FOREST COVER CHANGE DETECTION AND ITS IMPACT ON RAINFALL PATTERNIN THAK VALLEY (PAKISTAN)

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ABSTRACT: The study was carried out to focus on issues of deforestation of rangeland as natural resources during recent decades on a large scale. This rapid deforestation made great effect on the ecology, environment, health and economy of the country. Keeping all these aspects in views it was necessary to carry out forest cover change detection by focusing on the monitoring of the present and past status of forests cover and other related objects using remote sensing and GIS technique. Assessment of deforestation in Thak valley was carried out on temporal basis to elaborate the forests cover change from 1989 to 2009 using Landsat satellite data. Supervised classification and visual interpretation techniques were applied on each image. The integrated classes such as snow covered area, built up area, vegetation related to crop land and forest, water body, bare soil were created and major objects and land cover built-up area were also digitized. The statistical analysis detected a positive relation between two natural factors i.e. rainfall and forest through trend line. It was identified that rainfall pattern also decreased due to forest degradation.

Keywords: Forest cover; Thak valley; Remote sensing; Geographic Information System (GIS)

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INTRODUCTION

Earth's surface has a few landscapes remaining without any significant modification by humans in some manner. Anthropogenic activities such as agriculture, mining, deforestation and construction influence on shifting patterns of land use are a primary component of many current environmental concerns as land use and land cover (LULC) change is gaining gratitude as a key driver of environmental change. Changes in LULC are wide spread, increasingly rapid, and at local, regional and global scales. These changes have hostile impacts (Yang and Lan, 1999).

In recent years the use of remote sensing data has been of an immense help to monitor the changing pattern of vegetation (Hoffer, 1978). Change detection is the time-based difference in spectral reaction includes, where the spectral features of the vegetation or other cover type change over time in a specified location (Singh, 1989). For preparing accurate land cover map and for monitoring changes at regular intervals of time satellite remote sensing techniques are useful. In case of remote region, RS is the only method of obtaining the required data (Macleod and Congalton, 1998).

Forests have long been regarded as a national treasure in Pakistan. With the current depletion of forest areas around the world, it is important that we must manage these renewable resources in a sustainable manner. In order to formulate and exercise efficient forest management policies and practices, it is necessary to have reliable information about the LULC. Geographic Information System (GIS) technique and Remote Sensing (RS) from Satellite platforms which offer an alternative and economic tool for forest mapping. It has been noted over time through series of studies that Landsat Thematic Mapper is adequate for general extensive synoptic coverage of large areas. As a result, this reduces the need for expensive and time consuming ground surveys conducted for validation of data. Generally, satellite imagery is able to provide more frequent data collection on a regular basis (Coppin and Bauer, 1996).

RS technique for change detection in forest cover and monitoring has been used to assess the dissimilarities in forest cover over two or more time periods caused by environmental conditions and human actions which is used in estimating and validating ecosystem changes arising from forest use and forest management interventions. Through Quantitative knowledge of LULC changes enables the economic comparison, which is applied in different ecosystem services within and across different countries (Kreuter *et al*., 2001).

Forest cover area may influence the atmosphere and soil process and control the hydrological cycle as well. Relationship between forest and rainfall and especially between decline in forest cover and distraction of rainfall systems is supposed by this analysis. There are various climatic changes that occur as a result when an

area of rainforest is cut down. For example desiccation of previously moist forest soil is caused by deforestation. Dramatic increase in temperature results in moist region changes to desert, no water recycling, less CO2 and N exchange, soil erosion and more desertification is observed (Meher-Homji, 1992).

MATERIALS AND METHODS

Thak Valley is located between (73°59'35.29" - 74°11'36.06") E and (35° 9'46.12"-35°25'40.41") N. Figure-1.

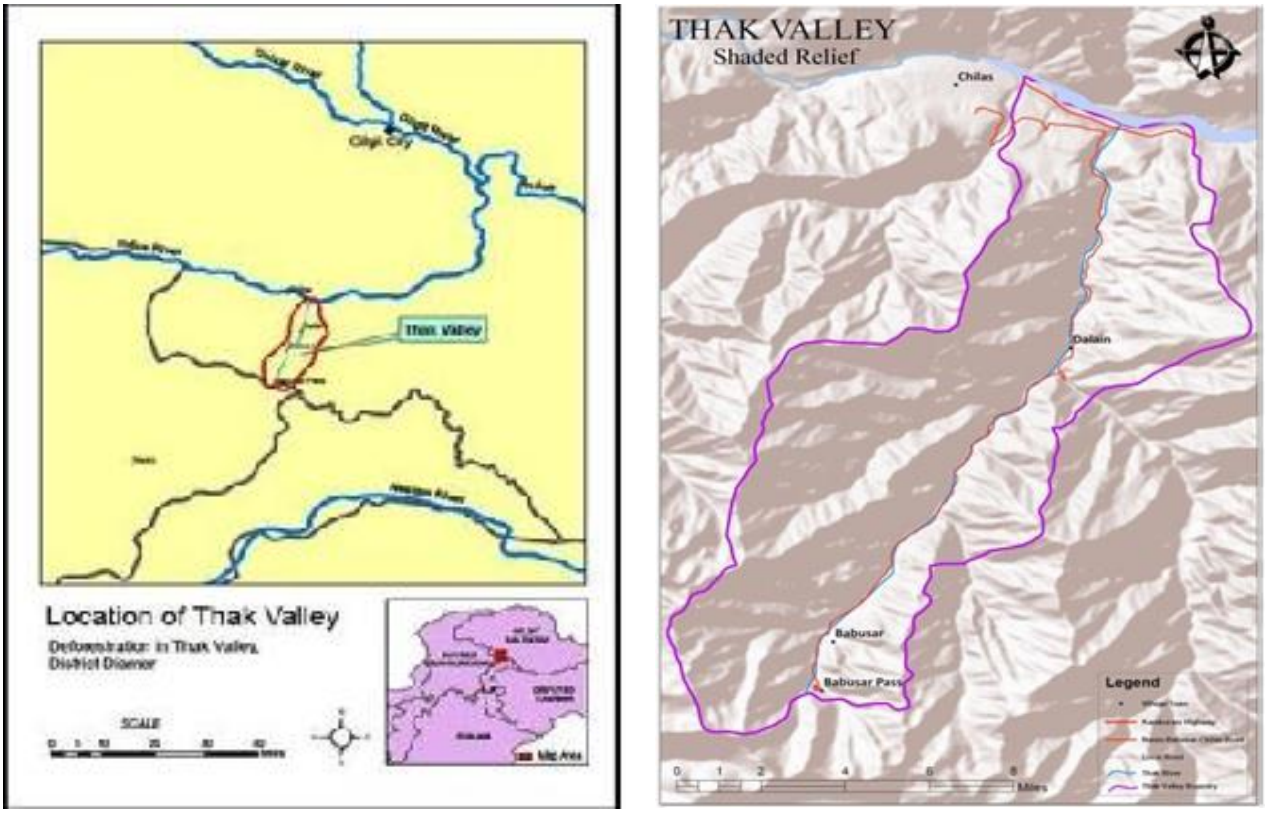

Figure 1. Showing study area of Thak Valley

There were two main objectives of study which were to identify the forest cover change on temporal basis for the years of 1989, 1999 and 2009, and to find out the correlation between forest change and rainfall.

Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times. Essentially, it involved the ability to the Application of Remote Sensing and GIS for Forest Cover Change Detection quantify sequential effects using multi-temporal data (Singh, 1989). Post-classification comparison change detection, the most commonly used quantitative method of change detection, was selected to perform Land Cover change detection in this study. Changes in area maps were generated from superimposed classification technique with an interval of 10 years. Graphs, tables and maps were also generated.

To assess the forest change cover change and its effect on climate different data sets was collected. In order to detect forest change over a period of 20 years, it required temporal satellite imagery of same season and same time period. Landsat Satellite images were acquired from United States Geological Survey (USGS). Change detection tool was used to detect change in area under land cover. The results so collected by superimposing maps were denoted with high change, some change, no change and shadow area.

Prior step before carrying out analysis was data preparation in which satellite imagery was refined and prepared to carry out detailed analysis. For the case of Land cover change detection it consisted of geo referencing and sub-setting of images. Sub setting of all three images were carried out and the study area was masked from a complete scene. Figures-2 and 3show original image and subsets of study areas that belong to three different years.

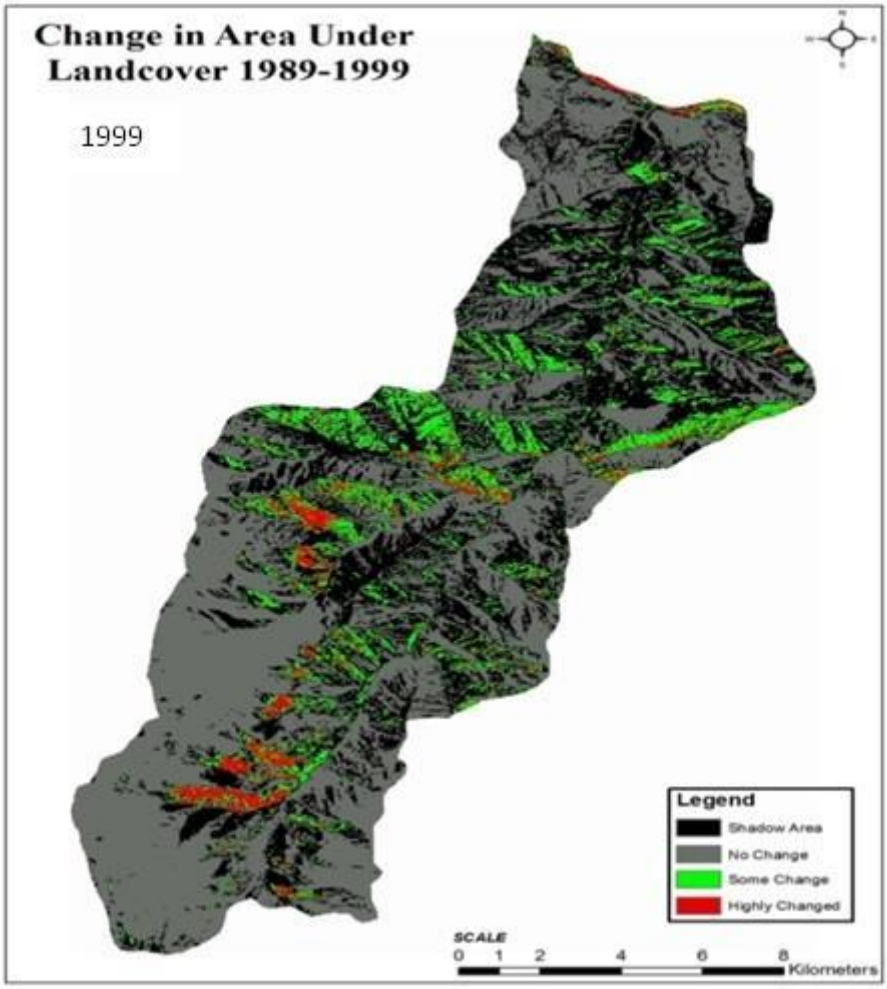

Figure 2.Map showing change under land cover 1989-99

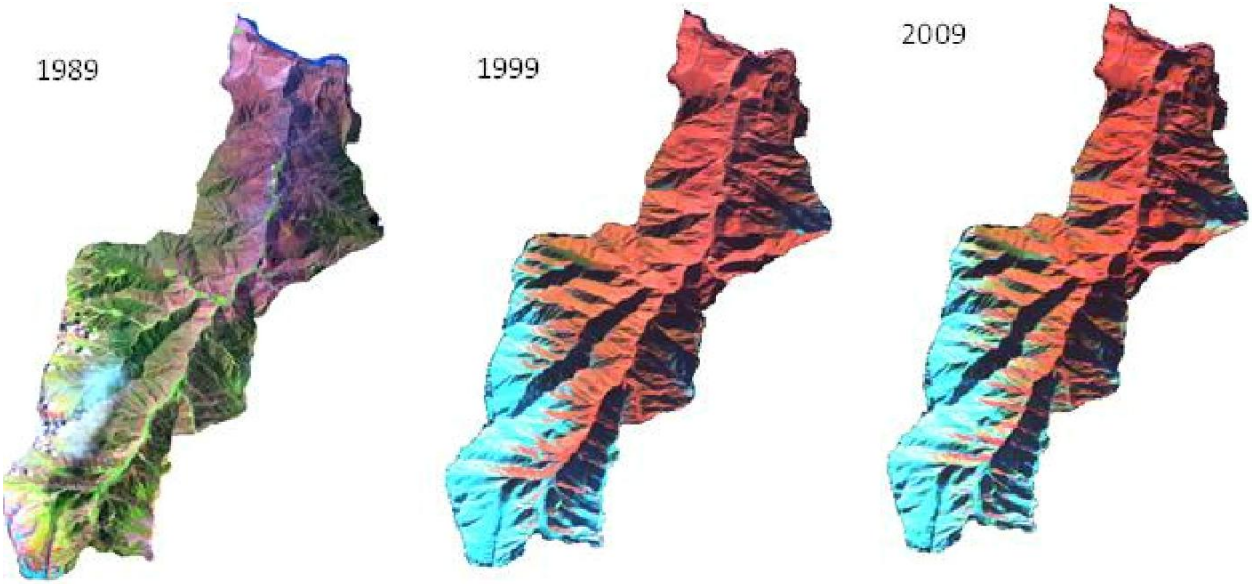

Figure 3.Showing original image and subsets of study areas

RESULTS

Classification was the process of sorting pixels in satellite image into a finite number of individual class, or categories of data, based on their data file values. If a pixel satisfied a certain set of criteria, the pixel was assigned to the class that corresponded to that criterion. This process was also referred to as image segmentation. Each class referred to the specific set of spectral resolution and wave length related to particular objects on earth surface. The following statistical formula was used to find out the positive correlation.

$$r = \frac{n-1}{1} \sum \left(\frac{x_i}{\sigma_x} - \bar{x}\right)\left(\frac{y_i}{\sigma_y} - \bar{y}\right)$$

Here different classification techniques, correlations and anomalies were applied on time series data. The temporal trend and final results were obtained after the complete analysis. Land cover classification technique was applied to assess the change in forest cover for the years of 1989, 1999 and 2009. The Supervised Classification of the three images succumbed land cover maps of the study area and from these, six LC classes were identified. Land cover classes portrait the decreasing trend of vegetation and forests. Figures-4, 5 and 6.

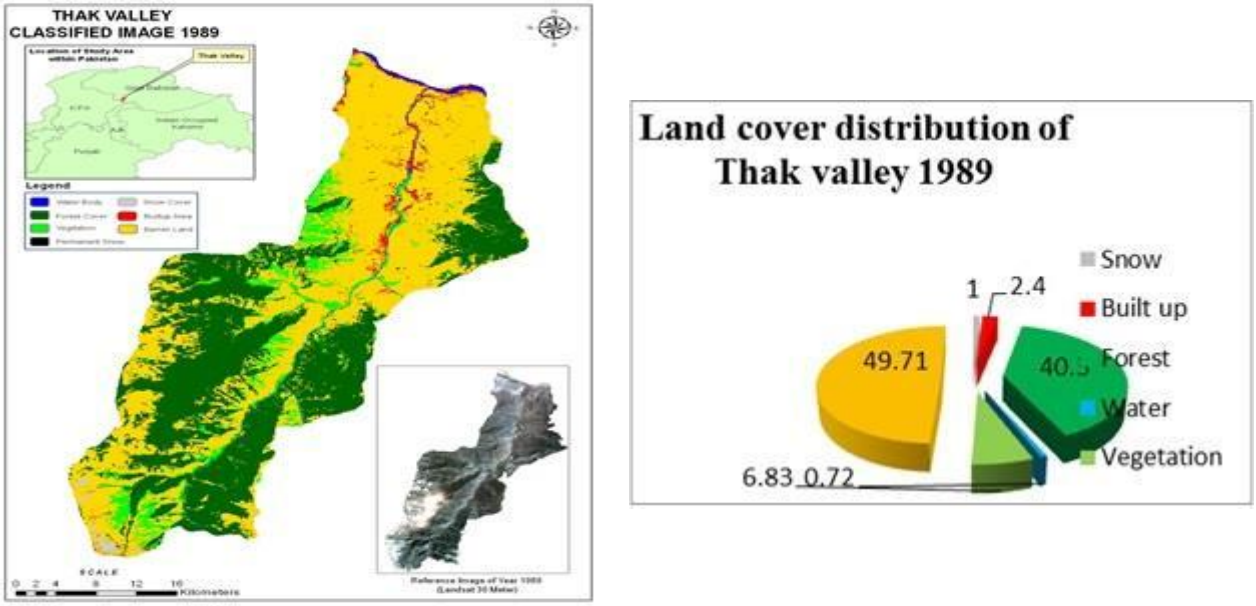

Figure 4.Showing percentage land cover 1989

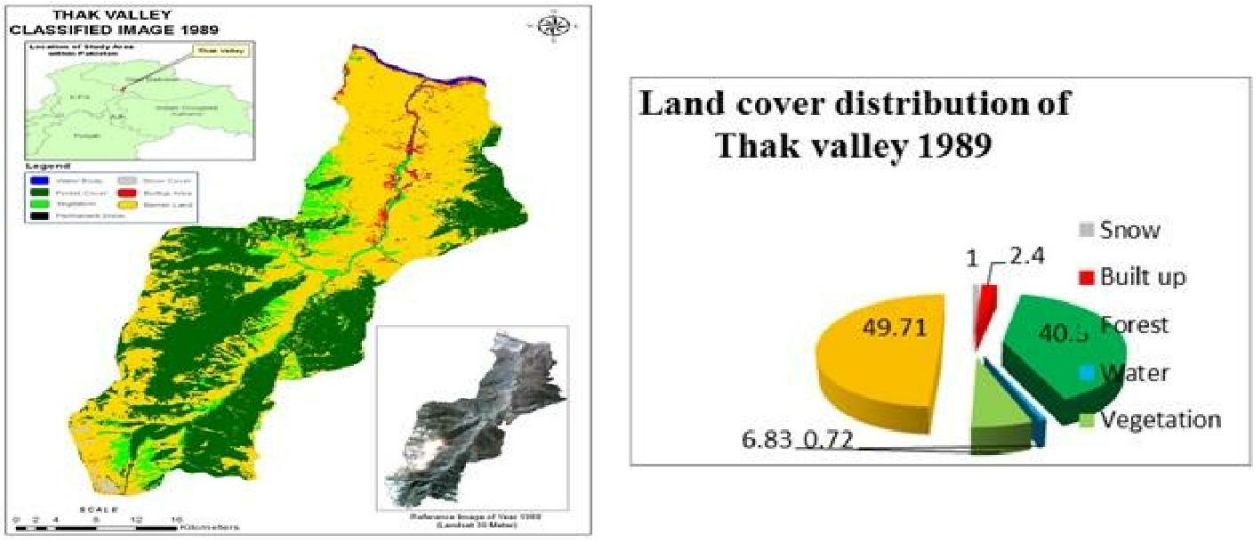

Figure 4.Showing percentage land cover 1989

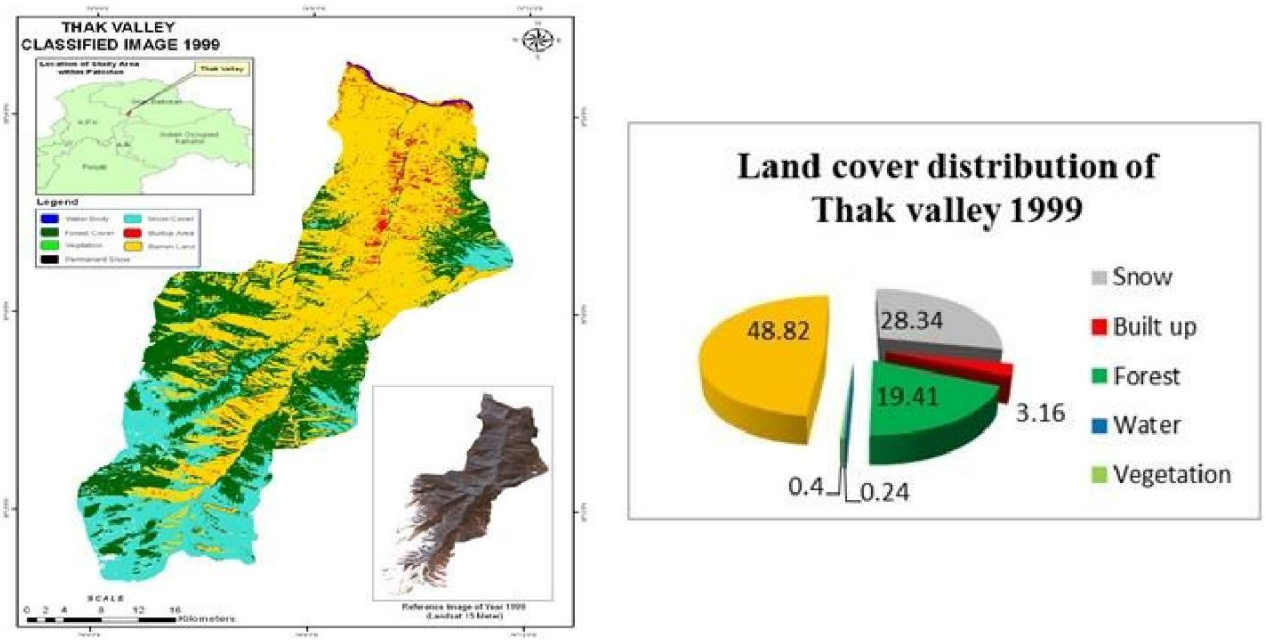

Figure 5. Showing percentage land cover 1999

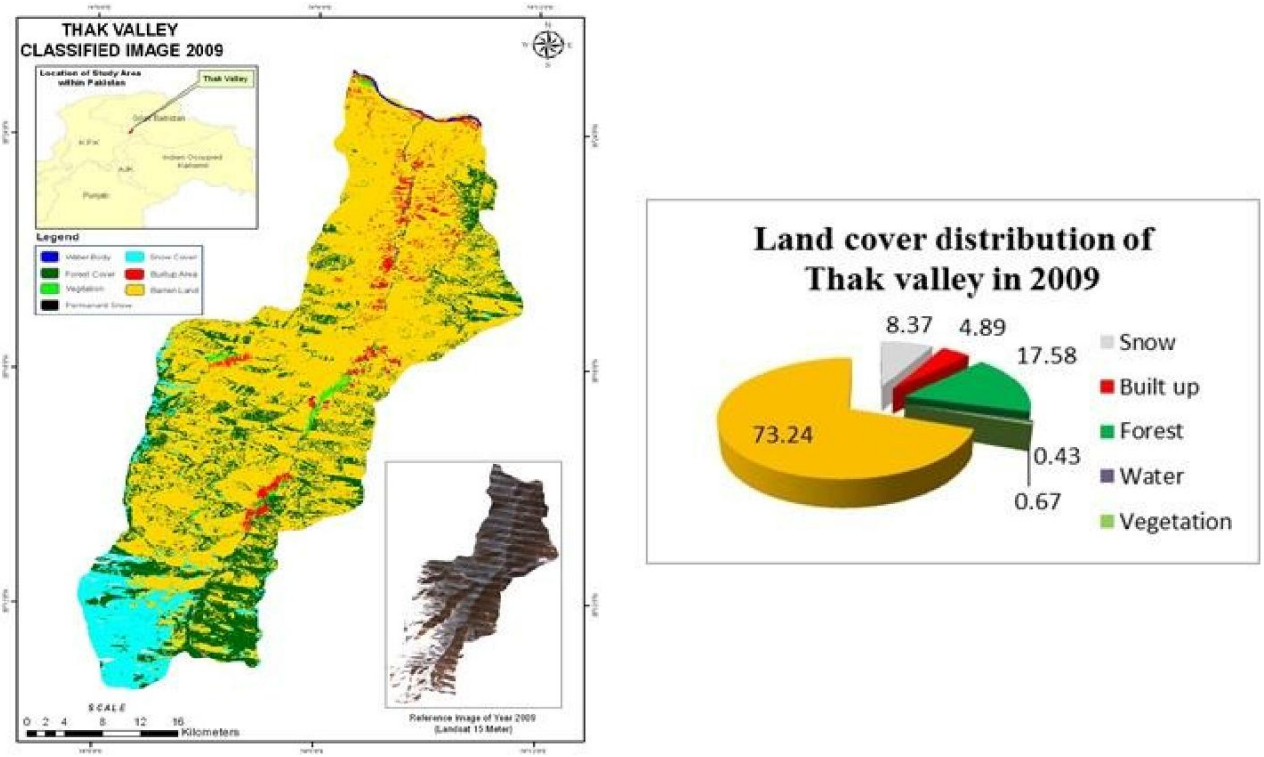

Figure 6. Showing percentage land cover 2009

Correlation technique was applied to get timely change detection from 1989 to 2009. And classes were made in four parts as some changes, Highly Changed and No Change. Whereas fourth part was shadow area which was not clear in these Landsat satellite images. Same technique was applied on pair of images 1989-1999, 1999-2009 and 1989-2009. Figures-7, 8 and 9.

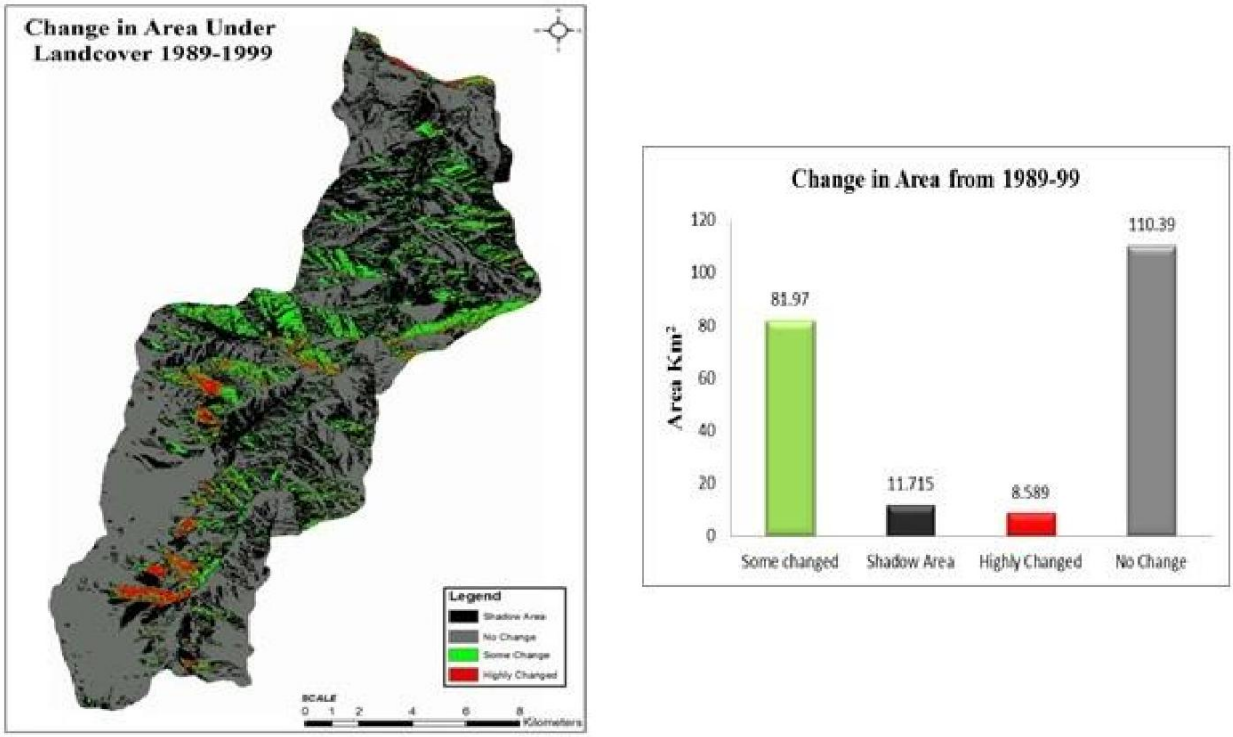

Figure 7. Change in area from 1989-99

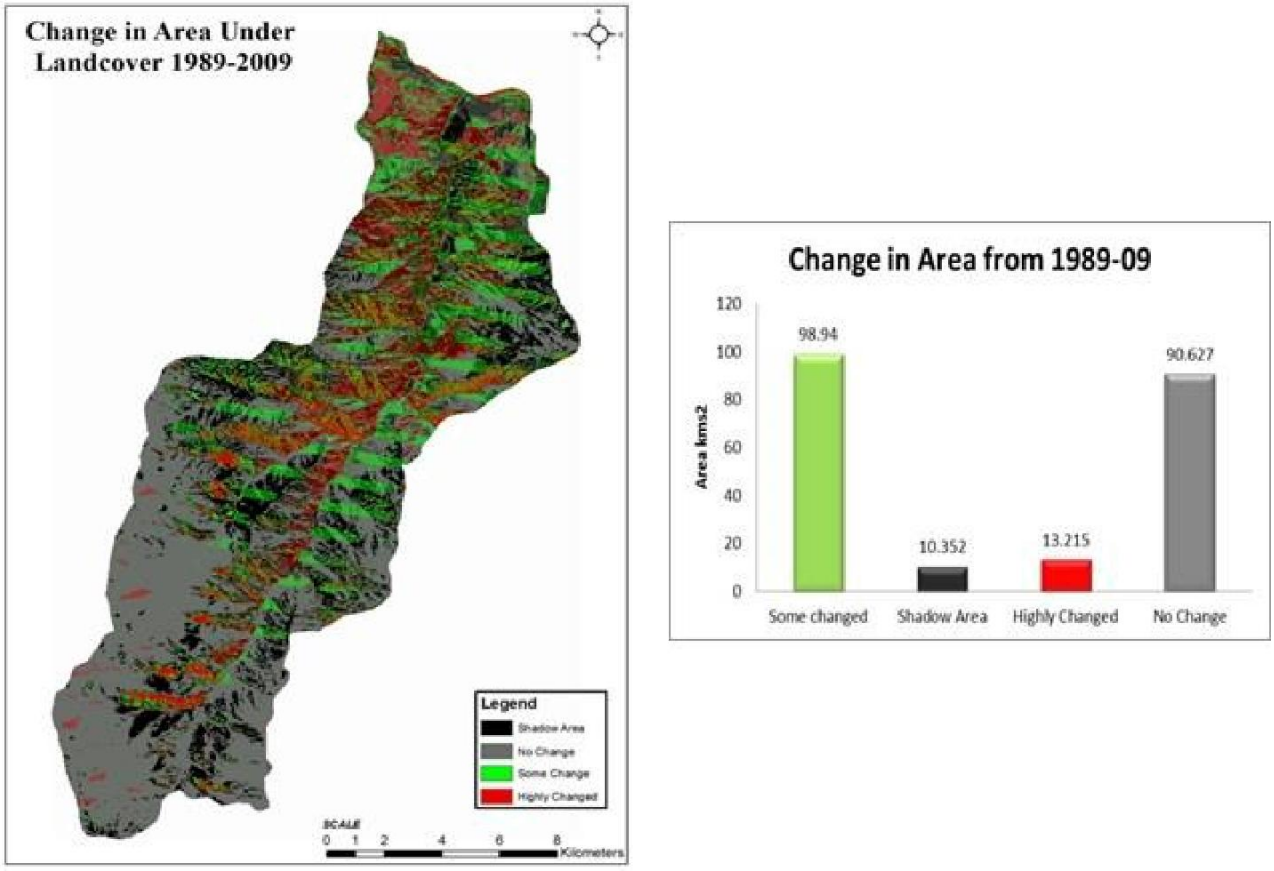

Figure 9. Change in area from 1989-09

Correlation analysis was carried out on results of deforestation for the years 1989, 1999 and 2009 with the rainfall data which showed clear decrement of forest and rainfall as shown in Figure-10.

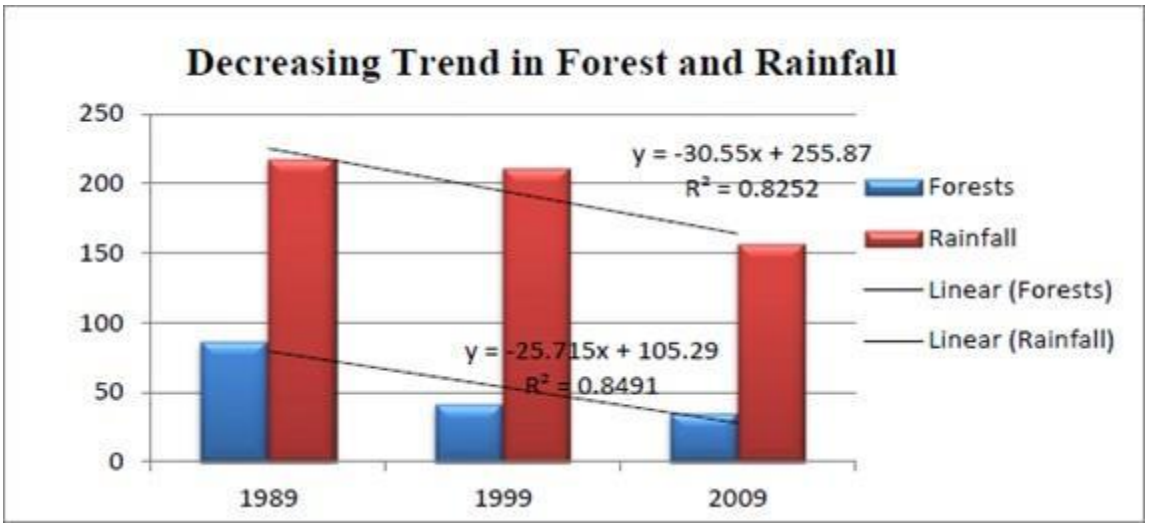

Figure 10.Showing decreasing trend in forest and rainfall.

As rainfall was directly related with the forest cover, that was why regression Y clearly decreased from 220.76 to 178.95 as show in

Table-1.Showing regression results of each year.

Year	Forests	Rainfall	Regression Y
1989	85.83	217.2	220.768373
1999	41.34	211	184.593554
2009	34.4	156.1	178.95064

DISCUSSION

Supervised classification was applied on Landsat images (Rozenstein and Karnieli, 2011). Supervise classification was chosen because of its accuracy for the large area and the main objective of classification was to extract 6 LC classes. The spatial extent of the 1989 LC map after the Supervised Classification yielded land cover classes with the high density forest occupying the higher percentage of the area (85.83 Km^2, 40.30%). This was basically found in the Eastern and western and south-eastern part of the map with the highest concentration around the Indus River Thak valley. The next important LC class was coverage of vegetation and the sparse forest (14.54 Km^2, 6.83%) which was scattered around the river and Southern and north-western parts of the area with very small patches within the forest reservoir. Built-Up area in this year was 5.11 Km^2 (2.40%) that was mostly scattered in the southern part of study area and around the river. Water bodies were 1.53 Km^2 (.72%) and their area coverage consisted of small patches along the river courses and bare soil/Sand had area of 105.88 Km^2 (49.71%) which covered the highest part. The Supervised classification procedure applied to the 1999 Landsat image yielded Land cover map. The spatial extant of forest cover was 19.41 Km^2 (41.34%) in the north eastern and south western part of Thak valley. Water bodies were mainly found along river courses and marshy areas with an area of .51 Km^2 (.24%). Built-Up occupied an area of 6.73 Km^2 (3.16%) and mainly concentrated at the Northern and central part where as small patches were found around the western parts of the map. Bare Soil/Sand had an area of 103.98 Km^2 (48.82%) with small patches within the entire scene except the reservoirs. The 2009 Landsat ETM image after classification procedures yielded Land cover map with the Forest density occupying the area of 34.4 Km^2 (17.58%) which was scattered in the study area in small patches with a few clusters around south-eastern part of the area. Sparse vegetation was very short in the study area. Built-Up occupied the area coverage as compared to other LULC classes having 10.43 Km^2 (4.89%). This was concentrated at the entire map, mainly; Northern and central part and some patches in the western parts and along the river in the study area. Bare Soil/Sand had an area of 149.37 Km^2 (73.24%) with large patches within the entire scene except the reservoir. Water, having an area of .91Km^2 (0.43%) was the last and least area coverage and mainly concentrated within the reservoir.

There was positive correlation (0.67) between rainfall and forest cover, which showed high correlation (Herrmann *et al*., 2005).In this correlation the vegetation was taken as an independent variable and rainfall as dependent one. The rainfall pattern changed on temporal basis as change in vegetation (Guo*et al*., 2014). So here it was agreed that due to anthropogenic factors vegetation

was being lost and it affected the local climate and rainfall factor. Decreasing trend of forests effected the precipitation and caused degradation in rainfall (Foley *et al*., 2005) because rain factor was directly dependent on deforestation. Relationships between variables can be investigated through regression analysis which was most important statistical tool. Figure-10. Usually, to find out the causal effect of one variable upon another variable this tool was taken by the investigator. If there was a relationship between the analysis and the goal could be approximated with a straight line, a linear regression technique could be used. There was positive regression result in analysis that showed that rainfall was dependent and vegetation or Forest Cover was independent (Du *et al*., 2013) which proved decreasing trend of forests which also changed the amount of annual precipitation.

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