



Implications of changing land cover dynamics for restoration activities in Pir Panjal Hills

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Abstract

Ecological reforestation and refurbishment activities in regards to deforestation are enormous environmental concern across globe, particularly in Pakistan, where forest resources are deteriorating at threshold level for last decades. In order to determine the status of forested land, accurate information on Land Use/ Land Cover (LULC) classes is pre-requisite that could be achieved using geospatial tools. Thereby, current study was intended towards the analysis of forested area in Murree Tehsil of Pir Panjal hills, one of the region targeted by Punjab Forest Department (PFD) for ecological restoration. Supervised Maximum Likelihood Classification method was applied to generate LULC maps for years 2000, 2008 and 2014 utilizing SPOT (2 & 5) satellite sensors. Five LULC classes were mapped i.e., forest, lower vegetation, bare soil, water and settlements. Research findings illustrated 62% decrease in lower vegetation class whereas, acceleration in forest and settlement class has been observed. Amelioration in forest class was primarily attributed to the efforts of PFD and non- governmental organizations (NGOs). Nonetheless, efficacious and methodical approach is needed for sustainable management of forests and other natural resources and it can be ensured by strengthening the capacity building of stakeholders.

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Introduction

Forested areas are depleting worldwide at a distressing rate because of excessive land clearing for commercial and cultivation practices (Khalid *et al.*, 2018; Hansen *et al.*, 2013). Around 13 to 15 thousand square kilometers of forest covered areas is losing every year (Chakravarty *et al.*, 2012). Universally, accelerating population pressure, unawareness and conventional agriculture methods, improper land use planning, timber mafia and environmental disasters are contributing towards degradation of forest resources (Keenan *et al.*, 2015).

In accordance with the alarming situation of deforestation, many initiatives have been taken globally for reforestation activities while scientists and researchers are deliberately working on forest cover analysis. A comprehensive and detailed analysis of land use and forest cover dynamics are required in order to obtain the sustainable management of natural resources (Bayramoğlu and Kadioğulları, 2018). Copious studies substantiate the capability of integrating remote sensor data with computational data for studying trends of land cover with better understanding and accuracy. In Turkey, Geographic Information System (GIS) based forest cover analysis was carried out in Bartın region through utilization of Landsat 5 Thematic Mapper (TM) Sensor imagery and results showed drastic decrease in forested area while significant expansion in agricultural land (Ateşoğlu & Tunay, 2010). Additionally, in Kenya over a time frame of twenty years, forest cover and its susceptibility towards the land use change was assessed temporally and spatially through GIS and Remote sensing (RS) (Wachiye *et al.*, 2013).

Pakistan is also among those countries where forested lands are degraded and exploited at a threshold level. In regard to it, various studies are conducted in Pakistan by utilizing the application of GIS and RS for analyzing the trends in Land Use Land cover changes (LULC). Thematic maps were prepared in order to draw the attention of stakeholders towards the threatened coniferous tree species in Pakistan (Ahmed *et al.*, 2012). Moreover, another study was

carried out on visualizing the harmful impacts of climate change on forest cover in Margalla Hills National Park through RS application (Khalid *et al.*, 2015). Consequently, current study is concerned with evaluating the landcover status of four union councils of Murree Tehsil with a purpose to provide meaningful and significant information on sustaining ecotourism in a particular area. The aim of the study is to delineate and map major LULC classes in the area under study by employing remote sensing data during fourteen years (2000 to 2014) time frame.

Materials and methods

Study Area

Murree tehsil comprised of ecological and economically significant Chir Pine and Blue Pine forest. Besides being chief source of fuel wood and timber and aesthetic importance, they are also a part of significant watershed area. Murree Forest Division (MFD) is an essential part of Murree Tehsil with six administrative units i.e. Four Forest sub divisions of Ghora Gali, Sambli, Lower Topa and Sehr Bagla and two Forest ranges comprising Ban and Municipal Forest. Murree tehsil comprise of around 20000 hectares (ha) area of forested land. Murree Tehsil comprises Charhan, Murree urban, Potha Sharif, Angoori, Dewal, Sehrbagla, Ghoragali, Ghel, Mosyari, Nambal, Phagwar, Daryagali, Rawat, and Tret (WWF, 2013). Present study recognized the LULC status of four Union Councils of Murree Tehsil i.e. Ghora Gali, Tret, Dewal and Rawat over period of fourteen years by integrating GIS and RS applications (Fig. 1).

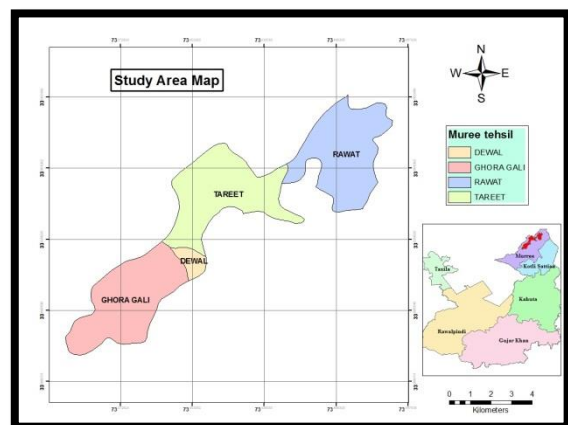


Fig. 1. Study Area Map showing four Union Councils of Murree Tehsil.

Methodology

Data acquired for conducting the present study was grouped into two classes: Satellite data and Ancillary data. Satellite data encompassed SPOT 2 (20 meter (m)) resolution imagery for the year 2000, while for analyzing the LULC change for years 2008 and 2014, SPOT 5 imagery of 10m resolution was attained through SUPARCO, Islamabad.

In the present study, data obtained from Forest Complex Rawalpindi and District Forest Office Jhika Gali were used as ancillary data sources. After data acquisition, images were initially added to ERDAS IMAGINE 9.1 software and then assigned projection of WGS 1984 and then finally subset the images in order to eliminate areas outside the study area to perform classification.

This was followed by Maximum Likelihood (ML) Supervised Classification technique in which per-pixel signatures were taken for each LULC class and stored in form of signature files whereas the raw digital numbers for each pixel in the scene were accordingly converted to radiance values.

After classification, accuracy assessment and post classification processing was done and area for each class was calculated. The area covered by every class

was then summed up to obtain total area under study. Furthermore, the percentage area covered by every class was calculated by a formula. Five main LULC classes were generated as a result of classification as mentioned in Table 1.

Table 1. Classes delineated on the basis of Supervised Classification.

Sr. No	Class Name	Class Description	Signature color
1	Forest	The Chir Pine Subtropical Forests and Moist Temperate Coniferous Forests	Dark Green
2	Vegetation	Grassland, Shrubs and Rangelands	Light Green
3	Barren Land	Bare Soil and Uncultivated land	Yellow
4	Water	Watershed, Springs, rivers, lakes and streams	Blue
5	Settlements	Commercial and Residential area and road network	Red

$$\text{Percentage Area Coverage of a class} = \frac{\text{area of the class (ha)}}{\text{total area}} \times 100$$

Consequently, different LULC maps were generated for respective years (2000, 2008 and 2014). Additionally, calculation of the percentage change occurred in every class in fourteen years was done by using following formula

$$\text{Percentage Change} = \frac{a-b}{b} \times 100$$

Where a= area of latest year, b= area of the previous year, on the basis of which overlay maps were generated.

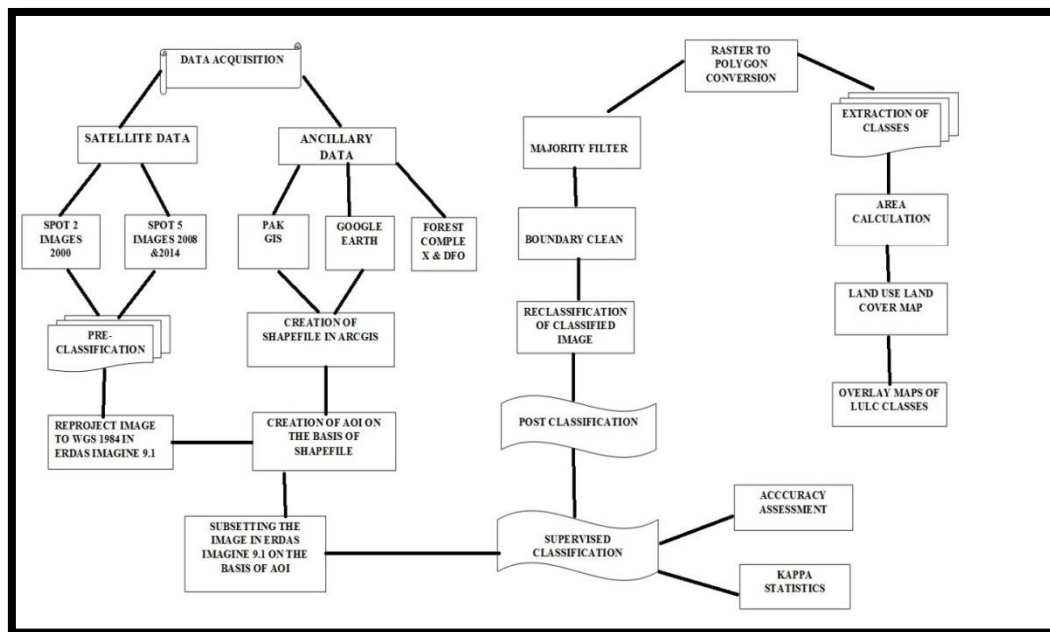


Fig. 2. Flowsheet of Methodology adopted in study.

Results and discussion

Results congregated by execution of the aforesaid methodology were classified into three sets i.e. Image classification, Accuracy Assessment and Observed LULC changes. Accuracy assessment was performed in ERDAS imagine 9.1 for classification results and

high rate of classification accuracy (93%, 91% and 92%) was acquired. The overall Kappa statistics achieved were 0.8145, 0.7504 and 0.7795 respectively for the years 2000, 2008 and 2014 respectively. Approximately 4191 ha of area was covered by LULC classes in Murree Tehsil presented in Table 2.

Table 2. Area statistics and percentage change in area of land-use classes in Murree Tehsil from 2000-2014.

Land Use/ Cover classes	2000		2008		2014		Percent Change		
	Area(ha)	Area (%)	Area(ha)	Area (%)	Area(ha)	Area (%)	2000-2008 (%)	2008-2014 (%)	2000-2014 (%)
Coniferous Forests	469.05	11	618.43	15	715.07	17	+32	+16	+52
Lower Vegetation	1702.09	41	918.43	22	635.98	15	-46	-31	-62
Water	896.47	21	177.42	4	537.10	13	-80	+66	-40
Settlements	272.41	7	1921.50	46	1370.88	33	+85	-28	+80
Bare Soil	849.03	20	555.62	13	932.13	22	-34	+67	+9.7
Total	4189.06	100	4191.40	100	4191.17	100			

Back in year 2000, the major portion of Study Area was occupied by lower vegetation accounting 41% ((1702.09 ha) of the total land (Table 2). Water was the second major class encompassing 896.48 ha (21%) of the Land cover including springs, lakes and rivers present in Murree Tehsil. Third major class was that of Bare Soil cover comprising 849.03ha (20%) of the Land (Table 2). Coniferous Forest class covered 469.05 ha (11%) of the Land while the remaining 272.41ha (7%) of the area was covered by Settlements. According to the results obtained from the Land cover /Land use map of Murree Tehsil 2008, Settlements increased over eight years and emerged as major class of Murree Tehsil in 2008 covering 1921.50ha (46%) of the Land. Lower Vegetation was the second major class encompassing 918.43ha (22%) of the Land cover. Third major class was that of Coniferous Forest comprising 618.43ha (15%) of the Land. Bare Soil and Water area had decreased over eight years and covered an area of 555.62(13%) and 177.42(4%). Settlements increased over fourteen years and again emerged as major class of Murree Tehsil in 2014 covering 1370.88ha (33%) of the Land. Barren soil was the second major class encompassing 932.13 (22%) of the Land cover. Third major class was again of Forest that showed increase over fourteen years comprising 715.07ha (17%) of the Land. Lower Vegetation has decreased over fourteen years and

covered an area of 635.98 (15%) while remaining area was covered by Water that increased after 2008 and covered 537.10 (13%) of the Land. Fig. 3 shows the comparison of different delineated classes for years 2000, 2008 and 2014 respectively. During the Fourteen-year time period union councils have witnessed substantial variations in main categories of Land classes. In reference to Lower Vegetation and Water region, dwindling was observed while inclination was observed in case of Bare Soil, Coniferous Forest and builded areas.

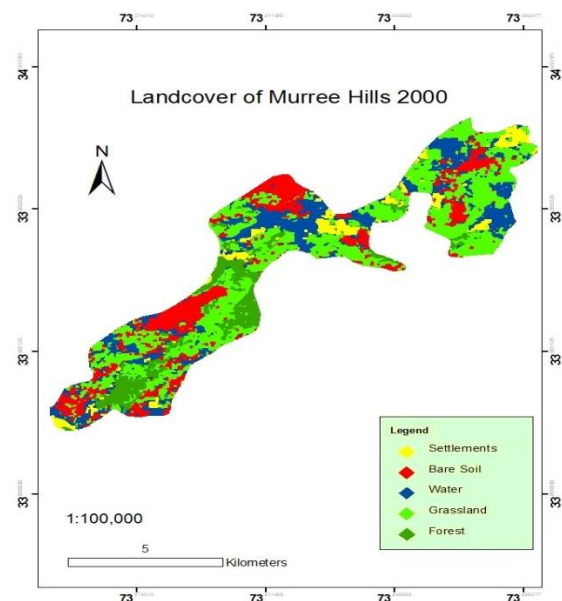


Fig. 3a). Landcover/ Landuse map of Murree Tehsil in 2000.

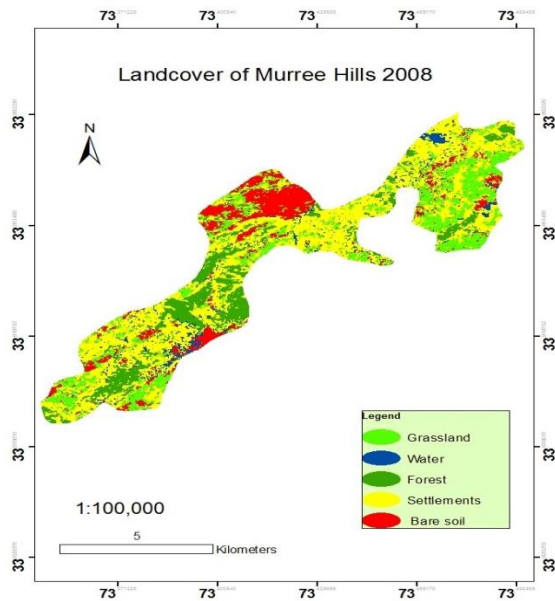


Fig. 3b). Land cover/ Land use map of Murree Tehsil in 2008.

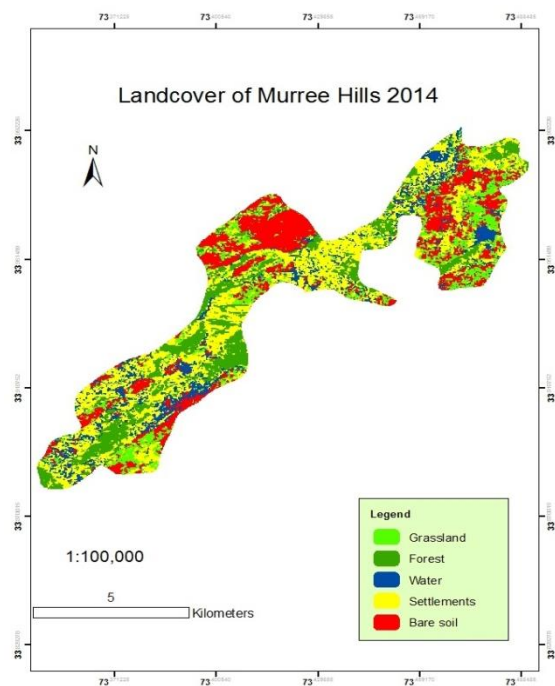


Fig. 3c). Landcover/ Landuse map of Murree Tehsil in 2014.

Coniferous Forest change

Coniferous forests are dominant forest reserve constituting approximately 41% of the total forested area of Pakistan (Nazir and Ahmad., 2018) and are exposed to ample physiographic contrasts and climatic variations. Excessive harvesting of fuel wood and timber and population expansion pose great

stress to the coniferous forest. Mostly conifer forests are located in Khyber Pakhtun Khwa (KPK), Northern Areas, Baluchistan, Azad Jammu and Kashmir (AJK) and northern Punjab of Pakistan having altitude between 1000 to 4000 meters. Considering their ecological and social importance, present study was primarily engrossed on the coniferous forests of Murree Tehsil utilizing SPOT satellite imagery. Aforementioned study showed amplification in coniferous forest cover since last years as shown in Fig. 4.

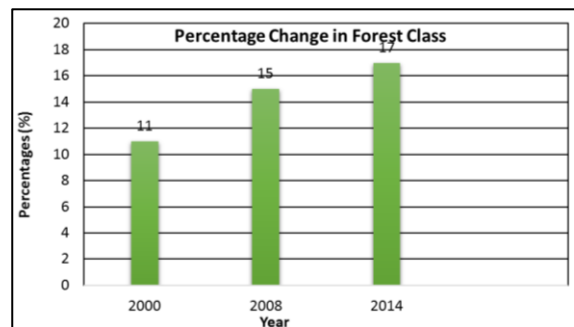


Fig. 4. Percentage of Land covered by Coniferous forests in year 2000, 2008 and 2014.

Coniferous forest encompasses 17% of the total land area in 2014 whereas back in 2000 and 2008, coniferous forest area was 11% and 15% respectively of the total area under study. Increased plantation of Chir pine and Blue pine trees in Murree Forest Division results in unpredictable increase in forested area illustrated in Fig. 4 and 5, and table 3.

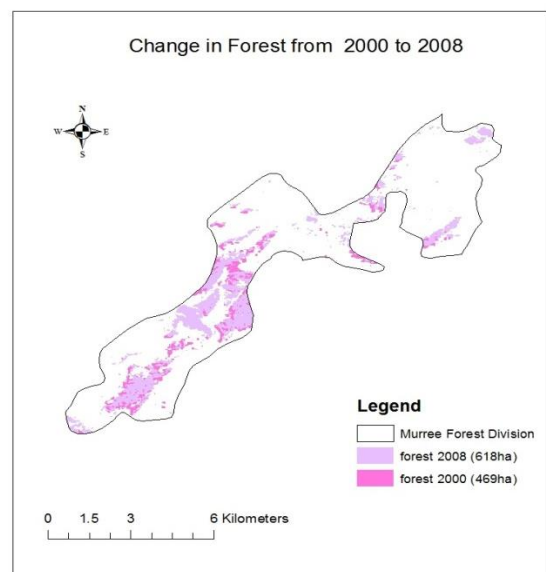


Fig. 5a). Trend of forest cover in years 2000 and 2008.

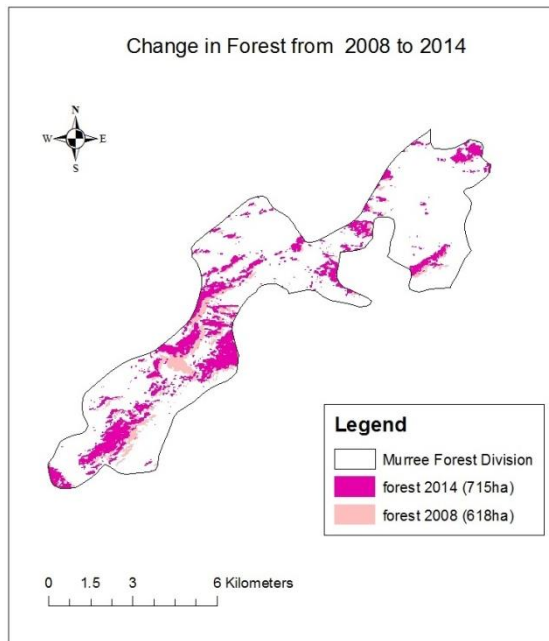


Fig. 5b). Trend of forest cover in years 2008 and 2014.

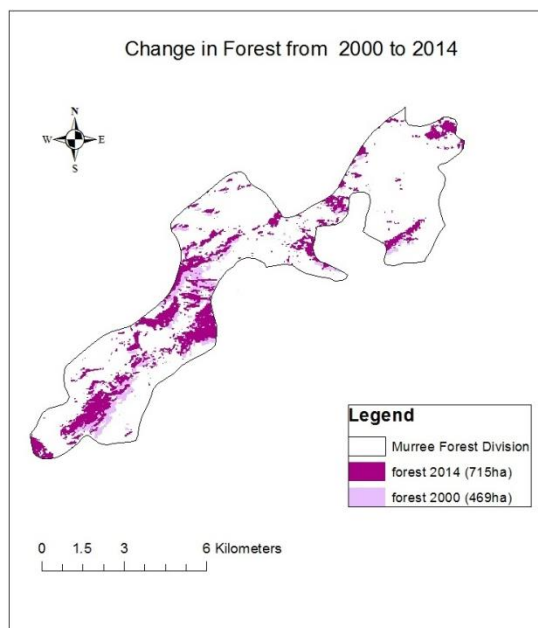


Fig. 5c). Trend of forest cover in years 2000 and 2014.

Since 2005, approximately 3034.5 ha of land was planted and 51 plantation sites were constructed by WWF and Punjab Forest Department (PFD). Another reason of increased forested area was the availability of gas pipelines in the area that reduces the tree cutting activities (WWF, 2013). Aforementioned results are in accordance with the results of another study that confirmed the afforestation and reforestation activities around Pakistan. These activities result in forest restoration at rate of 6600 ha

per annum. Punjab province showed 34 kilo hectares (kha) of total coniferous forested area in 2001 while in 2010, it has increased to 41 kilo hectares (kha) whereas in province of KPK 5000 ha of forested land has increased since 2001 (Ahmed *et al.*, 2010).

Conclusion

LULC map of four union councils of Murree Tehsil utilizing supervised maximum likelihood classification technique depicted marked changes over fourteen years (2000-2014). Coniferous forests shown 52% increase in cover area whereas partial transformation of lower vegetation and water class to settlements has been indicated. Commercial projects for escalating tourism industry results in degrading grasslands and water resource depletion in Pir Panjal Hills. Though recuperation of forest resources has been attained through collaboration of PFD with NGOs but still establishment of legitimate, political and economic reforms in environmental sector is needed. Moreover, correlation and interdependency of different LULC classes should be kept in mind while devising ecological reforms.

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