GIS/RS: A TOOL FOR FOREST COVERS CHANGE ASSESSMENT IN DISTRICT ABBOTABAD (KHYBER PAKHTUNKHWA), PAKISTAN

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ABSTRACT

Pakistan has a great variety of landscapes with a diversified relief, having total forest area of 4.2 million hectares (4.8%). Khyber Pakhtunkhwa occupies around 1.3 million hectares (30%). Land use and land cover change using Remote Sensing (RS) and Geographic Information System (GIS) has become a central component in current strategies for managing natural resources. Therefore, an attempt was made in this study to map out the status of land cover of District Abbottabad using RS and GIS. The total land cover area calculated was about 4, 41,408 acres. Forest (30.12%) was found to be the major land use followed by rangelands (23.80%), shrubs & bushes (22.32%) and agricultural land (19.94%).The change detection result shows that there is a considerable increase in Shrub & Bushes (21.33%), followed by Forests (9.76%). It also indicates a considerable decrease in land cover class agriculture land (28.34%), followed by the Rangeland land cover class (4.83%).

Key words: GIS/RS, Forest covers change assessment, Khyber Pakhtunkhwa

INTRODUCTION

Pakistan has a great variety of landscapes with a diversified relief. It has the majestic high mountain ranges of the sub-continental north, the Himalayas, the Karakorams and the Hindu Kush, the meeting point of the Himalayas, the Hindu Kush, and the Karakorams in the Northern Areas is the most varied features of the country's landscape (Murad, 2010). Pakistan with only 4.8% area under forest is a forest poor country. Per capita forest is only 0.03 ha as against the world average of 1.0 per ha. Given a very high population growth rate of 3%, per capita forest area is further declining. The forestry sector contributes only 0.3% to the GDP leaving aside the intangible benefits (Pakistan Forestry Sector Master Plan, 1992).

Forest cover is an important natural resource which should be conserved on priority basis for sustainable environmental management. However, escalating levels of anthropogenic disturbances have exhorted tremendous pressure on the forests. This calls for an immediate management and conservation of this natural resource (forest) of the region (Rabindra, *et al*., 2007). An accurate and continuously updated resource data is a prerequisite for the present day forest ecosystem management. Because of the synoptic and repetitive data acquisition capabilities, satellite-based sensors have the potential to detect, identify and map canopy changes that are important to the forest ecosystem managers. (Mitasova *et al*., 1996).

The practice of remote-sensing started in 1930 using aerial photos, prior to which the forest managers were totally dependent upon resource information

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obtained on the ground. However, with the initiation of the first Earth Resources Technology Satellite (ERTS-1) in 1972 (later renamed as Landsat 1), monitoring environmental resources and study of ecosystem processes from space was initiated. Since then, the utility of space-borne remote sensing platforms in resource monitoring and location had been demonstrated successfully in different parts of the world. Large scale changes in land cover and repeated monitoring of forests have popularized remote sensing technology as an essential tool (Vrieling *et al*., 2002).

Kristensen *et al*. (2006) have claimed that the forest change detection mapping from satellite imagery is the 'most powerful monitoring tool' for conservation agencies, local administration and the non-government organizations. The change is usually detected by comparison between two or multiple-dates satellite images or some times between old maps and recent remote sensing images. Most of the change detection techniques are based on a pixel-to-pixel analysis and essentially comprise quantification of temporal phenomena through multi spectral sensors. During the last few decades, visual interpretation became less popular compared to automatic processing. Earlier literature on remote sensing change interactive map editing and more possibilities for visual detection however, reveals that digital change detection is an easier said than done task, especially in case of tropical environments with prevalent landscape heterogeneity. Digital classification-based change detection methods are further complicated, because one has to consider the information about accurate sun sensor geometry and environment conditions at the time of acquisition of images to nullify the atmospheric effects. In contrast to this, an interpreter having sound ground knowledge, analyzing large-scale aerial photographs or satellite imagery with visual interpretation technique is likely to produce more accurate results with a higher degree of precision. In addition, visual interpretation is the preferred method for interpreting forest cover and land use in case of low and medium resolution satellite images. It has been an efficient technique to overcome the risk factors in digital interpretation techniques because it provides a better control to detect change based on sound-ground knowledge. Though it is a time-consuming approach and requires human expertise, which is not objective and repeatable, visual interpretation can better provide accuracy in classifying the satellite image.

MATERIAL AND METHODS

THE STUDY AREA

The city of Abbottabad was founded in 1853 by Maj. James Abbott (SMEDA, 2009), situated between 33° 48' 39" N to 34° 22' 02" N latitude and 72° 54' 09" E to 73° 31' 00" E longitude. The district is rich in biodiversity, comprising a wide variety of flora and fauna. It is bordered by Mansehra district in the north, Muzzafarabad district in the east, Rawalpindi district in the south and Haripur district in the west (IUCN,2004) (Figure 1).

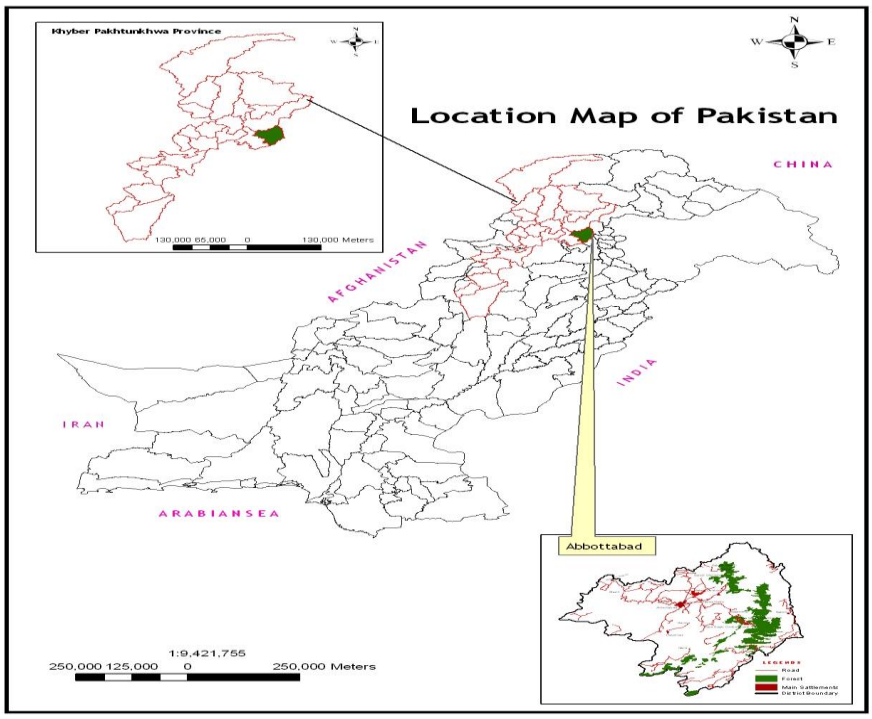

Figure 1. Location map for Abbotabad

The terrain of the area is both rugged and scenic, and its location at the base of the Himalayas lends it a temperate climate throughout most of the year. Spread over an area of 1,967 km2 (178,401 ha), Abbotabad district is located in predominantly mountainous terrain (IUCN, 2004). Temperatures begin to rise in the month of May, and by June the mean maximum and minimum temperatures recorded are 32.41°C and 19.67°C respectively. Temperatures are lowest during the months of December, January and February. In January, which is by far the coldest month, mean maximum and minimum temperatures stand at 12.56°C and 1.77°C respectively. Abbotabad district lies within the active monsoon zone. Most of the land is rain-fed, with 60% of average precipitation received during the July–August period and the remaining 40% unevenly distributed between September and June. The average rainfall reaches to 1366.16mm. The maximum rainfall is received in the month of august (261.27mm) closely followed by July (258.26mm) (IUCN, 2004).

Official figures vary; putting the district's total area at 178,401 ha Land use in the district based on official statistics employ a different system of technical demarcation. These figures show that a relatively high proportion of land in Abbotabad is classified as cultivated (35.6%), compared to the province as a whole (29.9%). Forest land in the district (46.7%) also exceeds that in the province (23.6%) (IUCN, 2004). Meanwhile, most of the land that is suitable for agriculture is already being cultivated. The percentage of land not available for cultivation is relatively low

(10.7%) in Abbotabad as compared to the whole province (28.5%). The majority of Abbotabad forested area is today so severely denuded that only 29% of forests support a density greater than 50% (IUCN, 2004). Meanwhile, the gap between use and regenerative capacity continues to widen. Overall, some 48% of land in the district is under agriculture and land use intensity is high (IUCN, 2004). Agriculture is the mainstay of the district's economy but the sector operates at a subsistence level. Of the 63,000 ha under cultivation, only 11% is irrigated. The remaining 56,000 ha of farmland depends exclusively on rain. As a result, per-hectare yields are low, and local demand for cereal crops such as maize and wheat is met through imports. Barring apples and potatoes, the district has few horticultural outputs Aggravating the scarcity of livestock feed is the fact that the development of rangelands, a major fodder source spread over an estimated 59% of the district, has largely escaped the attention of the concerned departments (IUCN,2004).

MATERIAL

a) ERDAS Imagine 8.4

Software used for geo-referencing, digitization, subsetting, classification, mosaicking, over laying, classification and interpretation of the images were:

b) Arc GIS 9.3

Software used to compliment the display and processing of the data. It was also used to develop existing land cover classes of district Abbottabad.

c) Microsoft word – was used basically for the presentation of the research.
d) Microsoft Excel -was used in producing the bar graph.
e) Satellite images

- Satellite Image 2007, SPOT 2.5m resolution

SPOT Satellite Image 2007, 2.5 m Resolution Coloured RGB of Abbottabad district.

- Landsat Image 1998 , 30m

Resolution Coloured RGB of Abbotabad. Visually interpreted (Land cover Map Prepared) by PFRI Study Under Forest Monitoring Circle, KPK Forest Department, Peshawar using Arc View 3.0.

f) Topographic sheets

- Topographic sheets published by SoP

Topographic sheets used in the study are of scale 1:50000, having reference numbers 43F1 & 2, 43F3, 43F4, 43F7, 43F8, 43G1 and 43G5. These Topographic sheets were published by SOP for the year 2004.

METHODOLOGY

For the assessment of forest Cover change the SPOT Imagery, 2007 was classified into seven major land cover classes named forest, shrubs & bushes, rangelands, agricultural lands, settlements, barren lands and water bodies. The classification was based on visual interpretation method.

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The steps or procedure which we followed in the methodology for the completion of project were as follow:

1. Import of image.
2. Geo- rectification, geo-referencing etc
3. Digitization, Sub setting (extraction of area of interest from the image) etc
4. Mosaiking of requisite geo-referenced & digitized topographic sheets of Survey of Pakistan
5. Visual interpretation of the image for existing land cover data
6. Overlaying of all thematic maps for interpretation

METHODS OF DATA ANALYSIS

1) Digitization

The image was digitized & classified image by Visual Interpretation to 7 different classes i.e. Forest, Shrubs & Bushes, Range Land, Agriculture Land, Habitations, Barren Land and Water Bodies in ERDAS Imagine 8.4.

2) Overlay operations

The overlay operation was done using ArcGIS 9.3, the Land use/Land cover SPOT satellite Image 2007, of district Abbottabad was. The requisite topographical sheets were mosaicked and were over layed with the 2007 image of district Abbottabad.

3) Calculation of the Area in Acres using the X-Tool of the resulting land use/land cover types for each class and subsequently comparing the results.

4) Development of classification scheme by visual interpretation.

The above two methods were used for identifying change in the land use types. Therefore, they have been combined in this study. The comparison of the land use land cover statistics assisted in identifying the percentage change, and rate of change between 1998 and 2007. In achieving this, the first task was to develop a

table showing the area in Acres and the percentage change measured for each land use land cover type. Percentage change can then be calculated by dividing observed Area in Acres by the Total Area in Acres multiplied by 100.

$$\text{Percentage (\%) change} = \frac{\text{Area in Acres}}{\text{Total Area in Acres}} \times 100$$

RESULTS

PFRI Study results (1998)

PFRI study using LANDSAT imagery of 1998 classified the image into six major land covers naming forest, shrubs & bushes, rangelands, agricultural lands, settlements and water bodies (Fig 2). The classification was based on visual interpretation method. (Provincial Forest Resource Inventory, 2001).

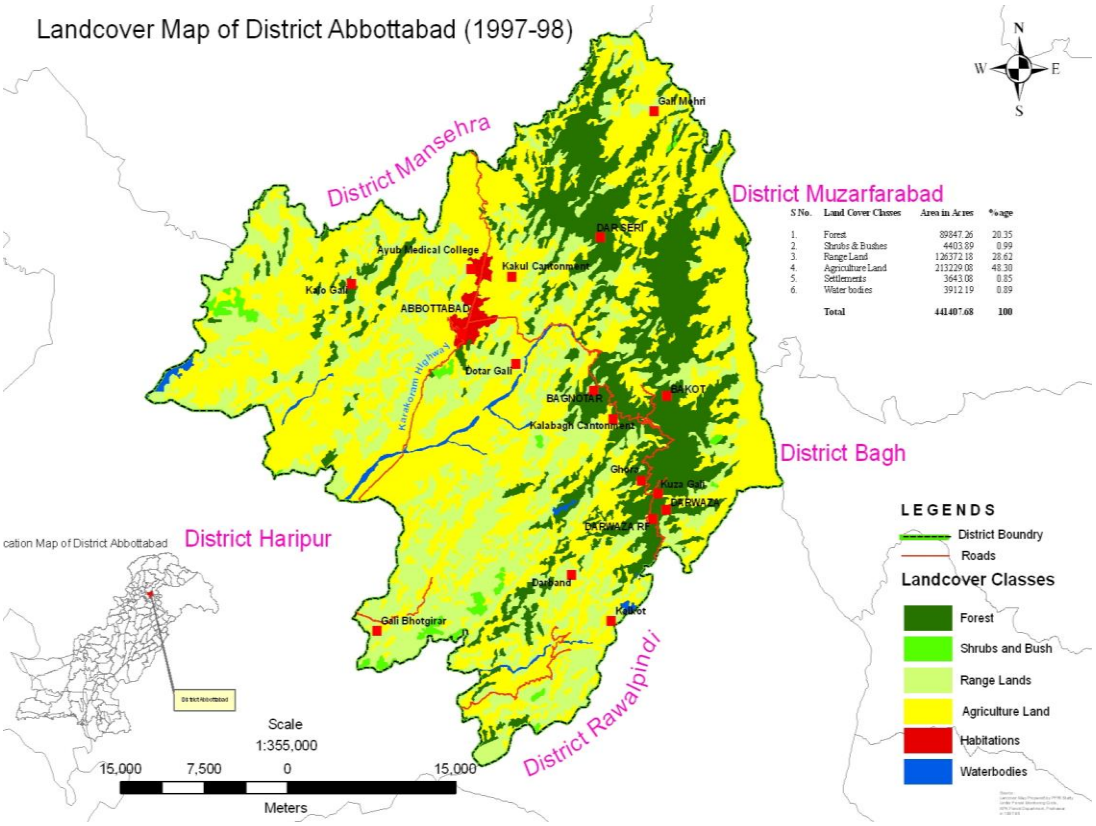

Figure 2. Land cover Map of District Abbottabad (1997-98)

Table 1. Statistics of Landcover in District Abbottabad, 1998

S No.	Land Cover Classes	Area in Acres	Percentage
1.	Forest	89,847.26	20.35
2.	Shrubs & Bushes	4,403.89	0.99
3.	Range Land	1,26,372.18	28.62
4.	Agricultural Land	2,13,229.08	48.30
5.	Settlements	3,643.08	0.85
6.	Water bodies	3,912.19	0.89
	Total	4,41,407.68	100

Source: PFRI Results

The total land cover area calculated was about 4,41,408 acres. Agriculture (48.3 %) was found to be the major land use followed by rangelands (28.62 %) and forests (20.35 %).The area under shrubs and bushes, settlements and water bodies was very less (Table 1).SPOT Imagery Results (2007).

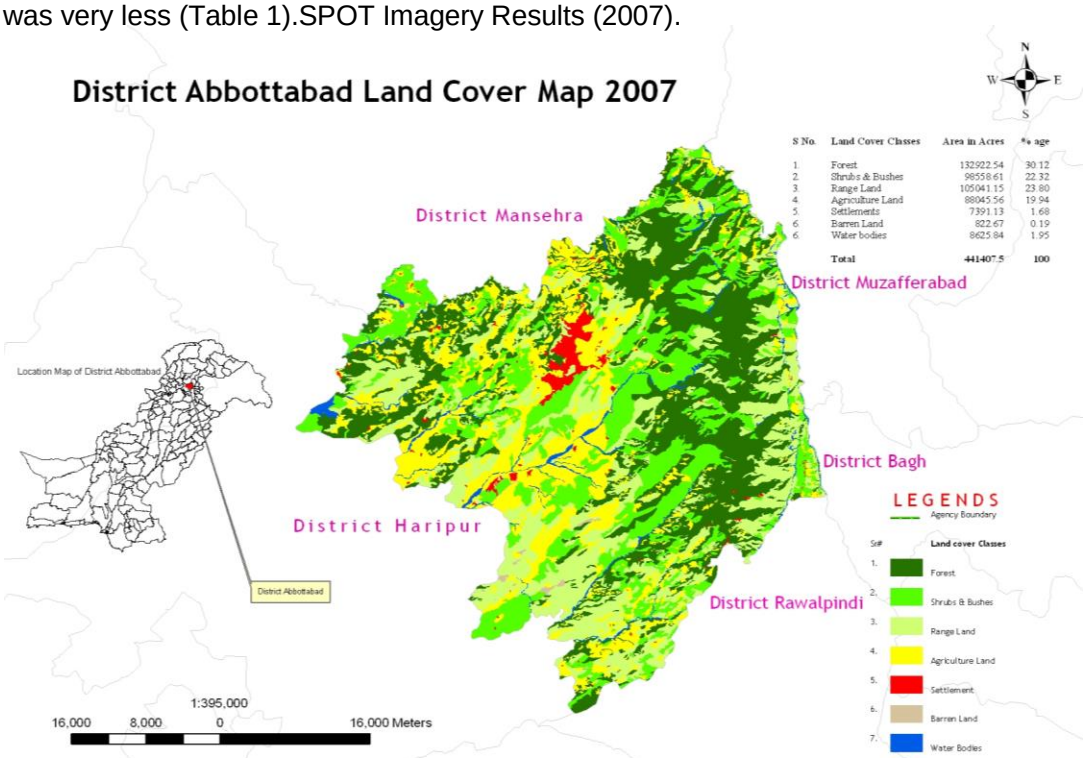

Figure 3. Land cover Map of District Abbottabad (2007)

For the assessment of forest change cover the authors of the present study classify the SPOT Imagery, 2007 into seven major land cover classes named forest, shrubs & bushes, rangelands, agricultural lands, settlements, barren lands and water bodies. The classification was based on visual interpretation method (Fig 2).

The details of area under each landcover along with its percentage are presented in table 2.

Table 2. Statistics of Landcover in District Abbotabad, 2007

S No.	Land Cover Classes	Area in Acres	% age
1.	Forest	132,922.54	30.12
2.	Shrubs & Bushes	98,558.61	22.32
3.	Range Land	105,041.15	23.80
4.	Agricultural Land	88,045.56	19.94
5.	Settlements	7,391.13	1.68
6.	Barren Land	822.67	0.19
7.	Water bodies	8,625.84	1.95
	Total	441,407.50	100

Source: Derived after the classification of 2007 image.

The total land cover area calculated was about 4,41,408 acres. Forest (30.12 %) was found to be the major land use followed by rangelands (23.80 %), shrubs & bushes (22.32 %) and agricultural land (19.94 %).The area under barren land, settlements and water bodies was very less.

Change Detection

The comparison of the land cover of PFRI study, 1998 and present analysis, 2007 are as follows (Table 3):

Table 3. Comparison of Land cover Change 1998-2007

Serial #	Land Cover Classes	Area (Acres)			Percentage (%)
		1998	2007	Change	
1.	Forest	89847.26	132922.54	43075.28 (+)	9.76 (+)
2.	Shrubs & Bushes	4403.89	98558.61	94154.72(+)	21.33 (+)
3.	Range Land	126372.18	105041.15	21331.03(-)	4.83 (-)
4.	Agricultural Land	213229.08	88045.56	125183.52(-)	28.34 (-)
5.	Settlements	3643.08	7391.13	3748.05(+)	0.85 (+)
6.	Barren Land	--------	822.67	---------	--------
7.	Waterbodies	3912.19	8625.84	4713.65(+)	1.07 (+)

(+) indicates an Increase (-) indicates a decrease
Source: After comparing 1998 and 2007 image

The change detection result shows that there is a considerable increase in land cover class Shrub & Bushes, followed by the land cover class Forests .It also indicates a considerable decrease in land cover class agriculture land, followed by

the Rangeland land cover class. A small increase in settlement area and water bodies was also observed.

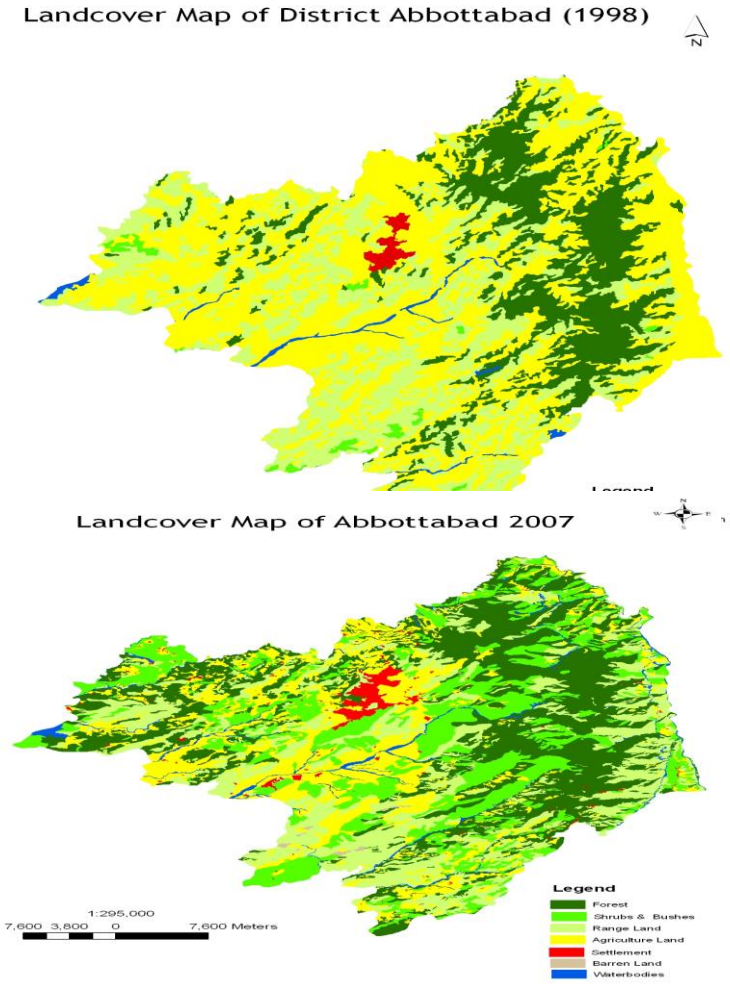

Figure 4. Landover Maps of District Abbottabad 998 and 2007

DISCUSSION

The results of the study are in consistence with PFRI study and the official (Government) reports for total area of the district as 176563 Hac. (4, 41,408 acres), 1,79,654 Hac. (4, 49,000 acres) and 178,401 Hac. (4,46,000 acres) respectively. The results of the study for various land covers are not in consistence with the other two reports. This may be due to faulty visual interpretation or difference of definitions of various land covers as made by technical (GIS/RS experts) and officials (Government) experts. The increase in forest cover area was due to the fact that forest department as well as the other environment related projects has carried out

mass plantation in the form of afforestation especially in Reserved Forest. Secondly, the people practicing agriculture in the forest area were pushed out resulting in reduction of agriculture area and increase in forest area.

It was also made possible through planting of fodder and fruit plants that the range area was decreasing and the area under shrubs and bushes was increasing. There was huge decrease in agriculture land cover since 1997 which shows that the visual interpretation by the PFRI, Project was not accurate. The visual interpretation of 1997 Image showed the agriculture land cover about 48 % of the total land area which is not possible in such a hilly terrain. However, the present interpretation of data is more realistic and authentic in terms of present land cover classification.

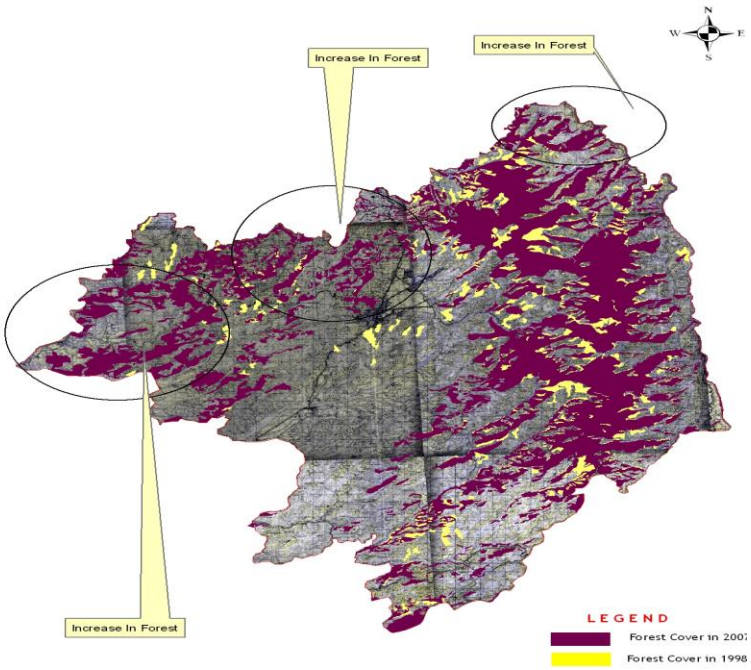

Figure 5. Change Detection in Forest of District Abbottabad

The subsetting and mosaicking of the baseline information with the images showed that the forest land cover was increasing in areas of Khand Khu, Dharam Pani, Bandi, Maira, Ghoran, Kana, bandiala and Sanjeela villages located in the vicinity of the Dhund Harroo river where mass afforestation programmes have been carried out by the projects and forest department in recent past, resulting in increased forest area.

FINDING AND CONCLUSIONS

Findings and conclusions has been drawn on the basis of study of land-use map. The following findings found during the study by comparison of two land-use map have duration of 10 years.

Forest

Forest area of District Abbottabad is increased in 2007 as compare to 1998. In 2005 a Huge and Deadly Earthquake hits the area and caused the heavy damage in the country especially in District Abbottabad. After the Earthquake the forest department planed to increase the forest area by plantation on reserved areas and Guzara Forest, so incredible increase in forest has been seen during the study.

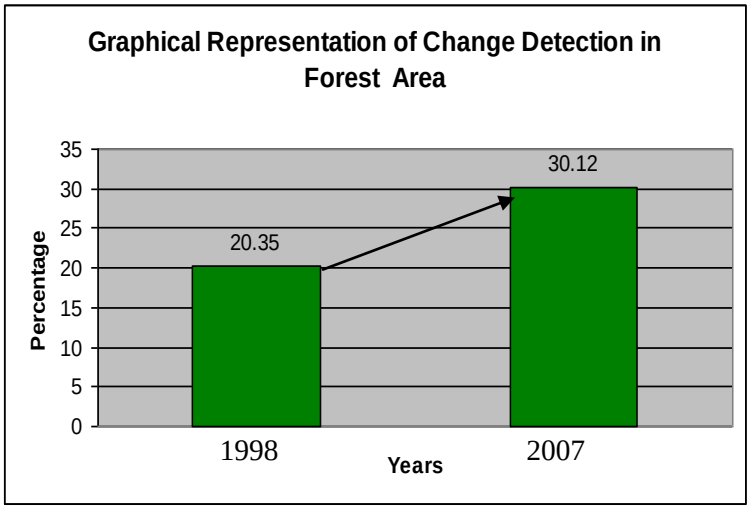

Figure 6. Landover Maps of District Abbottabad 1998 and 2007

Shrubs and bushes

Shrubs and Bushes are another feature which has increased during the 10 years tenure. The feature which is digitized as the shrubs and bushes in the image most of them are the young plantation which may convert into forest in upcoming years.

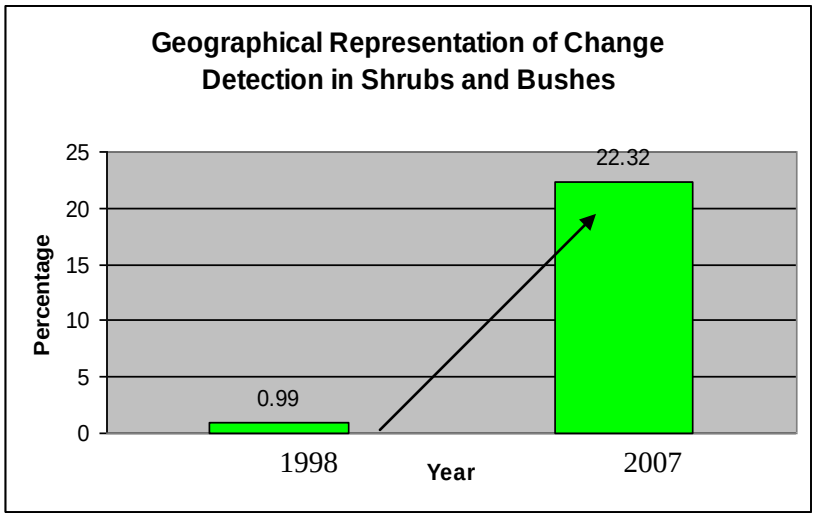

Figure 7. Shows the increase in Shrubs and Bushes

Range Land

The range areas have decreased because most of range areas are converted into the settled areas.

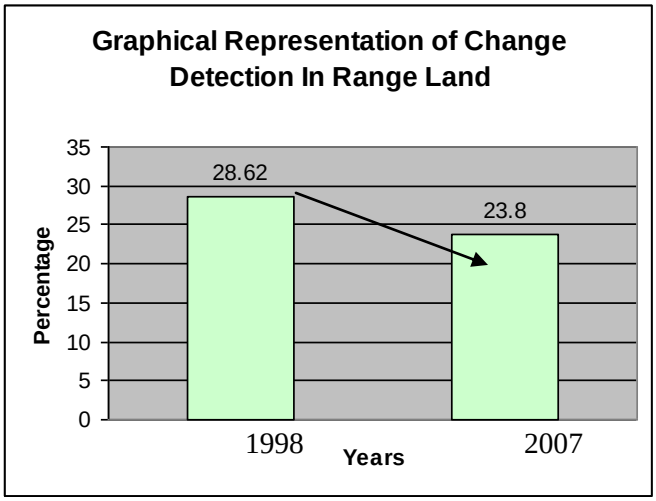

Figure 8. Shows the Decrease in Range land

Settlements

Habitations and settled areas are increasing day by day due to increase in population most of range lands which were marked in 1997 changed into settled area.

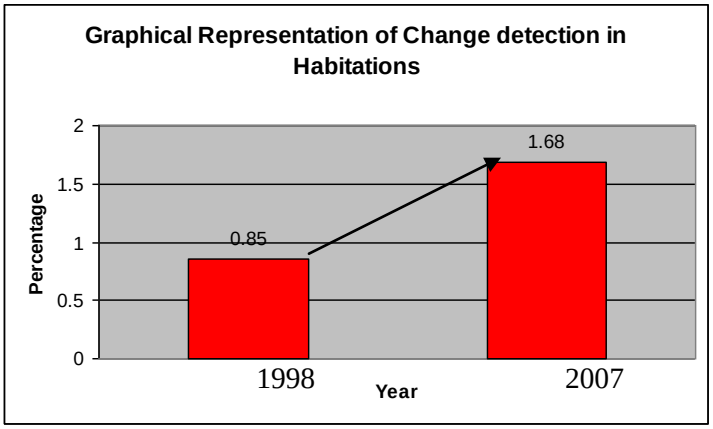

Figure 9. Shows the increase in Settled Area

Agriculture areas

Agriculture areas are decreased and most of them are converted into settled and other Features like shrubs & bushes and agro-forestry.

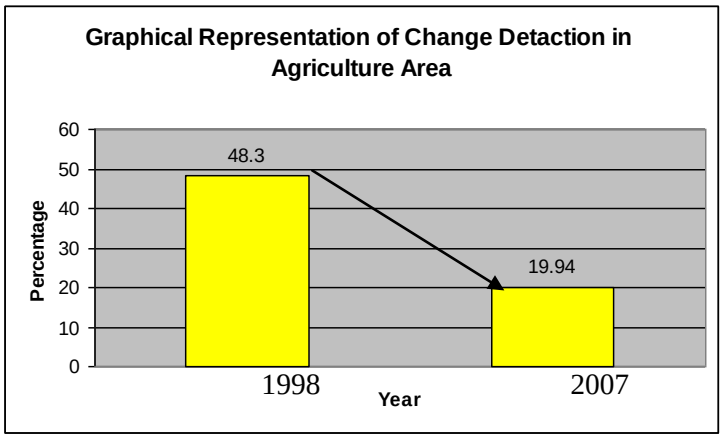

Figure 10. Shows the decrease in Agriculture

Water bodies

The water Bodies increased in 2007 map as compared to 1998 land cover area because after the earth quack most of mountain areas changed their places and Indus River found the places to flow.

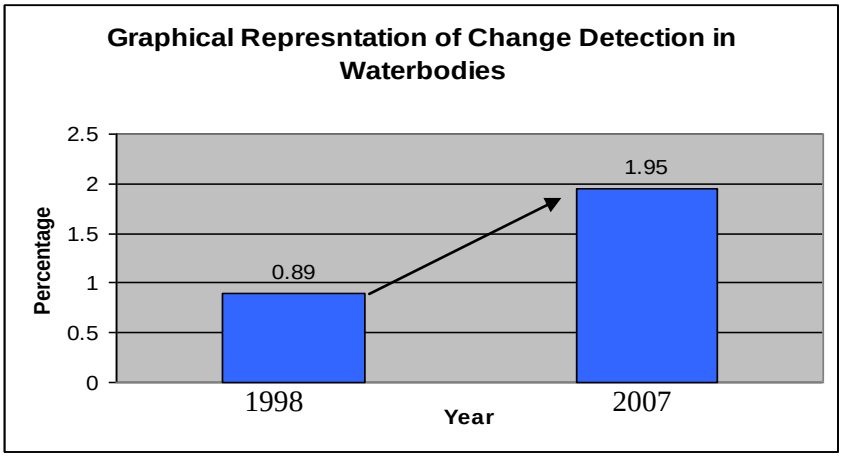

Figure 11. Shows the increase in water bodies

RECOMMENDATIONS

Although the Forest Department of Khyber Pakhtun Khwa has increased the forest area through plantations, Guzara Forest and private plantations but it is difficult to maintain the level. To avoid the misuse of forest the government has to provide facilities to the people like LPG and coal because people use the valuable forest wood as a fuel wood. One of the main problems which may cause the deforestation is illicit felling and wood smuggling.

1. Abottabad District, green cover in the period of 10 years is exemplary to other districts in order to raise forest cover through successive reforestation techniques. So, successive reforestation attempts should be focused in future.

2. The result of the study proved that use of techniques suited to the edaphic and climatic factors result in success. So reforestation in other parts of the country must be according to the edaphic and climatic factors.

3. Integrated natural resource management must be adopted in successive reforestation programmes.

4. Species must be indigenous and matched with the locality so that they could maintain indigenous ecosystem in that habitat, otherwise due to change in

species composition, it has been observed that habitat change occurs which results in disturbance of ecosystem. Ecosystem change undergoes adverse affect over environmental and climatic factors. So species composition in reforested area must be given importance in selection.

5. Area under observation can be protected by using control of wood extraction by department or local masses. So there must be strong legislation regarding extraction of wood by masses.

6. As reforestation programmes bears heavy expenditure so the best efforts should be focused to conserve the existing cover of forest.

7. For conserving the existing cover of forest, alternative means should be provided to masses e.g. Gas, Stoves, electricity on subsidized rates C.G.I. Sheets for construction of houses.

8. Illicit damage & Smuggling should be controlled by department in effective manner.

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