Evaluation Of Changes In Sand Dunes In Southwest Of Sabzevar By Satellite Images

Abolghasem Amirahmadi, Kazem Aliabadi, Maryam Biongh

Abstract: Carrying and spreading soil particles is called aeolian process and it is a main problem in arid and semi-arid regions in the world that threatens urban life, buildings, agricultural farms and even human health. This paper intends to evaluate sand dunes changes (determining of direct and amount of movement) in southwestern part of Sabzevar (Mazinan salt desert). IRS Satellites images (LISS III radiometer) of 2006 and 2013 with spatial resolution of 23.5 meters and also PNA radiometer images with spatial resolution of 2.5 meters have been used to perform this research. Change detection technique has been used by method of images differencing in MATLAB software environment that is one of the most useful techniques in remote sensing. Results of this research show that sand dunes direct to the west and the southwest, and amount of their displacement is in a range of 12 to 62 meters during a period of seven years in different areas of this region.

Index Terms: Sand Dunes, Mazinan Salt Desert, Remote Sensing, Change Detection

1. Introduction

Eolation process or wind erosion is a natural risk in arid regions, since not only destroys soil sources and makes facial morphological change, but also soft quicksands movement and their accumulation in farm lands and sediments damage human sources constantly. (Yamani, 2011) Dunes dynamicity makes quicksands to damage farm lands, dwelling places and communication roads annually and destroys them. (Seyf, 2012) In like manner, Southwest of Sabzevar area is a place in which attack by quicksands damages inhabitants annually. Therefore, exact study and knowledge of process and amount of movement of dunes in considered area can be very useful for environmental crises management of the region and using natural sources optimally. Considering the importance of aeolian processes in the world, there are some studies and researches concerning the regions influences by aeolian processes which are cited briefly as follows: Using TM landsat satellite images, laboratory and field data, C.I paisley Elizabeth (1991) studied reflection spectrum of Kelso dune in California Mojave desert in order to compare active and inactive gravel dunes. Results showed that there are higher percent regions which consist of dark inactive sands and granules compared to active sand regions in which there are less percent of dark sand and they consist of composition of quartz and gravel.

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Al-Harthi (2002) studied on direction of sand dunes movement and their connection with main wind in a district in Saudi Arabia between Jaddah and Altitah and then formulated an experimental relation among hill height, hill width, length of wind, length of inclined surface and dunes movement speed, and examined damages which those hills made on man-made installations in this district. Al-Harati deduced that igneous rocks and changes in west of Saudi Arabia are causes of dunes. Using field method, Liu (2005) studied dunes movement influenced by wind speed in 2 meters above the ground surface based on three parameters of speed, time and wind direction in Ordos plateau of China, and announced that dunes movements often happen in the Spring, also the affiliated relation between wind speed and its frequency is explained by power function. Strong winds have less frequency but they have more important role to move sand dunes. Using satellite images of Landsat during 1973 to 1991 & 1991 to 2000; Wang (2007) studied dunes movement in northern plateau of Mongolia. Six transverse hills, and three barchans and a composite hill were studied. According to the results of this research; dunes movement rate and total area of hills have been increased from 1973 to 2000. Using aerial images and LANDSAT & AVIRIS satellite data, Del Valle (2008) analyzed dunes morphology and measured direction and rate of movement in a period of 33 years (1969-2002) in southern part of Valdes Island. The aforementioned concluded that direction of dunes movement is to the east and average of dunes movement is estimated about 9 meters annually. Using GIS and remote sensing by SPOT satellite images, Ghadiri (2012) evaluated rate of gravel movement in western deserts of Egypt. As per result of mentioned study, gravel dunes movement speed was determined between 3 to 9 meters for a time interval of 1997 to 2007 annually. Movement rate was measured between 0 to 6 meters for prevailing dunes and this rate was 6 to 9 meters in a few dunes. Hermas (2012) used relation of optical pixels of remote sensing multi-temporal images to evaluate gravel dunes movement in Sinai Peninsula. They measured that there has been annually side movements from 6 to 19.4 meters with annual average of 7.7 meters and from 9.3 to 15 meters with annual average of 11.9 meters respectively for all the barchans hills and a selected barchans hill. Further, movement arisen from correlation showed that direction of dunes movement is to the east and southeast. Iranmanesh et al (2004) investigated dust particles origins region movement and their spreading characteristics in storms of Sistan district by satellite images process.

Measurement on images showed that direction of winds in Sistan region is mainly between 339 to 346 grades that is consistent with general direction of erosive winds in Zabol weather station. Observing and interpreting images specified that the main origin region of dust particles is located on Hamun Saburi Lake and storms are in line of Iran, Afghanistan and Pakistan. Khalife et al. (2007) studied on sand sources of Ardestan dunes and analyzed wind conditions by satellite images process method. They recognized considered moved materials by using image processing techniques such as increase of image brightness & contrast, spectral thresholding, colorful false composition, spectral analysis and boring method and putting results together in one side and analysis of sand and mud produced from region anemometry statistics from the other side, and by communicating them appropriately. Also, the aforementioned announced that older hills (inactive) are bulkier, more uniform and they have less line in their surface while active hills have a known geometrical shape and situation.Dadreasi Sabzavari (2007) investigated quantity of desertification or desert progress and analyzed its situation and reasons of their movement in an area about 410,000 hectares in Sabzevar plain lands. TM Landsat satellite numerical data were used after geometrical amendment for mentioned purpose concerning two time series of 1987 and 2001. The Study on changes around the sand dunes showed that amount of 2756.6 hectares have been added to region dunes in direction of north and east. Mesbahzadeh et al. (2010) studied statistical wind analysis, wind regime role on discharge level and direction of sediment transfer in Sabzevar region and they showed that winds with middle speed and more abundance have the most important role to move quicksands and forming the sand dunes. Maghsudi (2012) studied risks arisen from quicksands of Hojat Abad region in Hojat Abad village located in west of Lut Desert (East of Shahdad). This research was from type of descriptive-analytical based on field, laboratory and comparative methods and in next step studied the change and displacement of quicksands in four time periods by using aerial photos and satellite images. Results of the study show changes, area and displacement of sand region; its area has been increased about 22 hectares during 1998 to 2009 and this increase has taken larger part of lands under quicksands.

2. Geographical Situation of the Region

The region considered for this study is a part of Sabzevar city located in Khorasan Razavi province between coordinates 35°50′ to 36°2′ N and 57°1′ to 46°1′ E. Mean annual rainfall is 200 mm, and mean monthly temperature is 18.4°C and mean height of this region is 960 meters. The considered area is a part of central part of Iran structure which the oldest signs of its geology is related to geology units of second period and the newest signs are related to alluvial terrace and wind dunes. It is regarded as a part of central plateau climate and has a semi-desert climate with winters partly cold and summers partly hot and arid. This area belongs to drainage basin of central Iran. The main drainage of this plain is Kalshur river that flows from west to the east and finally enters into central salt desert. Figure 1 shows study situation of this region in Iran.

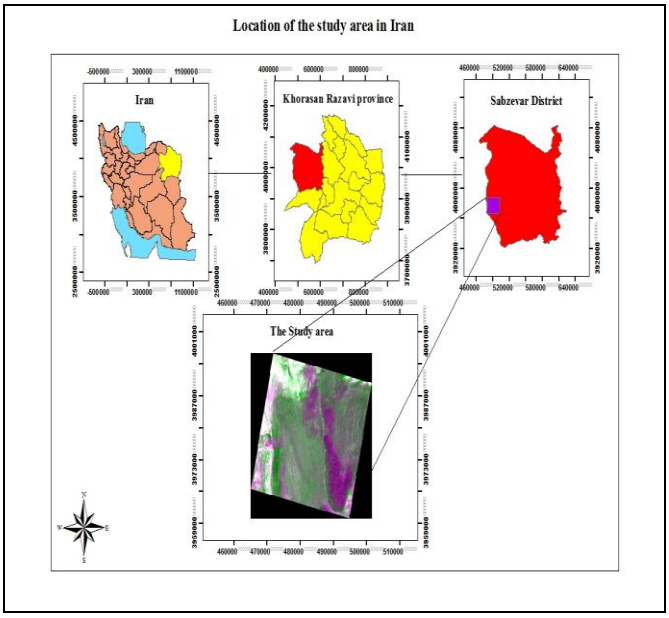


Figure 1: Situation of study area in Iran

3. Research Data and Method

3-1. Research Data

Remote sensing has an important role to study sand dunes activities for clear reasons. Although, main part of activities are related to hills topography and study on wind regimes, but recently, a significant part focused on quantitative methods to study sand dunes (Hugenholtz 2012 ,Bishop ,2007 ,Bourke ,2008 ,Ewing,et al,2010,Silvestro,et al,2010).Using remote sensing techniques, sand dunes activities have been investigated in southwest of Sabzevar. The first step is to determine direction and amount of movement of dunes in southwest region of Sabzevar and IRS Satellites images (LISS III radiometer) with spatial resolution of 23.5 meters and also PNA radiometer images with spatial resolution of 2.5 meters concerning 2006 and 2013 have been used. The main remote sensing software which have been used in this research are: MATLAB, ENVI and ERDAS. These programs have been used for remote sensing techniques and operations. Also, GIS software was used to make output maps.

3-2. Research Method

At first there should be an accurate definition from change and its nature in order to discover concept of change. The suitable method can be used for analysis after specifying the appropriate goal and radiometer to discover change. There are various methods to detect change. Images differencing method was used in this research to evaluate and discover dunes change in study region that achieved good results.

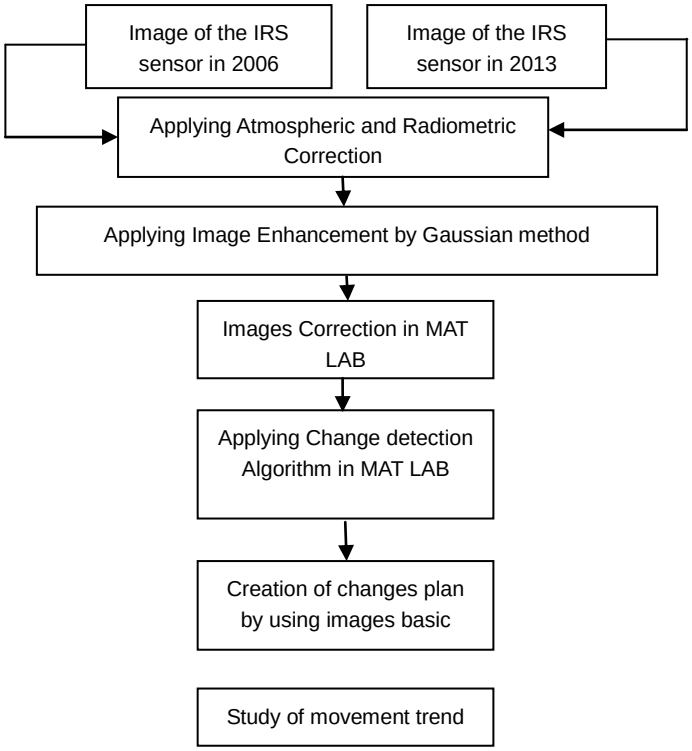


Diagram1-Steps of Researching

Achieving the study goals, at first, region images were investigated considering errors type, and necessary corrective techniques were applied on images as follows:

3-2-1. Pansharpening Algorithm

As we know satellites used for earth observation, produce data and they are different regarding spatial resolution and spectral resolution. (Kitaw, 2007) One technique to reach the best spatial and spectral resolution in remote sensing is Fusion technique. According to this technique process, PNA images is combined with Multi-Spectral images, so that the produced image is equal to PAN image regarding spatial resolution and it is equal to Multi-Spectral image regarding spectral resolution. Fusion or image combination is performed with different algorithms such as LMM, LMVM, HIS, Wavelet and Pansharpening. Pansharpening algorithm was selected as the best algorithm based on studying the statistical parameters and visual interpretation of resulted images. Pansharpening algorithm enables you to combine LISS III image with PAN image of the study region easily, so spatial resolution of LISS III image which is 23.5 meters is decreased to 2.5 meters and helping by LISS III images spectral resolution, the black and white image of PAN would be transformed to a colorful image and this would be effective to extract more accurate output images in this research. This algorithm was applied for the considered region images in a way that the results of combined multi spectral images show higher spectral quality and better resolution. Figure 2 shows image of study region after applying the algorithm

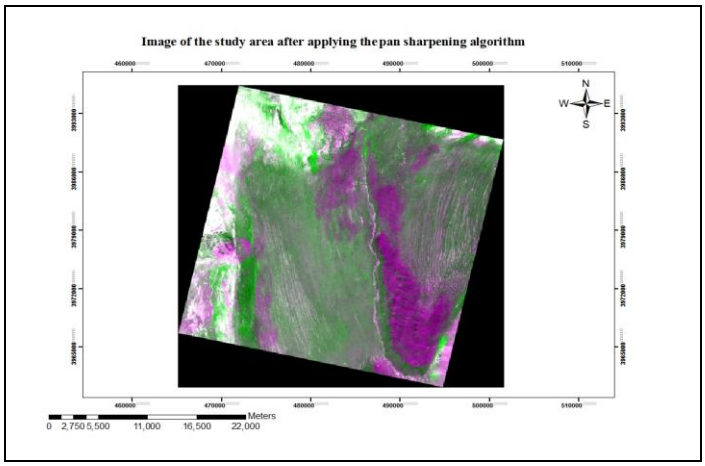


Figure 2: Image of study area after applying the Pansharpening algorithm

3-2-2. Images Processes

When radiometers record the reflective waves, three groups of error may be happened. The first type of radiometric errors are related to radiometers, the second type is atmospheric error concerning atmospheric effective factors for level of reflected part to the radiometers and the third type is geometrical errors concerning earth circularity, turning, height, situation and satellite location in space etc. Therefore, mentioned corrections are necessary to use recorded digitized data by radiometers.

3-2-2-1. Atmospheric Correction

Nature of remote sensing requires solar radiation to pass through atmosphere before collection by instrument. (ITT, 2009) As a result of atmosphere particles dispersion, exact details would be hidden in image data at the time of imaging. (Richard, 1993) Atmospheric correction removes absorbing & dispersion effects of radiation in satellite images by atmospheric corrections. Removing atmospheric participles, surface reflection problems and noises may be discovered exactly. (Gareth, 1999) There are two methods to correct satellite images atmospherically: QUAC method and FLAASH method which the latter has been used in this research to retrieve spectral reflection for region images.

3-2-2-1-1. FLAASH Method

FLAASH method is the most important method for atmospheric correction that corrects wavelengths in visible band, near-infrared and short-infrared until the level higher than 3 micrometer. Various parameters have been considered to perform the method such as radiometer type, number of bands, spectral polishing, flight date, geographical length & width, ground elevation, water retrieval, aerosol retrieval and pixel size. Results of this method are observed in this image:

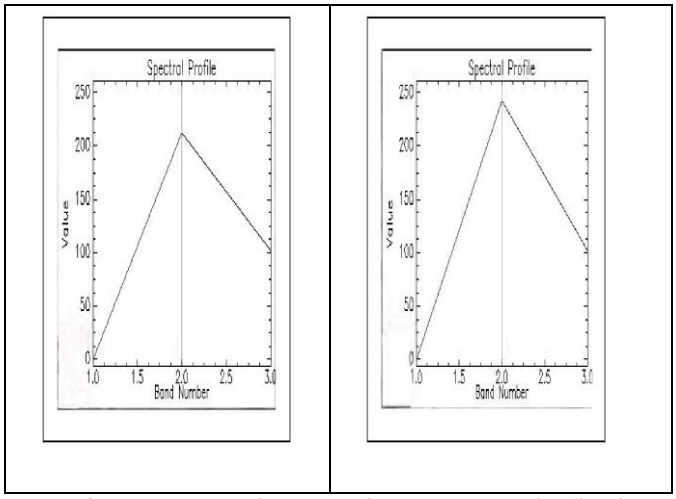


Figure3-Spectral reflection diagram before applying the FLAASH algorithm

Figure4-Spectral reflection diagram after applying the FLAASH algorithm

Using FLAASH algorithm, spectral radiation quantities have been transformed to spectral reflection and effects concerning lighting conditions change, season, geographical width and climate conditions are removed from image and final image is relative standardized. Comparing spectral diagram before and after the FLAASH algorithm (figures 3 & 4), it is clear that spectral reflection quantities have been increased after FLAASH algorithm that indicates on deletion of atmospheric errors.

3-2-2-2. Images Enhancement

Images enhancement operations usually are performed after various corrections on images. There are different methods to enhance the images, of which Gaussian expansion method has been used to enhance the images in this research after mentioned corrections and it had best results that are presented in figure 5. Contrast change or images enhancement are very useful to extract output images with appropriate accuracy.

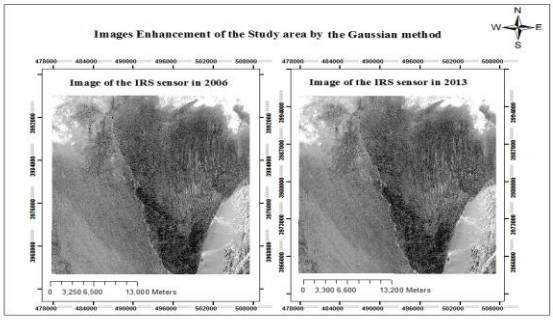


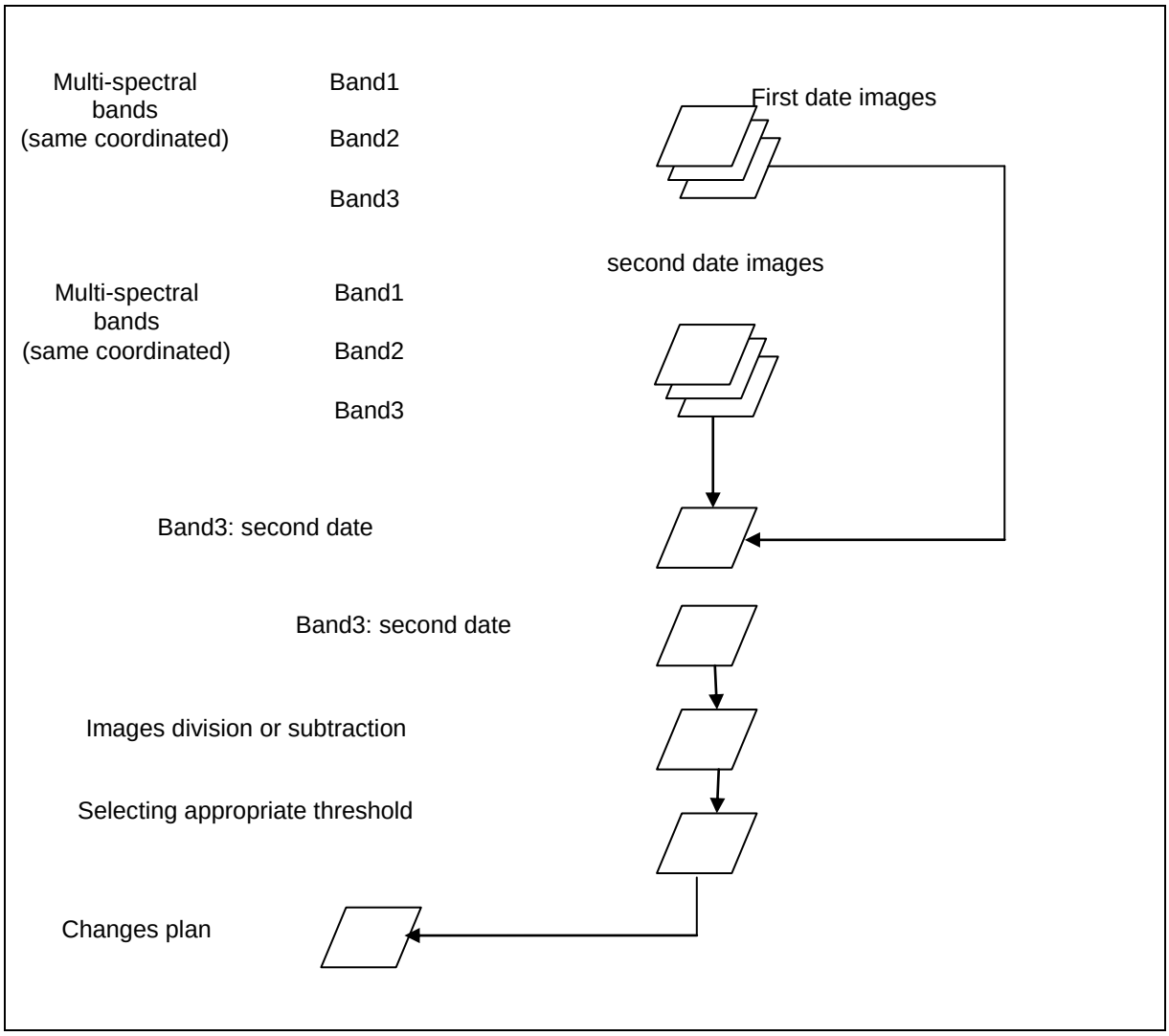
Figure 5- Images Enhancement for Study Area

3-2-3. Change Detection

Change detection technique is one of the most useful applications of remote sensing. Change detection includes multi-temporal data application in order to specify the regions in which land cover and use changed in various times of imaging. (Rabiei, 2005) Change detection usually is done by comparing two or several images of same region in different times. To perform this technique, two images shall be registered in a way that similar coordinates in image should relate to parallel region on the land. After exact images registration, it can be assumed that changes between two images are the only real changes of land. Various techniques of change detection have been submitted by remote sensing multi-temporal images during recent years. (LU, 2004) Images differencing, images division, main component analysis etc. are such techniques that Images differencing has been used to reveal changes in study region.

3-2-3-1. Images Differencing

Images differencing by change detection algorithm is a prevalent method in remote sensing data to enhance changes. The purpose images differencing for two correspond images of a region with different times, is to evaluate and show changes in the region in time interval of two imaging. (Najafi Disfani, 2008) Images differencing is performed by subtracting quantities concerning a certain band in certain time from pixels quantities of the same band in other time. Previous studies show that; errors in relation to detection by images differencing are less than other detection methods. (Hall, 1995) According to this method, after coordinating images of two different times with respect to each other, digitized values of two images should be subtracted from each other, pixel by pixel, so a new image is formed that consist of change information between two different times. .(Yuan et al, 1999, Jensen, 1996 Singh, 1989) Hence, in this research, images (2006 & 2013) were coordinated in MATLAB software and then digitized values of two images subtracted from each other, pixel by pixel to form a new image that show changes between two different times. Differencing images are very useful to discover changes and analyze images information.



Plan2: Changes discovery by calculation on images (Hosseini Asl, 2004)

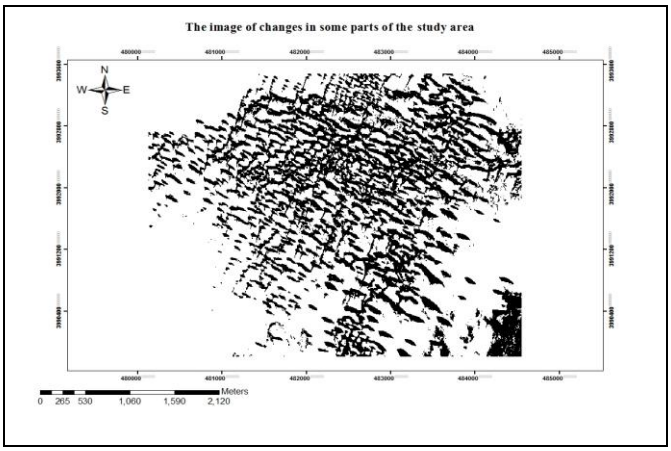


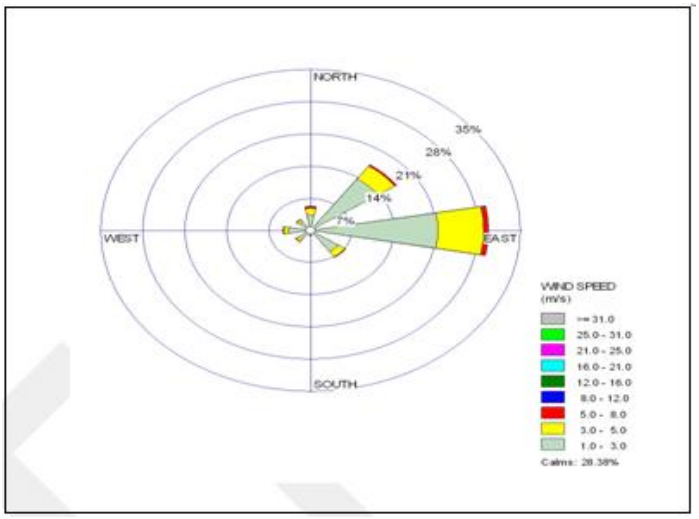
Figure 6: Image of Changes in part of Area

3-3. Characteristics of Area Wind

The wind is the main factor of destruction and erosion in desert regions. If there is no wind, then there is no sand dune, no matter what amount of sand are there in the area. Therefore, if other factors are ready, then sand dunes are stronger in areas which wind has more energy rather than in environments with weak winds. Generally, measurement of sand terrain dimensions is a function of wind speed and wind speed is a factor which depends on amount of movable materials and wind power. (Ahmadi, 1998) Awareness of climatic conditions particularly area wind regime is necessary to study direction of quicksands movement. Synoptic analysis and wind aerology was performed by drawing wind rose for study area during a 21 years statistical period in order to recognize direction and abundance of the strongest winds in the study area. Figure 7 shows annually wind rose for study area during statistical period of 1989-2000. Considering drawn wind roses, directions of prevailing wind in this region for whole the year are respectively eastern, northeast and southeast. Average of prevailing wind speed begins from 6.7 m/s in June, July, and August until 2.5 m/s in December and January. In contrary, the weakest and fewest winds in the region are those which blow from south, north or southwest. As we know, annually constant and prevailing winds make initial sand dunes while subordinate winds extends arms.

3-4. Research Findings

Aeolian process is a serious problem in arid and semi-arid regions in the world which makes economic, social and hygienic damages. Low rainfall together with sun radiation power and strong wind blowing increase evaporation in such regions and this fact decreases humidity and as a result, aeolian process would be more powerful. Risks arisen from quicksands in southwest part of Sabzevar city was investigated in this research by IRS satellite images and remote sensing techniques. According to studies, it was determined that this region has been under quicksands influence so that the quicksands damages agricultural lands, gardens and residences. Investigating region wind rose



Annually wind rose for study region during statistical period of 1989-2000.

Show that prevailing winds blow from directions of eastern and northeast in this region and southeast and southeast winds are in third rank. Winds between 2 – 6 meters have the most abundance in all directions and that is the reason that dunes move to the west and southwest. Figure 6 is output image after performing change detection algorithm that shows changes in the region. Generally, changes in spectral characteristics of images produced from study region, happen due to change in regional features and phenomena. As it is observed in figure-6, white pixels show big changes while black pixels show slight change or lack of change. It is observed in images that there are more white points in comparison with black or grey points and this confirms the fact that there were many changes in this region relatively. Amount of materials movement and/or sediment displacement are very important in aeolian process researches. Because awareness of amount of sediments displacement is very useful to plan procedures in order to prevent sands movement. Generally, sand terrain dimensions are effective in amount of their movement in a way that, smaller terrain dimensions makes more speed while bigger sand dunes dimensions are moved by wind slower. According to the calculations on region images of this research, to find amount of sand features displacement, the region images were divided to six groups due to high volume of images and also due to obtain better results. So, the results are showed in table 1 as follows:

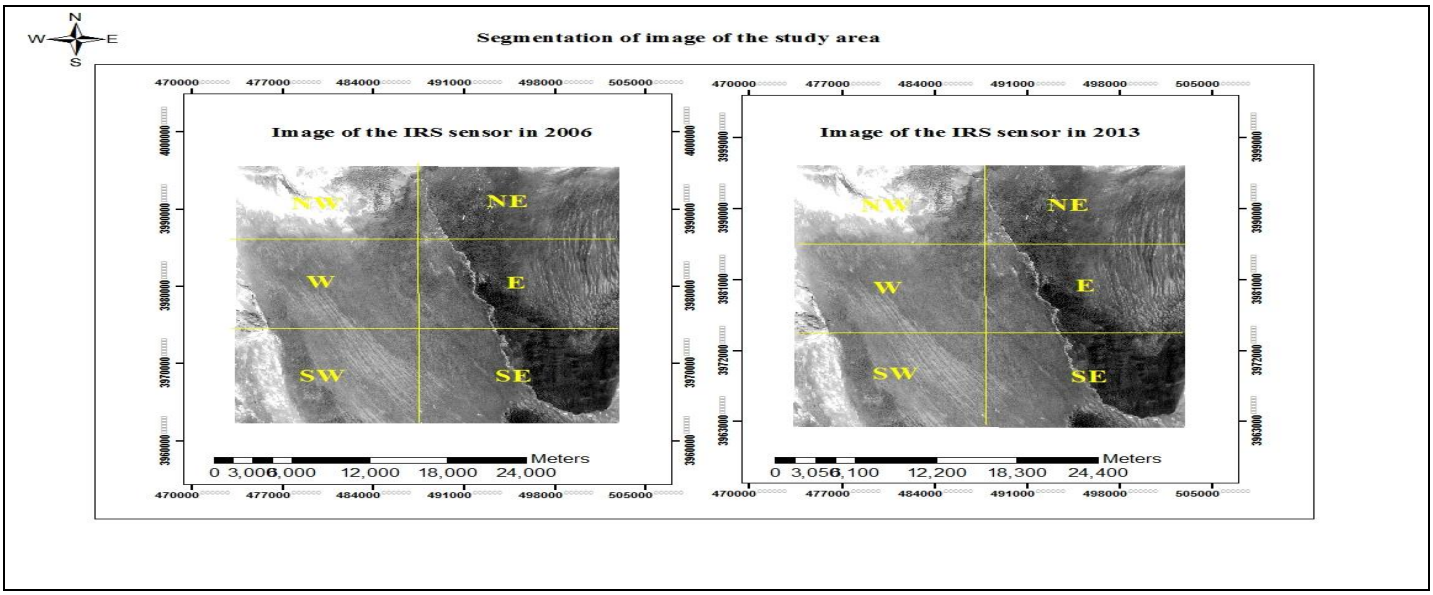


Figure 8-Segmentation of image of the study area

Area Situation	Northeast	East	Southeast	Northwest	West	Southwest
Displacement (meters)	57	55	50	62	62	12

Table1-Amount of changes in sand dunes

As it is observed from numbers in table 1, measure displacement of sand dunes in this region shows the highest rate between 2006 with 2013 belongs to the west and northwest parts. Because there is no obstacle against blowing eastern winds and these winds are fast enough to move dunes and their continuity provides sand feature movement. Sand dunes have not reached to a special height yet in this region which is necessary to resist against movement by the wind. Also there are many movements in eastern parts relatively and it is about 50 to 75 meters during these seven years since there is no obstacle against blowing of eastern and northeast winds. But movement rate has a significant decrease in southwest part. According to Mahmoudi (2001) type of features dispersion have a determining role to change direction of winds and their height and volume are very effective to increase or decrease wind speed because wind erosion destructive influences have been recognized at most up to 2 meters above the ground surface. The main factor to decrease movement of sand features is Paround mountains in east of this region. These terrains always are obstacles against blowing of eastern and northeast winds and this is the reason of decrease of sand dunes movement in these regions. Plant cover is other effective factor to decrease sands feature in these regions that is main factor of soil protection. Plants are obstacles against wind blowing in one side and as a result they decrease ability to carry sands and on the other side they both protect soil by their roots network and moisten surface parts, so coherence in soil particles would be more and they would be very effective to control aeolian process. As we know, if the condition are ready then annually moving ahead by quicksands is a serious threat for many natural and human structures and sometimes they destroy such structures completely. Next, Google earth images were studied to recognize region status in relation to human installations and residential area and agricultural lands.

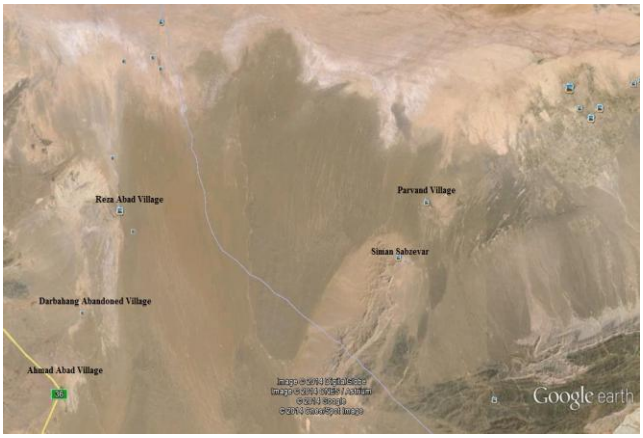


Figure 9 – Study Area Status

Figure 9 shows partially the region status in relation to neighbor residences. As it is observed, Reza Abad rural district is exactly located in west of these sand dunes. This village consists of a 300 people and it is exposed to quicksands attack. Also Ahmad Abad village with a population more than 1000 people is located in southwest of study region and dangers of quicksands movement threatens this area too.

Figure 10 – A view of Reza Abad village

3-5. Conclusion

Generally, moving the soil by the wind is a complex phenomenon that is under influence by climate and geomorphology and other factors. Changes in sand dunes of southwest of Sabzevar was studied by images differencing method during a time interval of seven years (2006-2013) by IRS satellite. This method requires less budget and time with respect to the traditional methods of quicksands movement measurement which need to more costs and times. Also results of this method are more reliable than traditional methods. Results of this research showed that direction of sand dunes movement is mainly western and southwestern regarding prevailing winds blow in direction of eastern and northeastern. Extension of barchans arms to the west and southwest confirms our claim. Also sand dunes movement was measured between 12 to 62 meters for this seven years period. Quicksand has irremediable influences and damages for daily rural life. In addition to physical damages, it makes financial loss such as farms destruction and communication ways and installations. Darbahang village located in south of Reza Abad village, is other region which has been under attack of sands and sands made huge damages to the extent that villagers left the area and immigrated to other villages. If there would be no effective action to control wind erosion and dunes movement, then Reza Abad and Ahmad Abad villages will encounter with the same situation of Darbahang village and this fact needs to serious attention by responsible authorities to prevent such conditions by exact planning and necessary actions.

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