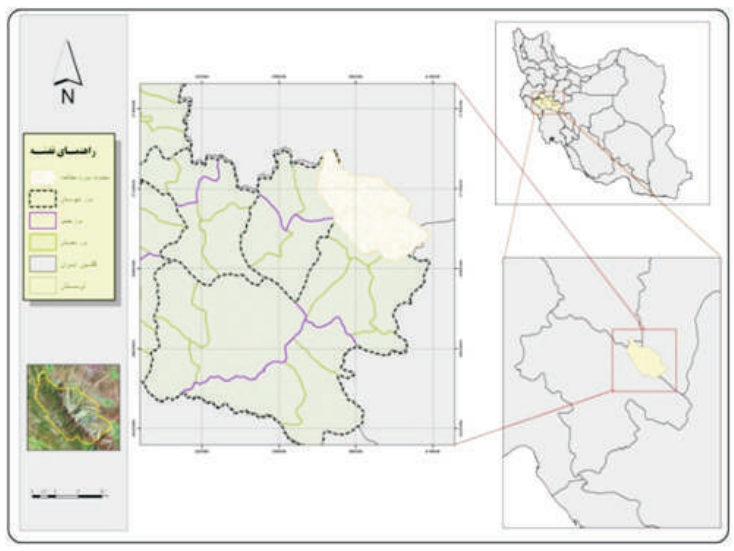
The current research has used GIS technology and the last available resources from the countries having natural glaciers including Canada, America, Sweden, China and Japan. Two following important parts have been also paid attention too.

2.1. The studied region:

The protected areas of Western-Dena with the surface of about 94000 hectares in the north east of Kohkilouyeh and Boyer Ahmad province and along the Zagros mountain series. Dena is the highest and most uneven part of mountain series of Zagros. This area, from the year 1988, has been part of the protected areas of the country. Dena is one of the richest areas of Iran. The least height of this region from sea at the crossing point of Marbor and Beshar Rivers is 1300 meters from the sea level, and the maximum height is 4400 meters. The highest difference of these two spots is about 1100 meter. The intense difference in heights within a short distance has caused the changes in climate, weather and formation of different climates and micro climates which would help growth of a variety of plants and animals.

Right now, Western-Dena is one of the richest areas of country and the world and includes an extensive part of fauna and flora of Iran. The number of plant varieties of Dena is 1300 and it is equal to the 16 percent of the total flora of Iran in area which is 0.07 % of the country area. The wild life of Dena is rich in its own kind too. The number of mammal variety of Dena is 24, the number of birds is 85 and the reptiles are 39.Therefore, Dena is one the richest areas with regards to environmental variety.

Figure.1: The position of the protected areas of Western-Dena



2.2. The changes in the glacier surface of Dena:

This region has several mountainous ecosystems with their own special variety. In the study limit, the Dena glacier is one of the most important features of the earth surface. It consists of a great deal of pure water which is indicative of the temporal climatic changes. Using the GIS techniques in this study, the extension of Dena glacier during the years 1986-2010 have been studied. Therefore, using the pictures from TM series (including all the ray bands), the indicator of NDSI and categorizing with the method of the highest vicinity, the glacier has been recognized and its surface has been calculated.

At present, satellite pictures and GIS are the best technologies to analyze the glaciers and the snow covered surfaces; because it does not need an extensive visiting of earth. The speed and precision of the calculations have been increased to a considerable extant. The base to use this technology is its power to separate locations in the pictures and differentiate rays reflection. That is why we'd better use pictures such

as Spot, Aster, TM, and Modis. In this study, the pictures of TM series have been used.

The processing and interpretation of satellite pictures make up one important stage of this research. The separation of the snow and ice covered surfaces from other natural features such as plan surface, stones, clouds and the shadow covered areas has been done using different algorithms and the processing of pictures. The method is based on the correction and processing of pictures. First, the picture's haze has been corrected. This correction is to remove the effects of water evaporation and the hanging particles in the air; because it reduces the context of visible and red waves.

The band combination of 3, 4, and 5 is the best ray combination in the visual separation. The ray proportion of Tm4/Tm5 is the most appropriate one in separating the reflections; because it can very well separate the snow cover from other phenomena. The indicator of NDSI is to visually separate snow from other phenomena. Using the ray proportion cannot offer an appropriate quantity for comparison, because its result will change between zero to infinity. Therefore, in order to recognize snow from light colored soils, clouds and stones the indicator of NDSI is used:

$$NDSI = \frac{r_2 = r_5}{r_2 = r_5}$$

In this formula, r2 and r5 are respectively the reflections of rays number2 and 5(with the wave length of 0.57 and 1.68 micro meter). Usually, snow will be separated in the picture only when NDSI level becomes more than 4%. Studies show that this threshold changes according to season. For example, based on the researches done by Vogel (2002), this threshold differs between 48% in July and 6% in September.

These studies have done on a small scale and the ETM pictures are used. The probability of ray combination in the multi-ray picture and its combination with the ability to locational separation (band 8 with the separation ability of 15 meter) is a proof for the high value of such pictures, because it shows the separation of snow from other phenomena. For an example, Vogel(2002) could reach at a local threshold for band 8 combining the results from indicator NDSI (bands2 and 5)and the ray combination in the rays 2,4 and 5.That is why the smaller snow pieces could be extracted in the separation capability of 15 meter. Of course, the shadow covered areas would be included in this method and using the height model, these areas could be removed. Usually, the pure snow has a high NDSI, but combining with other material including smoke and dust, the percentage of its purity will be decreased. This indicator is, also, used for the separation of snow from the cloud in the visible part and the infrared part which have a high a frequency. Table1 shows the ABSCI specificities of the used band in this study.

Table.1: The used bands in the extraction of snow covered surfaces in the glaciers of Dena using the ETM pictures

Micrometer wavelength	resolution of	Bond Number
0.52 - 0.60	28.5	2
0.76 – 0.90	28.5	4
1.55 – 1.75	28.5	5

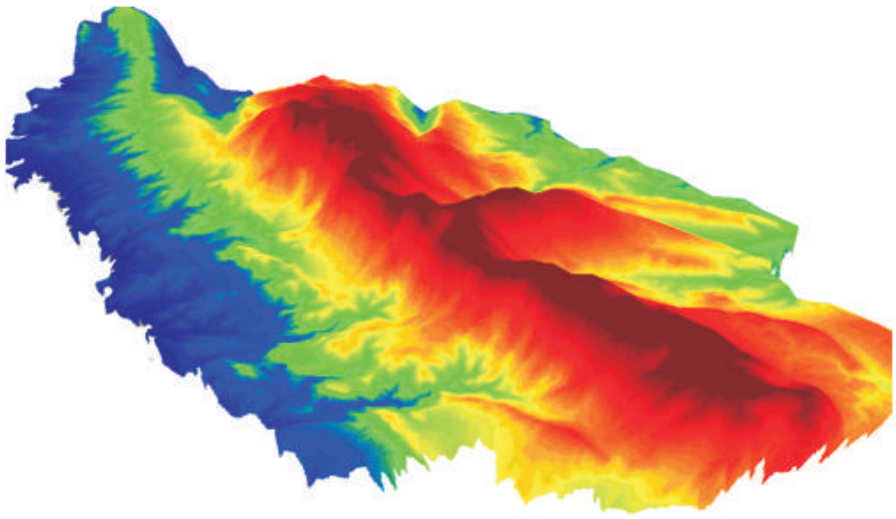
In general, to map the glacier surface, the following stages had to be done:

- The generation of the numerical height model.
- The processing of pictures.
- The analysis of the three dimension pictures to compare the calculated surface.

The generation of numerical height model:

The numerical model in the limit of the plan has been made using the topographic maps with the scale of 1:50000. Using the world system of UTM, the specificities of this model have been defined in the base of WGS84 and zone 39.

Figure.2: The three dimension numerical height model



The study scale is small in comparison to the countries with extensive glaciers. Therefore, using the pictures in this research includes the following:

- ETM Picture from 1980's (on 18 June 1987)
- ETM picture from beginning of 1990's (on 12 July 1998)
- ETM picture from 2000's (on 24 May 2010)

3. The processing of pictures:

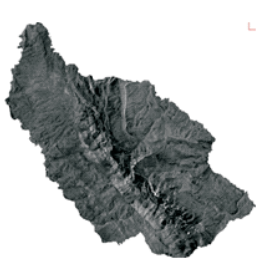
Different phenomena have different reflections in a ray band. On the other hand, one phenomenon has different reflections in different bands too. Consequently, the reflection of snow covered surfaces in rays of blue, green and red is completely changeable. Therefore, it is required that the extant difference in the ray band be shown in one file in these studies. Because there would be a better visual recognition from the phenomenon surrounding snow covered surface. To do that, algorithm of PCA has been used. In the TM pictures, there will be 6 PCA as there are 6 rays. But from among these 6 factors, the numbers 2, 3, 4 give the best distinction between snow and other phenomena.

In the following stages, ray combination in the bands 3, 4, 5 has been provided. Using this ray combination, we can recognize snow and ice covered surface from surrounding phenomena. In another stage, the proportion of Tm4/Tm5 is calculated in order to better recognize feature using the method of ray proportion. In the end, using the ability of GIS, the calculation of the snow covered surface will be done and the area covered by glacier in the time period of 1987-2010 is calculated.

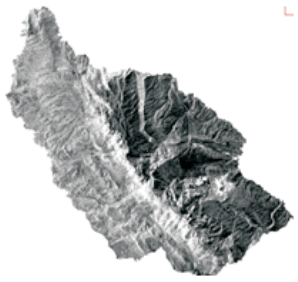
4. Analysis:

The figure -3 is the analysis of the factors of picture in different years. In fact, the analysis of factors of picture is to reduce the solidarity between the bands TM and increase the contrast of pictures.
Figure.3: The analysis of the factor of picture in different years

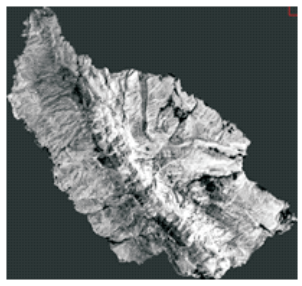
1987



PCA2rd

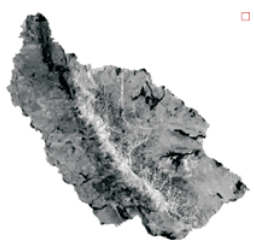


PCA3rd

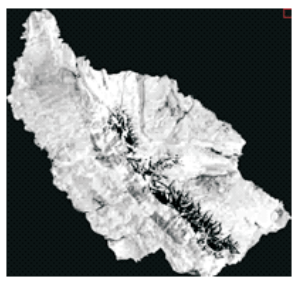


PCA4rd

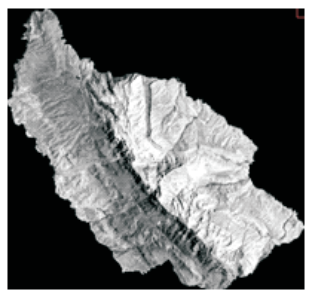
1998



PCA2rd

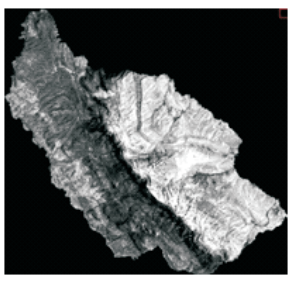


PCA3rd

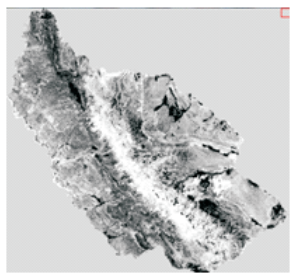


PCA4rd

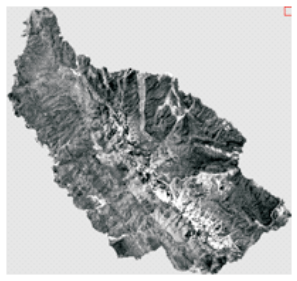
1999



PCA2rd

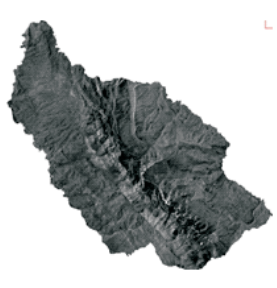


PCA3rd

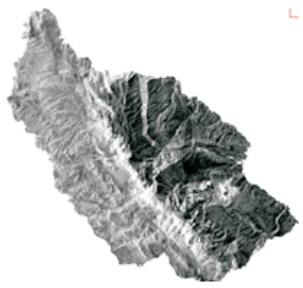


PCA4rd

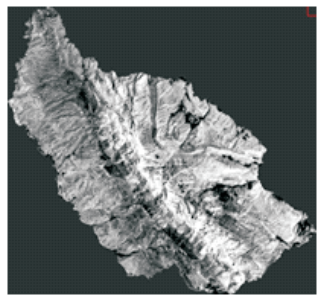
2010



PCA2rd



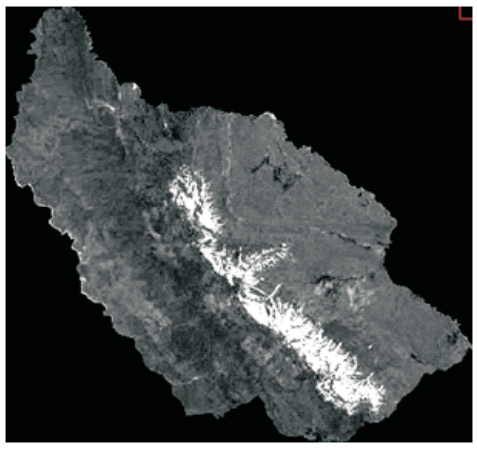
PCA3rd



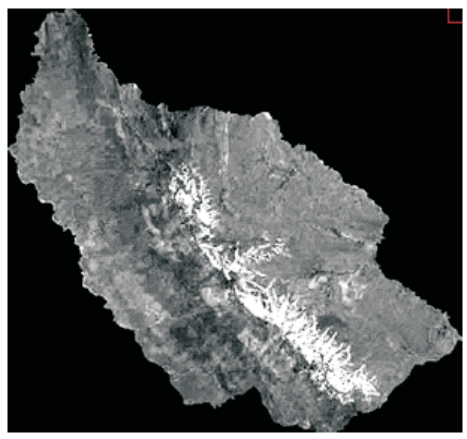
PCA4rd

In the next stage, the proportion of TM4/TM5 is calculated in order to better recognize the features using the method of ray proportion. Figure 4 indicates this ray proportion in the time period of 1987-1998, 1999 and 2010.

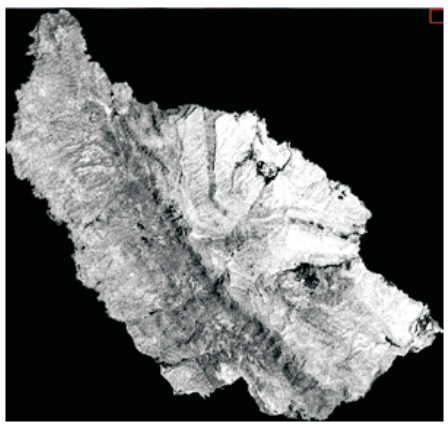
Figure.4: The ray proportion of TM4/TM5 in different statistical years



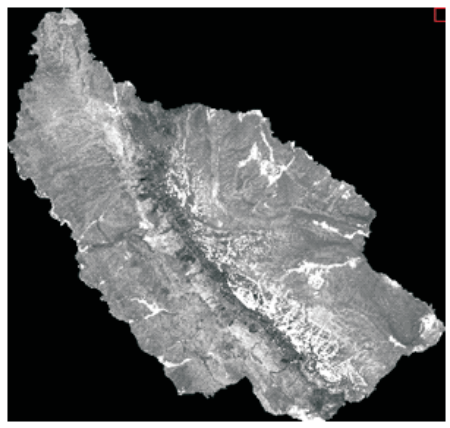
1987



1998



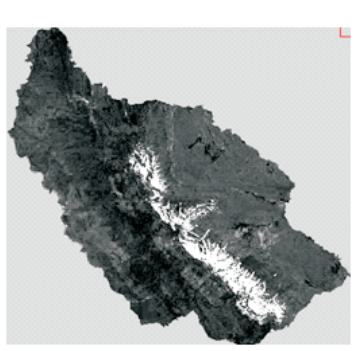
1999



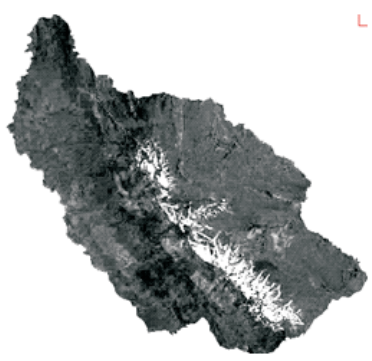
2010

As it is seen in the above figure, there has been an intense snow cover near the glaciers in the years 1987-1998, 1999, and it indicates the hydrologic period of having plenty of water. But this cover has decreased in the year 2011. In the last stage, the extraction of the indictor of NDSI has been done. Figure-5 shows this indicator.

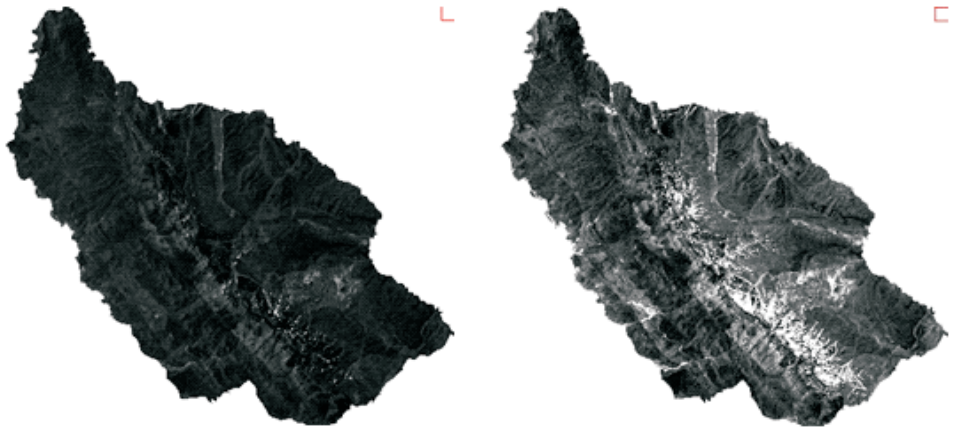
Figure.5: Indicator NDSI in the study stage



1987



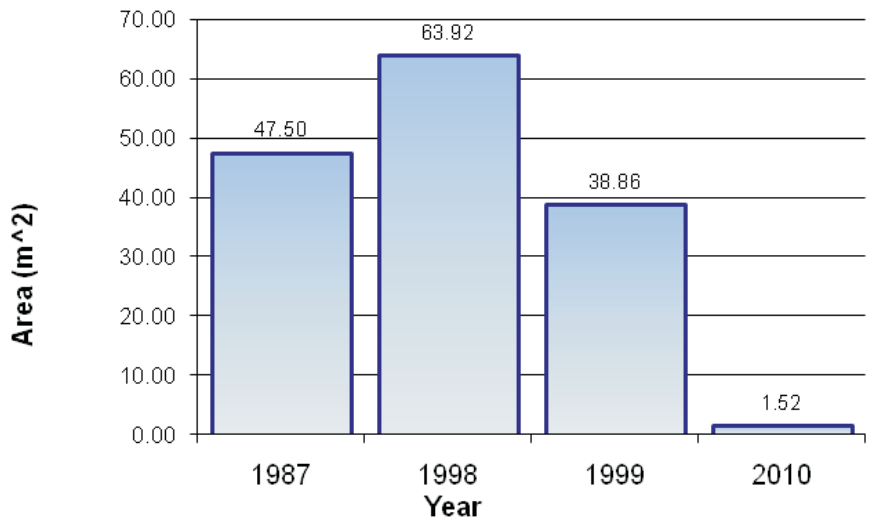
1998



1999 2010

Using GIS system, the calculation of the snow covered surface has been done and the area covered by glacier in the time period of 1987-2010 has been signified. This surface indicates the potential of pure water in the peak of Dena.

Figure.6: Graph of changes in the level of snow covered surfaces in Dena glaciers during 1980's, 1990's and 2000



The above graph clearly shows changes in the glacier level in the study region. From the year 1999 till 2010, there has been a considerable decrease in the glaciers levels which is about the droughts of 2007-2009.

Conclusion:

Graph of the changes in the snow level between 1980's-2010's indicates that there is an intense snow cover in the region in the years 1987, 1998, 1999, and it indicates the hydrological period of having plenty of water but there is a considerable reduction in the glacier level in the year 2010 which is about the drought of the years 2007-2009.These snow levels in the glacier show potential of pure water in the peak of Dena. The sum total of snow covered surfaces between 1980's and 2000 has a reducing tendency. It is so much so that the highest amount of snow and ice in the glacier of Dena is related to 1987 and the least snow cover is related to the year 2010. Based on the statistical results, there has been a more appropriate climatic condition for Dena glacier from the year 1987 till 1998, but results show an inappropriate situation for Dena

glacier from the years 1999 till 2010. It has a very negative effect on the ecosystem and other environmental aspects of Dena region.

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