Sindh Univ. Res. Jour. (Sci. Ser.) Vol.49(2) 303-308 (2017)

SINDH UNIVERSITY RESEARCH JOURNAL (SCIENCE SERIES)

Land Cover Change Detection Using Change Vector Analysis and Land Cover Ratios

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Received 12th October 2016 and Revised 12th January 2017

Abstract: Remote sensing is an art of acquiring of information about earth surface without actually being in contact with it as observation can be performed by capturing image through satellite having sensors. The process includes the transmission of electromagnetic energy from satellite to target and then reflecting back to satellite. It remains quite interesting to get land cover change detection observations with correct change percent and ratio estimation of each land cover existence using different classification and mathematical approaches. The aim of this research is to analyze and observe cover changes, variations, transformations and distributions pattern of each land covers. The obtained results shows decrease of water and forest while increase of soil, agriculture and meadows. Furthermore, it is noticed that maximum change occurred is water surface, which is decreased by 8.39 %.

Keywords: Change Vector Analysis (CVA), level of change, Land Covers Ratios, Suitable Thresholds and Distribution Pattern.

1. NTRODUCTION

One of the primary applications of remote sensing is to identify patterns of land covers and to access changes in covers from one form to another due to climatically change or environmental effect. Land covers that are identifiable by other measurement methods must produce a different spectral signature in order to be distinguished by remote sensing.

Changing of earth surface from one surface to another is the natural phenomena due to floods, climate effect and due to cultivations. Land covers include the vegetation areas, soil and water. Vegetation further divided into other categories which are highly dense vegetation like forests, normally dense vegetation like agricultural and lower dense vegetation like meadows and their coverage and type of dense vegetation can be easily analyzed using vegetation index (V.I). Other approaches like Normalized Difference Vegetation Index (NDVI) and Bare Soil Index (B.I) were also derived to analyze vegetation and difference between agricultural and non-agricultural land (John, 2000), (Boehmer, 2004) , (SON Tong Si, LAN Pham Thi, CU Pham 2009). For the set of images of different bands used in the study the NDVI worked well in identifying and analyzing vegetation densities (Peijun *et al.*, 2008). The computation of vegetation densities from remotely sensed data is best application owing to more sophisticated space-based sensors and computational resources of Land sat images. Computed vegetation maps can be used in applications such as measuring deforestation, land change detection, increase and decrease of vegetation level to judge the density whether it is low or high. Change Vector Analysis (CVA) provides enough information about land cover changes, change intensity and direction of changes (Anusha *et al.*, 2012). The obtained threshold from change intensity also indicates the level of change; i.e. low level of change, normal level of change or high level of change (Anusha *et al.*, 2012), (SON Tong Si, LAN Pham Thi, CU Pham Van,2009).

2. METHODOLOGY

For this purpose, District D. I. Khan has been selected. It is one of the districts of Khyber Pakhtoon Khuwa (KPK) Province, Pakistan. The district location is 31.8424 latitude and 70.8952 longitudes. The AOI (Area of interest) has been drawn as square shaped polygon covering near about 60 Km area. D.I. Khan is one of the largest districts in province having an area of 7326 $km^2$with mostly vegetation and dry land. District accommodates hot summers from May to September and mild winters from October to April. The images are downloaded from United States Geological Survey (U.S.G.S.) maps after drawing polygons. U.S.G.S. maps serve as a ground truth and display the regions of various types of groundcovers of all over the world. Each database has twelve spectral bands to estimate the desired outputs. These two images are of same location with two different times 2013 and 2015 which are T1 and T2 respectively. The six desired bands are Green, Blue, Red, NIR, SWIR1, and SWIR2 which are band 2 to band 7 in database. The desired bands are combined to a single image with multiple bands and process of

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combination is known as layer stacking. The North's of downloaded images are corrected. Other image characteristics like wavelengths, sensor type values were also added as header information.

3. <u>CHANGE VECTOR ANALYSIS (CVA)</u>

CVA is the good method to detect the change of intensity direction. The desired indices used to calculate the change intensity and direction are NDVI and BI used as x-y Cartesian coordinates respectively. The NDVI required near infrared region (NIR) and red bands for calculation. It is calculated vegetation density. BI desires the SWIR1, red, blue and NIR bands for calculation. It differentiates the agricultural and non-agricultural land. The mathematical expression for both NDVI and BI are given below:

$$\mathrm{NDVI}=\frac{\mathrm{NIR}-\mathrm{Red}}{\mathrm{NIR}+\mathrm{Red}},(1)$$

$$\mathrm{B.I}=\frac{(\mathrm{SWIR1})+(\mathrm{Red})-(\mathrm{NIR})+(\mathrm{Blue})}{(\mathrm{SWIR1})+(\mathrm{Red})+(\mathrm{NIR})+(\mathrm{Blue})},\ (2)$$

Change of intensity between two times T1 and T2 is given in **(Fig. 1):**

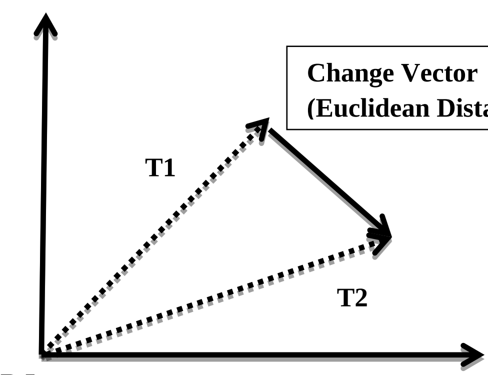


Fig.1 The concept of change of intensity

The magnitude of the change intensity can be calculated by given mathematical expression:

$$\mathrm{S}=\sqrt{(\mathrm{NDVI}_2-\mathrm{NDVI}_1)^2+(\mathrm{BI}_2-\mathrm{BI}_1)^2}\ , \qquad (3)$$

Where, S=magnitude of the change vector, $\mathrm{NDVI}_1, \mathrm{NDVI}_2$ and $\mathrm{BI}_1, \mathrm{BI}_2$ are the vegetation and bare soil indices at time T1 and T2 respectively.

Fig. 2 Change of Intensity resultant image

In above **(Fig. 2),** change of intensity can be seen from dark to bright areas. More the intensity value, more the brightness means more the change or soil expansion. Very low intensity value or high darkness shows the no change and between the dark and bright (grey) reflects normal change or going to be change (Tong *et al.*, 2009), (Xiaolu, *et al.*, 2011). Change of direction monitors the land transformation from one form to another using the tangent angle between the BI and NDVI.

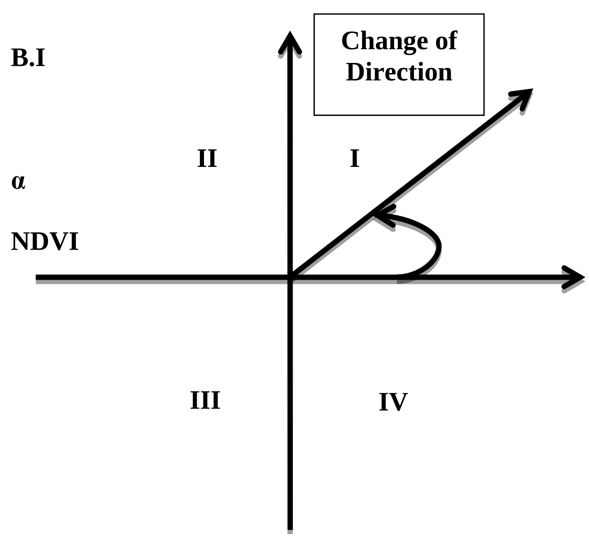


Fig. 3 The concept of change of direction

The mathematical expression is given below:

$$Tan\alpha = \frac{(BI_2 - BI_1)}{(NDVI_2 - NDVI_1)} , \qquad (4)$$

Where, α = the direction of change vector.

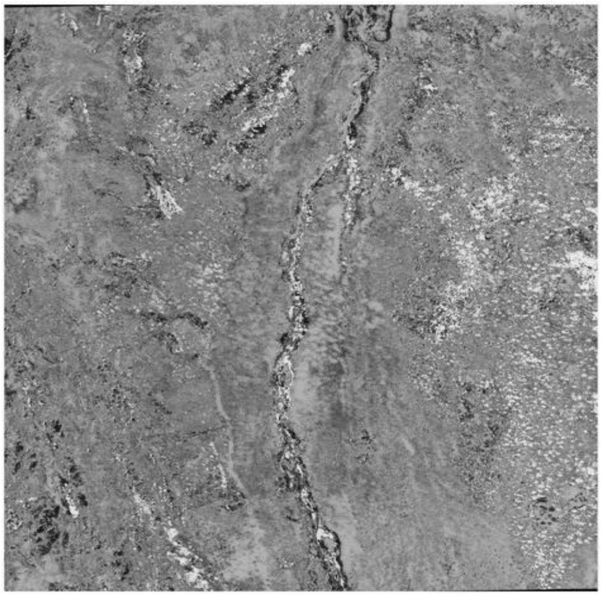


Fig. 4 Change of Direction resultant image

The resultant change of direction image can be seen above which composed of four classes represented in four quadrants.

Table 1: Change dimension in four quadrants

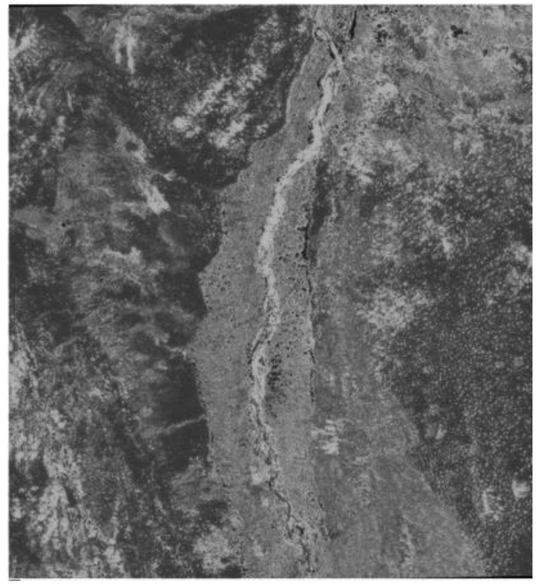
Dimension	B.I	NDVI	Description
III	-	-	**Water or high moisture land**
II	+	-	**Expansion of soil**
IV	-	+	**Chlorophyll increase**
I	+	+	**Moisture reduction**

The first quadrants how moisture reduction with both NDVI and BI positive. The second quadrant II in which the BI is positive and NDVI negative shows increase in soil, most similar with brightest areas of change intensity image. The third quadrants where both indices are negative shows water or high moisture land. The fourth quadrant has positive NDVI and negative BI which shows increase of chlorophyll or vegetation density.

Level of Change

The level of change has been observed using the threshold values obtained by the mathematical expression of Euclidean distance magnitude in eq.3.

The above figure 5 shows the level of changes. The level of change has been divided into three categories representing with three colors, as shown in the **(Fig. 5).**



- **No change (No-spectral change)**
- **Normal level of change (Spectral change)**
- **High level of change (Land surface transformation)**

Fig. 5 Level of Change resultant image

The above fig. 5 shows that the mostly area in the district remains same. The normal level change (variation in quantity due to spectral change) occurred in the Indus River while high level of change (Land transformation) is in very little amount

4. Land Covers RATIOS (Post-Classification based approach)

A Post-classification method has been adopted for each image. Each and every step is independently process for both images to avoid difficulties for change detection in two different times by satellite sensors. It's the good and accurate method to analyze each land cover, land covers distribution patterns and change detection between two different times. It gives information about percent changes of each land cover using ratios of wavelength to get the maximum reflectance for each type of land covers using spectral signatures. For each type of land cover, the ratio is taken between maximum reflectance wavelength band and minimum reflectance wavelength band depending upon the spectral signature. The suitable meanvalue is usually taken as threshold value between the minimum and maximum value range, however other value can be taken with in this range as threshold value to get the suitable results, to get more accurate results and to get look able reflectance for each land cover. A flow chart diagram has been drawn in Microsoft Visio 2010 which can be seen below in given fig. 6 for the change detection and image analysis using classification based approach for different land covers. Each step including estimations of accuracy assessments, kappa coefficients and percent changes in land covers has been performed separately as post-classification based approach technique.

Decision tree classification in ENVI 5.1 has been used for the implementation of these steps.

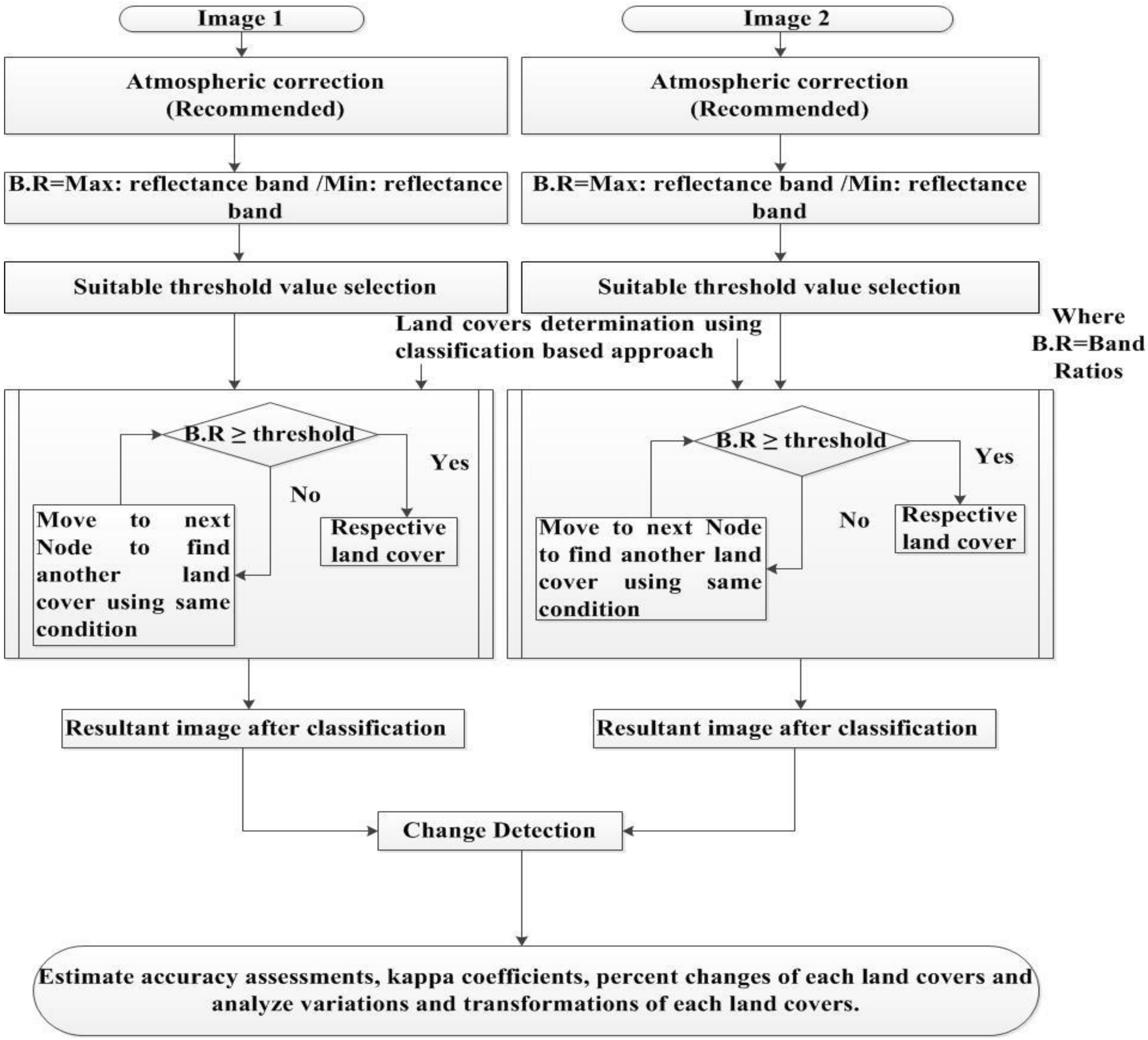


Fig. 6 Land Cover Ratio implementations steps

(Post-classification based approach flow chart implemented in Microsoft Visio 2010)

5. CHANGE DETECTION

The changes can be observed in two images shown in fig.7. The obtained images are classified in decision tree classification software in ENVI Classic and then land surfaces are pointed with text in paint to show these. The resultant images indicate that mostly vegetated area is along the Indus River on both sides mainly composed of forest and agriculture. Existing of agriculture and forests indicates very strong amount of chlorophylls as these are in the category of highly dense vegetated area. The arrow points are indicating the changes in land types in below **(Fig. 7).** Major changes can be detected easily in given two images. The given two different times images also show the variation and transformation of vegetation types. For vegetation land cover, the forest has been transformed to meadows and agricultural. Water surfaces in 2013 have been transformed to meadows or either reduced too much in 2015 to form soil land. The change in width of Indus River also shows the change of River level. River width in 2013 is some greater than in 2015 which indicates the availability of water surface much in 2013 than 2015 means much flow of water in 2013.

6. PERFORMANCE ANALYSIS OF RESULTS AND DISCUSSIONS

After observing, analyzing and comparing all the results of change intensity, change direction, level of change and land cover ratio using classification based approaches; it is observed that changes occurred in some of are as while mostly remained same. Classification based approach in decision tree classification also remained helpful in verifying change of direction result and to analyze the existence of chlorophyll in land covers (SON Tong *et al.,* 2009), (Nguyen *et al.*, 2012), (Morgan, *et al.,* 2015). Strong availability of vegetation reflects the high amount of chlorophyll, vegetation density and vegetation coverage while the low amount of vegetation reflects the decrease of chlorophyll causing decrement in plantation coverage (Sohlman, 2001). From the results of classification based approach, the vegetation coverage and other land coverage results are shown below:

The total vegetation coverage observed in 2013 is 65.01%, while in 2015 the vegetation coverage is 66.50%. It means that total vegetation coverage in 2015 was near 1.007 times more than in 2013 (Sohlman, 2001). Water land remained 4.17 times much in 2013. Soil coverage remained1.28 times more in 2015 than in 2013 which indicate that soil density become higher in 2015 than 2013. The overall accuracy assessments are 90.47% and 95.45% and kappa coefficients are 0.82 and 0.86 respectively for images at time T1 and T2 respectively.

7. CONCLUSION

Land cover change detection using change vector analysis and land coverage ratios provides enough information about the intensity and level of change from one land cover to another and also informs about the change direction. Change detection using cover ratios also remained quite enough to detect the change in percent coverage variation and transformation of land covers. From the year 2013 to 2015, vegetation land turned into soil expansion due to cultivation. During classification of 2013 image, some of tiny clouds are detected although these did not interfere in overall implementations for change detection. There effects are minimized using atmospheric correction. These tiny clouds are kept a side and the change detection and land cover analyses remained enough viewable and observe able after reducing the effect of moisture in air using atmospheric correction. According to the resultant image obtained as level of change, most of the area remained same which can be verified after seeing the results in the table 2. Large variation occurred in only water and soil surfaces while forests, agriculture and meadows changed only slightly.

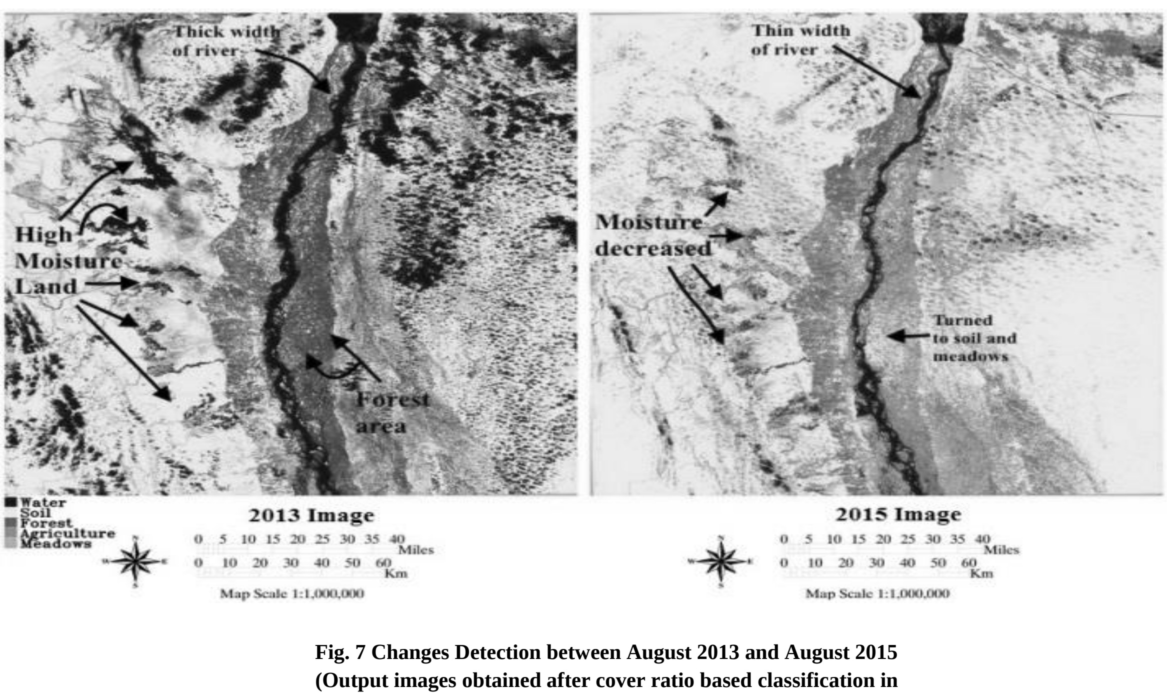


Fig. 7 Changes Detection between August 2013 and August 2015 (Output images obtained after cover ratio based classification in Decision Tree Classification to analyze change detection)

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