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Research Article

Application of Remote Sensing and GIS in Forest Cover Change in District Haripur, Pakistan

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ABSTRACT

Remote sensing & GIS datafrom satellite platformsoffer a best way to detect areas of deforestation and reforestation, and thus a spatial analysis based study was piloted in Haripur district, Punjab region. In forest management the impost of forest cover and its change is an essential issue, on the fashion to estimating the forest resource and its changes to support the decision makers that may ensure and conserve the resource. The aims of this study were to detect the change in forest extent over the last 10 years. Multi-temporal Landsat imageries of the 2007, 2012 and 2017 were used to prepare forest cover map in exacting and LULC maps in general. Post-classification comparison and normalized difference vegetation index (NDVI) were employed. Unsupervised image classification technique was applied on satellite images of 2007, 2012 and 2017 for LULC mapping. The results indicated fluctuating trends during the last 10 years in District Haripur, forest cover declined from 79763.324 ha in 2007 to 50971.866 ha in 2012 and forest cover amplified 69721.099 ha in the year 2017.The decrease was mainly due to socioeconomic factors like expansion of agricultural land, demand of fuel wood, construction materials and population growth.Some of the valuable tree species disappeared during the period 2007-2012 due to massive deforestation, reforestation occurred in 2013 and highlighted a positive feedback in 2017 forest cover map.Several vitalities have been made to standstill deforestation events. Therefore, in order to lessen the problem of deforestation, curative measures are suggested.

INTRODUCTION

For monitoring vegetation and forest remote sensing has been used for years. With the passage of time and advancement in techniques qualifies more accurate results in vegetation and land use land cover calculation. Hence, satellite based geospatial technology for monitoring land use land cover has become more trustworthy than ground based surveys and interpretation. Due to physical and environmental factors forest cover has been degrading in many parts of the world. Thus this is the necessity to constantly monitor the forest cover through available high resolution satellite data.Forest cover changes is a dynamicand accelerating processmainly compelled by anthropogenic activities, which ultimately impact natural ecosystem.Understanding forest outlines, patterns and coverage changes relations between anthropogenicand natural ecosystem are indispensable for proper forest administration, monitoringand future policy making.

Globally satellite data is available and useful for forest monitoring and forest change detection analysis.Forest biophysical and structural variables can empower accurate understanding of forest ecosystem. Remote sensing is applicable in many domain however, change detection and monitoring of forest cover is one of the main applications. Change detection is a procedure of pinpointing changes in the state of an object by discerning multi-temporal images (A.Singh, 1986).

Using specific spatial change detection algorithms we can detect changes from a set of multi-temporal images covering specific time period.Geospatial Technology has developed advanced techniques in different areas of applications, which can be addressed through decisions support tools such as remote sensing & GIS systems(ESCAP, 1996).

In Pakistan out of its total geographical area forest covers is only 4.8 million hectare(H.Lubna, 2001). Coniferous hill forests1.96 million hectare area which is about 43% of the total forest; foot

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hill forests or scrub 1.72 million hectare area which is about 37.2% of the total forest;irrigated plantations0.234 million hectare area;0.35 million hectare area is mangroves in the delta of Indus River; riverine and 0.297 million hectare area (I.A. Qazi, (1994). Forest mostly found in northern side of Pakistan 40% in Khyber Pakhtunkhwa, 15.7% in GilgitBaltistanand 6.5% in Azad Kashmir. In northern areas there are major three mountainous ranges Korakoram, Hindukush and Himalayas which is almost loaded with forest .Scrub and coniferous forests are mostly found in the upper slopes of district Dir, Swat, Mansehra and Chitral, alpine forest mostly found at the ridges(A.Sajjadet al., 2015).

Forest plays a vital role in our sustainable ecosystem also provides services and goods including folder, nutrientcycle, shelter, cultural and re-creation values. Forest recovers land degradation and desertification and helps in providing haunt for wildlife (UNFCCC, 2007).In the rural livelihood Trees and forest resources have a vital role. People aredependent on forest resourcesfuel wood for fire and wood for houses construction. Additionally local people gather various NTFPs from forests for household use and cash income (S.R.Khan, and A.Naqvi, 2000). United Nations Framework Convention on Climate Change (UNFCCC, 2007),dispensed the main root of deforestation was agriculture. Remote sensing and GIS becoming very popular since1970s, because of tools for resources monitoring, detection of the change evaluation and planning on forest globally or locally (Erika et al., 2005). Spatial modelling and analysis are gaining mass momentum in recent years. Majority of stakeholders are interested in natural resources geospatial analysis based on remote sensing and GIS data.Professionals in forest cover changeand urban planninginsinuationis now getting considerationof Remote Sensing and GIS analysis.

The Haripur District covers area of about 189143.0057582ha. its upper parts contain moist temperate forest, middle have chir zone , still lower parts fall in sub- tropical broad leaved zone, while areas adjacent to Punjab has tropical vegetation.In 1959 Haripur Forest Division was established and consisting of the following fivesub- divisions/ Ranges. One of Pakistan's greenest provinces is becoming greener still: in last 3 years, Khyber Pakhtunkhwa has added three-quarters of a billion new trees, as part of a "tree tsunami" aimed at reversing deteriorating forest cover loss in District Haripur. The objectives of the study was to 1) Mapping LULC for different classes of land use and land cover; 2) limit the trend, and extent of forest cover change; and 3) prepare maps of forest cover change of different time periods in District Haripur.

MATERIALS AND METHOD

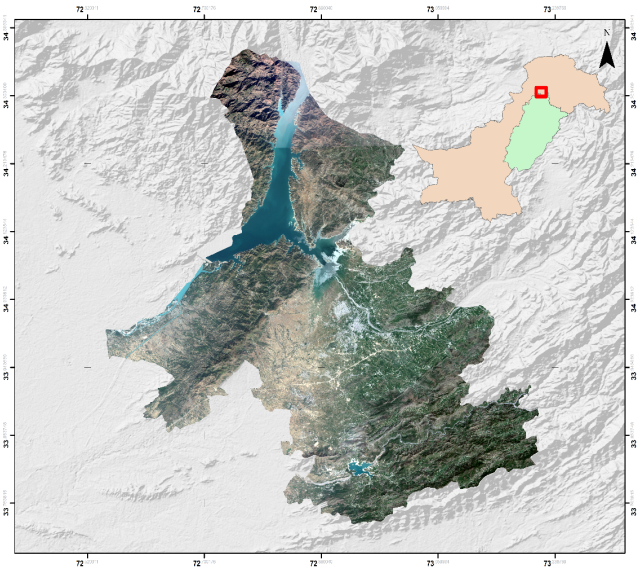
Study Area

The Haripur District covers area of about 189143 ha Fig. 1. It has unique diversity as its upper parts contain moist temperate forest, middle have chir zone , still lower parts fall in sub-tropical broad leaved zone, while areas adjacent to Punjab has tropical vegetation.

Haripur Forest Division was created in 1959 and consisting of the following sub- divisions/ Ranges.

- Haripur Forest Sub-Division
- Khanpur Forest Sub-Division
- Ghazi Forest Sub-Division
- Satora Forest Range
- Makhnial Forest Sub-Division

Figure 1: Study Area District Haripur, Pakistan.



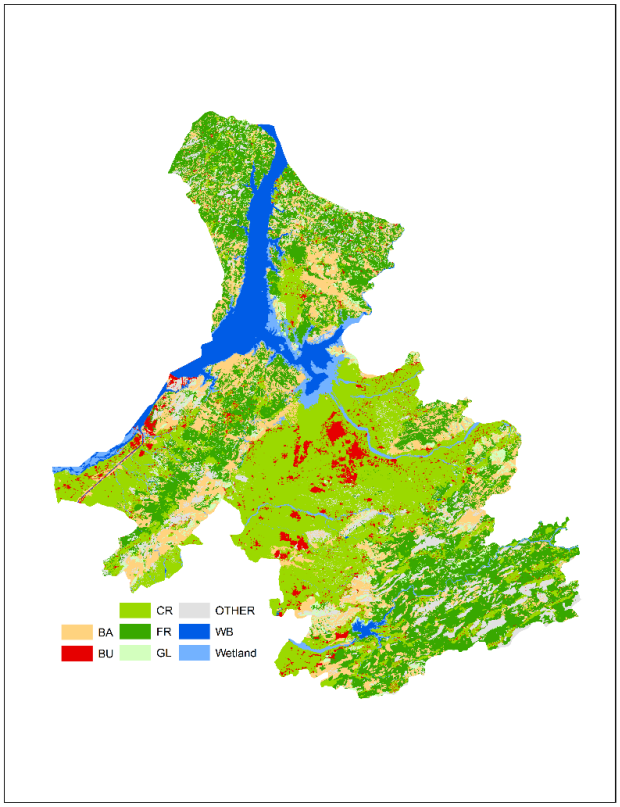
Data Used

In this study, for change detection over a period of time multi-temporal satellite imagesused include Landsat of three time periods i.e.2007, 2012 and 2017 were downloaded from United State of Geological Survey website (http://glovis.usgs.gov/). Radiometric and geometric corrections were applied to the images.

LULC Cover Map

Unsupervised classification was used to produce LULC map using the multi-temporal images 2007, 2012 and 2017 (geo-referenced in UTM projection zone 42, WGS84 ref. ellipsoid). Iterative self-organizing data analysis (Iso-data) algorithm classification technique was executed in each satellite image. The data pre-processing involves mining of study area, radiometric and geometric corrections. Eight land use land cover classes weremapped:bareland(BA),water(WB),forest(FR),grassland(GL), wetland,other,cropland (CR),built-up (BU).Land use land cover map of study area is shown in Fig.2

Figure 2: Study Area District Haripur LULC map.



NDVI differencing Change Detection

Normalized Difference Vegetation Index is actually a non-linear transformation of the near infra-red band and redbands of satellite imagery data. Chlorophyll absorbed in the red region and the strong reflectance of the near infra-red region of the (EM) electromagnetic spectrum. The NDVI index is symbolized by the equation:

$$NDVI = (NIR - R)/ (NIR + R)$$

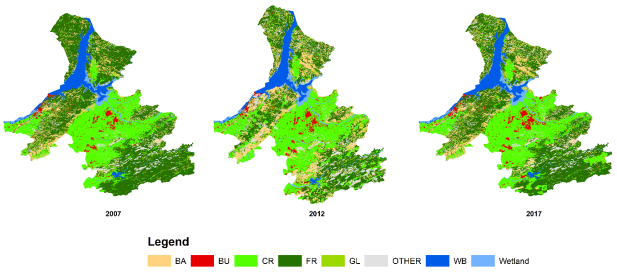
For relative measure for monitoring biomass NDVI index is very useful. This indices is used to discriminate healthy vegetation from other or non-vegetative cover by using red and infra-red band values.NDVI values thresholds between -1 to +1 positive sides shows more greenness in pixel value. From equation NIR measured values from near infra-red band of images and R measured values from Red band.

RESULTS AND DISCUSSION

Analysis of LULC Area Change

Satellite images were classified in to major eight classes of Wetland, Water (WB) ,Cropland (CR),Grass land (GL),Forest (FR),Others, Settlement (BU), Bare land (BA). Land use land cover change statistics were calculated and potted in (Table 1) to detect the change in LULC on the years 2007, 2012 and 2017. The dominant land use changes can be seen in tabular data, unplanned urban growth and population cause an instability in ecosystem. LULC changes described in pixel format because each pixel contain some DN which define LULC class after image classification. Temporal classified map is shown in Fig 3.

Figure 3: Land Use/Land Cover maps for the years 2007, 2012, and 2017.



Cropland is dominant land use in this district after forest class. In 2007 cropland covers 56684.840 ha, forest covers 79763.324 ha which include, bushes, shrubs and tree species, settlement covers 5683.700 ha .There is a decreasing trend of forest class from 79763.32 ha to 69721.099 ha in 2012 from base data 2007, which is about 36%.built-up class have a inclined trend due to population growth and to incorporate the increasing demand of urban population. From 2012-2017 built-up still have an incremental trend about 2% and total change in percentage is 19% from 2007-2017.Bareland is increasing due to deforestation, actually forest cover first convert to barren land then it can be used in any purpose like for cropping or built-up. There are fluctuating trends in District Haripur form 20007-2017.there is a transition phase when government took a decision to retrieve forest ,they stated a billion tree marathon to convert available land into forest cover. Water class is almost constant in all years, because water level and quantity based on seasonal variation and other environmental situations.

Table 1: Classification matrix of study area from 20072017 (ha).

Class	Area (ha)			Change in Area (ha)		Change in Area (%)			
	2007	2012	2017	2007-2012	2012-2017	2007-2017	2007-2012	2012-2017	2007-2017
Water	13188.890	12861.065	13040.6527	-327.8	179.6	-148.2	-2%	1%	-1%
Barren	15863.146	29161.023	19266.060	13297.9	-9895.0	3402.9	84%	-34%	18%
Grassland	4652.811	6826.999	5245.833	2174.2	-1581.2	593.0	47%	-23%	11%
Cropland	56684.840	62063.591	58897.900	5378.8	-3165.7	2213.1	9%	-5%	4%
Built-up	5683.700	6877.238	7014.383	1193.5	137.1	1330.7	21%	2%	19%

Wetland	6333.765	7664.916	6782.242	1331.2	-882.7	448.5	21%	-12%	7%
Forest	79763.324	50971.866	69721.099	-28791.5	18749.2	-10042.2	-36%	37%	-14%
Others	7401.0522	12716.303	9175.610	5315.3	-3540.7	1774.6	72%	-28%	19%

Analysis and Interpretation of NDVI

The processed satellite data put to (NDVI) Normalized Differential Vegetation Index analysis to extract valuable information.NDVI gives the vegetation cover of study area, and distinguished the vegetative cover form non vegetative cover based on threshold values.NDVI calculated form multi-temporal images of years 2007, 2012 and 2017.NDVI ranges between -1 to +1 results obtained are classified based on ranges. Range 0.3-0.5 indicate moderate vegetation i.e. bushes and small tress.0.5-0.7 indicates dense vegetation.0.7 and above indicate very high density of vegetation.in District Haripur proportion of Forest and Cropland are almost equal .ranges are defined very accurate to discriminate cropland from forest. Forest change detection is carried out for the time span of 10 years which is very optimal for forest cover monitoring. The imagery yielded the increasing and decreasing trend of forest cover in study area.

Forest Classification Accuracy

Classification accuracies results , obtained from multi-temporal Landsat satellite images for the years 2007, 2012 and 2017 fluctuated from 84% to 92%, with Kappa coefficients fluctuating from 0.81 to 0.90 (Table 2). Landsat image 2012 showed the maximum accuracy, of about 94.24% of the pixels were classified correctly as forest class. Lowest accuracy values obtained 89.12%, 84.65% for the years 2007 and 2017 respectively. Actually unsupervised classification was applied which based on spectral values so, lower values could be ascribed to high spectral resemblances between cropland (e.g., maize and soybean plantations) and forest area.

Table 2: Total forest cover of 2007, 2012 and 2017 (ha) and percentage.

Time Period	Kappa	Overall	User accuracy	Producer Accuracy
2007	0.85	89.12%	88.32%	88.45%
2012	0.9	92.24%	93.74%	91.51%
2017	0.81	84.65%	85.62%	84.31%

Areal Extent and Forest Cover Change

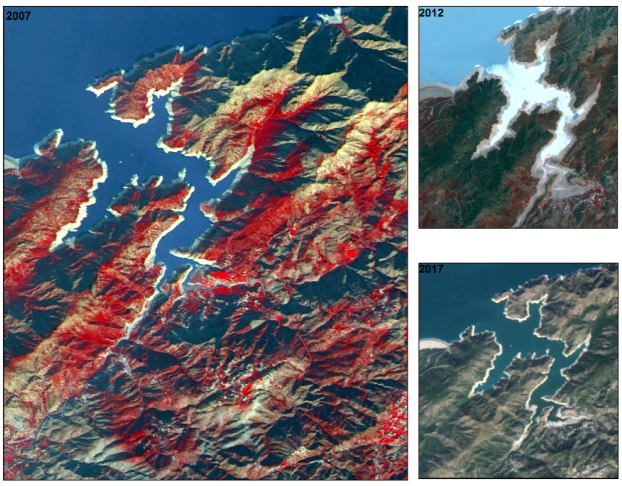
Temporal Landsat satellite images of 2007, 2012 and 2017 were used to observe the areal extent and forest cover change within time series. Image interpretation of forest cover area was performed throughout the years and results were calculated in hectors and in percentage andsummarized. Total forest cover of 2007, 2012 and 2017 is presented in Table 3. There is a dark time for forest from 2007-2012 forest area accounted for 79763.32 ha and 50971.866 ha in 2007 and 2012 respectively.

Table 3: Total forest cover of 2007, 2012 and 2017 (ha) and percentage.

Year	Forest Cover unit from the total area (ha)	Forest Cover in %
2007	79763.324	42%
2012	50971.866	27%
2017	69721.099	37%

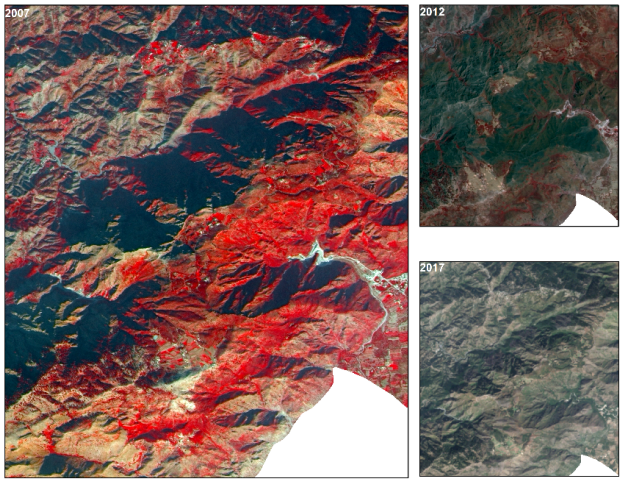
Forest experience a most negative change between 2007-2012, forest have been highly depleted over the period due to unplanned urban growth and timber mafia. Wood fuel is used in massive quantity which ultimately leads toward deforestation in this area, 42% forest was in 2007 which depleted to 27%.The conversion of forest land to agricultural land proceeds the lion share to meet the increased demand of food for rapidly growing population.

Fig 4: Forest Cover comparison maps for the years 2007, 2012, and 2017.



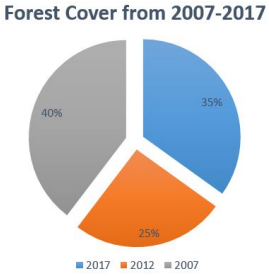
In Fig 4 shows that in 2007 image along water body there was a bunch of dense forest which cut down in 2012 image and land is converted into barren land.one more comparison can be seen in Fig 5. Forest is almost vanished in these parts. Rate of change of forest was very threatening.

Fig 5: Forest Cover comparison maps for the years 2007, 2012, and 2017.



Majority of valuable tree species vanished due to rapid deforestation. There was an alarming situation in this region stakeholders and government took initiative to plant a forest again in this region, for that they started a "The Billion Tree Tsunami" project. There is actually a transition zone from 2012-2017, in 2013 government started a plantation marathon and the success on the ground is now phenomenal.It aims to turn around deforestation and increase the province's forested area and in 2017 results shows increased in forest cover, and rates of deforestation decreased gradually from 27% to 37%.

Fig 5: Forest Cover graph for the years 2007, 2012, and 2017



From worst condition to sustainable condition it took 2-3 years more but things are going to improvement for this area. In preparation for the reforestation skirmish, the provincial government helped set up a network of tree nurseries athwart the province in 2016, providing loans and purchase agreements for tree saplings. This is not just about planting trees but about changing attitudes. In 2017 image forest can be seen clearly in majority of deforestation parts. Deforestation befallen mainly due to anthropogenic activates in this area to compensate the daily necessities like fuel wood, house construction. Now deforestation is going to decrease which ultimately turned to dense forest in future. From 2007 position which was 42% Haripur District is now in the limelight phase and current results extracted from satellite imagery 2017 is about 37% which is considerable change in forest cover.

CONCLUSION

The association between the forest covers and its allied LULC classes were reconnoitered and spatial maps were developed, and identified main LULC classes in study area are barren land, built-up, cropland, forest, grassland, wetland, water and others. For the development of human life forest management and conservation is very important. However, deforestation is a major environmental delinquent revealed at District Haripur. It was observed that forest cover has changed abnormally from the period 2007-2012, due to anthropogenic activities forest loss was observed but these were not scrutinized. Haripur District forest resources declined by 79763.32 ha to 50971.866 ha between 2007 and 2012. Increased demand of agriculture land to meet the food requirement of increasing population was the cause of forest cover change. Timber mafia, demand for fire wood, Charcoal production, alarming rate of population growth leads to further depletion of forest resources in the area. Forest cover in particular and other LULC in general observed deeply that it was drastically changed from 2007-2012. Transition phase occurred in 2013 when government took initiative to replant a forest in District Haripur. Reforestation started in 2013 and after four years forest cover is showing incremental results.in 2017 forest cover is about 69721.199 ha although it is not same as it was in 2007 but now it's about 37% of District Haripur. Fluctuating values showed forest cover percentage 42%, 27% and 37% for the respective years of 2007, 2012 and 2017.

Hence, to preserve forest cover from further depletion, farmers should be heartened to plant fast growing plant species on their farm land boundaries, degraded lands and stop cutting existing forest. Government should introduced fuel saving stoves instead of using forest wood as fuel for house hold use. Other construction material should be introduced rather to use forest wood as construction material. Proper awareness and optimum utilization of forest resources to concerned departments and farmers could play a significant role in rehabilitation of reforestation and minimizing of further anthropogenic and environmental degradation.

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