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LANDCOVER DYNAMICS IN RELATION TO WESTERN TRAGOPAN OCCURRENCE IN PAKISTAN: A REGIONAL ASSESSMENT

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Abstract

In order to establish relationship between landcover dynamics, human demography and western tragopan abundance in Pakistan, a regional scale landcover map consisting of categories Glaciers, Pastures, Conifers, Broadleaves, Shrubs and Built-up/agriculture classes was prepared using ISODATA clustering of MODIS 16-day composite images (MOD13Q1) for year 2011. Subsequently, time series-analysis of ten years' MOD13Q1 data (Feb. 2000 – Feb. 2011) was performed using STL procedure to infer landcover dynamics (progressive, stable and regressive trends). From these data, various landcover metrics and ratios were calculated to compare sub-regions using principal component analysis (PCA). Pearson correlation was then calculated among PCA scores, human population and tragopan abundance to provide a multi-criteria habitat evaluation. The tragopan reported sites were found to have minimum landcover disturbance i.e., both regressive and progressive landcover locations seem to negatively affect the tragopan abundance. The progressive trends are mainly attributed to the human influence and were recorded mainly for the Built-up/agriculture landcover types. Most of the regressive trends were observed in high coniferous landcover that form the core habitat of the western tragopan and also seem to be mainly anthropogenic. Thus the human population had both positive and negative impact on the landcover that in general was found prohibitive for the occurrence of western tragopan. The Palas valley being well preserved from the landcover disturbances (both negative and positive) and having sparse human population does qualify for a very important conservation area particularly in context of holding world's largest population of western tragopan.

Introduction

For many biodiversity studies, landcover and its change is a basic parameter in understanding the habitat loss and dynamics and satellite sensors have emerged as useful means for the purpose at varying spatial and temporal scales (Evrendilek & Gulbeyaz, 2008). In this regard, vegetation indices such as normalized difference vegetation index (NDVI) have been particularly focused as proxy for vegetation/landcover (Redo & Millington, 2011). The NDVI can be calculated from a variety of sensors, by dividing the difference between near infrared (NIR) and red (RED) reflectance measurements by their sum which provides the effective measure of greenness/photosynthetically active biomass (Coppin *et al.*, 2004). The free of cost online availability of NDVI as a 'readymade' product with hypertemporal coverage extending over 10 years or more make its use further attractive for deriving landcover dynamics (Justice *et al.*, 2002). The MODIS (onboard Terra platform) based vegetation indices MOD13Q1 are 250m resolution composit products at 16-day intervals with aim to produce high quality, cloud free mosaics, available free of cost since 2000 and have been focused in many studies for landcover mapping and coarse scale change detection (Coppin, *et al*., 2004; Fraser *et al.*, 2005). The measurability of intra-annual or seasonal variations in the landscape through such hypertemporal datasets (Kerr & Ostrovsky, 2003) form the basis of identifying vegetation types or main land cover types (bare soil, natural vegetation, crops, etc.) at regional scales and inter-annual variations in the seasonal patterns could be used to characterize the amount, rate, direction and timing of any changes occurring therein (Clark *et al.*, 2010). The MODIS based NDVI has been successfully utilized in wide areas of research emphasizing vegetation monitoring and mapping such as insect damage to vegetation (Spruce *et al.*, 2011), crop yields (Mkhabela *et al.*, 2011), landcover change (Redo & Millington, 2011), vegetation degradation (Jacquin *et al.*, 2010) and phenology (Busetto *et al.*, 2010). Despite its immense usefulness such data has never been utilized in landcover monitoring or its relation with wildlife in Pakistan.

The western tragopan pheasant (*Tragopan melanocephalus*) enlisted as IUCN Vulnerable C2a (i) has been reported from Kaghan, Muzaffarabad, Neelam and Palas valleys in Pakistan (Table 1). The specific landcover inhabited by this pheasant include montane to sub-alpine areas with specific broadleaved (e.g., *Aesculus indica*, *Acer sp*. and *Betula utilis*) and coniferous *(Cedrus deodara*, *Pinus wallichiana*, *Abies pindrow Picea smithiana)* vegetation (Duke, 1989). Out of its distribution range in Pakistan, the discovery of largest global population of the tragopan consisting of 330 pairs (global estimates: 1600 - 4800 individuals) in Palas valley (35.00º N; 71.25º E) is often attributed to the availability of relatively pristine habitat since it is very shy bird and avoids disturbance (Duke, 1989). The valley has been identified as area of special conservation importance for hosting best protected west Himalayan forests providing habitat to many rare plant and animal species that are threatened elsewhere (Duke., 1989; Rafiq, 1996; Saqib *et al.*, 2011). The, commercial logging activities and local resource use are considered to threaten the habitat of many species including western tragopan (Chaudhry, 1992; Ashraf *et al.*, 2004).

Table 1. A summary of Western Tragopan Surveys in Pakistan showing number of birds reported from various localities.

Area ►	Kaghan valley				Neelam valley		Muzaffarabad	Palas valley	Reference
Location	Bichla	Bhunja	Nuri	Nila	Salkhala	Kuttan	Machiara		
Number of birds reported	+	+	+						Wayre, 1971
					18	20			Mirza *et al*., 1978
					5	10	14		Islam, 1982
					47	0	59		Gaston *et al.*, 1983
				5				330	Duke, 1989
						17	46		Chaudhry, 1992

This research paper is an attempt to map and derive dynamics (progressive, stable and regressive trends) for recent major landcover types (2011) within a region where western tragopan pheasant has been reported in Pakistan based upon time-series analysis of MODIS vegetation index product MOD13Q1 (2000-2011). It is a quest to correlate landcover composition and dynamics with the abundance/distribution pattern of the pheasant and human population. Apparently Palas valley can be referred as being maintained in pristine conditions due to largest occurrence of tragopan but there has been no scientific study at regional level undertaken to provide evidence that Palas valley really has best protected landcover in the region or what have been the recent trends in landcover? Is it still being maintained in pristine conditions? Can abundance of western tragopan be used as indicator of undisturbed conditions?

Materials and Methods

The dataset (NDVI image time-series): The dataset to map the regional landcover and evaluate dynamics of each of the landcover category included MOD14Q1 time-series (MOD13Q1; tiles h23v05 and h24v05) at 250 m resolution and ten-year period (Feb. 2000–Feb. 2011) i.e., inter-annual change in NDVI as proxy for landcover activity. The data were obtained from Land Processes Distributed Active Archive Center (ftp://e4ftl01.cr.usgs.gov/MOLT/MOD13Q1.005/) and consisted of a total of 253-16-day composite NDVI images per tile (23 images/year; except 2000 and 2011). The low quality NDVI data ('VI Usefulness' index 7-15) was removed from the series (Huete *et al.*, 2002) and replaced by linear interpolation of neighbouring values (Verbesselt *et al.*, 2006). The noisy data were managed by temporal smoothing through adaptive Savitzky–Golay filter in software TIMESAT (Jönsson & Eklundh, 2004). The extent of data analyzed was set to the region with reported occurrence western Tragopan in Pakistan and Azad Jammu & Kashmir viz., Allai, Battagram, Jalkot, Kaghan valley, Muzaffarabad, Neelam valley, Palas valley and Siran valley (Fig. 1).

Landcover mapping: The regional landcover consisting of categories Glaciers, Pastures, Conifers, Broadleaves, Shrubs and Built-up/agriculture was derived from NDVI time-series image set of 2011 using Iterative Self-Organising Data Analysis Technique (ISODATA) in software ERDAS Imagine (Anon., 2003). The accuracy of resulting map was assessed by calculating accuracy descriptors such as kappa statistic, user, producer and overall accuracy (Congalton, 1991).

Landcover dynamics (Inter-annual trends): The landcover dynamics for study area was inferred by the time-series analysis of MOD13Q1 dataset (Feb. 2000–Feb. 2011; total 282,981 pixels ~ 1,216,818.30 ha area). The Seasonal-Trend Decomposition Procedure Based on Loess (STL) was adopted for the purpose that splits the time-series data at any given point/pixel Y_t at time t into seasonal (S_t), trend (T_t), and noise (ε_t) components (Equation 1) (Cleveland *et al.*, 1990).

$$Y_t = T_t + S_t + \varepsilon_t \ \ldots\ldots\ldots\ldots\ldots\ldots \text{(Equation 1)}$$

The 'trend component', modelled by piecewise linear function, contains information on the dynamics of landcover (direction and magnitude of change) for each decomposed pixel location during reported period. The direction (positive/progressive or negative/regressive) and significance ($\alpha \leq 0.1$) of trends was determined using seasonal Mann-Kendall (SMK) test (Gilbert, 1987) and the magnitude of trend was determined by Theil-Sen/Sen's slope estimator $\boldsymbol{Q}$ i.e., median of the slopes between every pair-wise combination of values (Sen, 1968).

Landcover, its dynamics, human population and Tragopan abundance: In order to correlate landcover, its dynamics, human population and Tragopan abundance various landcover related metrics/variables were extracted from the data. These metrics included proportions of landcover categories in a sub-region/site showing progressive or regressive trends viz., Broadleaves progressive (BAP) and regressive (BR), Built-up/agriculture progressive (AP) and regressive (AR), Conifers progressive (CP) and regressive (CR), Habitat of western Tragopan (HB) (areas located between 1800-3200 m a.s.l. (Islam & Crawford, 1987)), Shrubs progressive (SP), and regressive (SR), total dynamic habitat as overall habitat of Western Tragopan showing significant (both progressive and regressive) (TDH) and overall proportion of landcover showing either progressive (TPH) or regressive trends (TRH). An estimate of overall potential habitat lost - Habitat lost (HBL) for western tragopan was assumed to be the proportion of Built-up/agriculture category. The ratios of these metrics related to tragopan habitat were calculated viz., TDH/HB, TPH/HB and TRH/HB to reflect status of potential tragopan habitat in respective sub-regions. Out of these metrics, those having Pearson r>0.75 were excluded from further analysis thus remaining with HBL, TRH, SP, CP, SR, CR, AR and TPH/HB and TRH/HB (Fig. 5). The sites were compared using these uncorrelated landcover metrics and ratios through principal component analysis (PCA) with the objective to assess the similarities in patterns of landcover composition and condition in each of the site i.e., relatively pristine or disturbed. The relationship of human population and tragopan abundance with landcover and its dynamics was finally established through their Pearson correlation with sites' similarities (PCA site scores) so as to present a multi-criteria evaluation of tragopan habitat in the sub-regions/sites (Fig. 5). Tragopan abundance (TA) data was extracted from the literature available as average number of tragopans reported from a given area (Table 1). The statistics for human population were obtained from Population Census Division (according to 1998 census), Government of Pakistan. The population related variables included human population (POP), human population density (calculated by excluding pasture area and approaches ecological density since people do not inhabit the pastures for long-term) (ED) (Table 2). The analyses were carried out in software R for windows (R Development Core Team 2011).

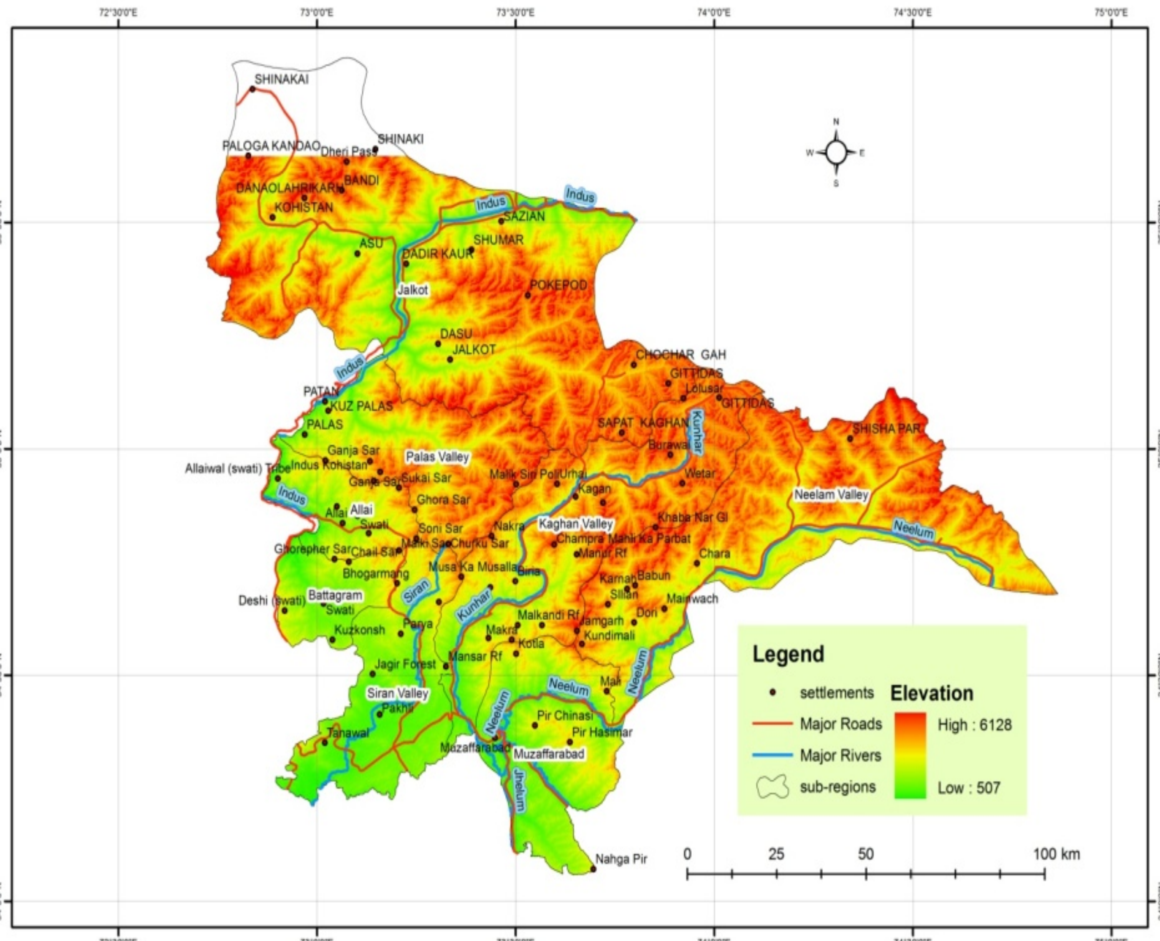


Fig. 1. The extent of NDVI data processed for landcover mapping and trend analyses.

Table 2. Population and human population densities for the sub-regions/sites.

Site/sub-region	Alai	Battagram	Jalkot	Kaghan	Muzaffarabad	Neelam	Palas	Siran
Population (million)	0.122	0.307	0.185	0.175	0.77	0.159	0.166	0.575
Crude density (No. of Individuals/ha)	2.079	6.029	0.815	0.772	7.602	0.553	1.186	4.568
Ecological density (No. of Individuals/ha)	2.171	6.055	2.014	1.599	7.656	1.402	2.287	4.621

Source: Government of Pakistan, Population Census Division (1998 population census)

Results and Discussion

Landcover map: The spatial distribution of regional landcover classes and sub-region-wise breakdown of the area occupied by each landcover class has been summed up in Fig. 2. Overall accuracy of landcover map was 92.8% with value 0.88 for Kappa quotient of 0.88 (95% confidence interval 0.88 and 0.89) which shows that the mapping results were appreciably better than the random results (Congalton, 1991). The landcover map produced was much generalized whereby the individual landcover classes seem to follow a well known regional climatic and altitudinal pattern as discussed in related assessments (Champion *et al.*, 1965; Schickhoff, 1995; Schickhoff *et al.*, 2005; Khan *et al.*, 2011; Ahmad, 2012), e.g., the glaciers occupying the summits > *c*. 4500 m a.s.l pastures occupy elevations > 3000 m a.s.l. followed down-sequence by conifers that further down give way to broadleaves at around 1800 m a.s.l. (Fig. 2-a). The spatial resolution of maps of 250m may well suit a regional scale assessment; however, the individual maps may only contain the subsets of landcover class being represented due to pixel resolution. A similar visual and quantitative approach was adopted to classify vegetation of conterminous United States on the basis of phenology and it was found that the individual landcover classes contained multiple pheno-classes due to altitudinal differences (Gu *et al.*, 2010) or such instances may also result from genetic variations within the dominant plant species (Beck *et al.*, 2006).

The prominence of land cover class 'Built-up/agriculture' towards the low lying sub-regions/sites seems to be function of demographic conditions as well as the availability of suitable land for cultivation. The association of greater population densities and associated agriculture/settlements has also been documented in low lying areas of Iberian Peninsula (Alcaraz *et al.*, 2006). The low lying areas in the study region fall well within the range of summer monsoon and occasional availability of canal irrigation and moderate climatic conditions may favour the cultivation of two crops in a season. Otherwise, in the elevated areas, the settlement and agriculture dominate along the major rivers and rivulets where large alluvial fans and cohesive talus slopes are available to support irrigated agriculture while sediment load carried by irrigation water add to the fertility of these alluvial soils (Brady & Weil, 1999).

Landcover dynamics (Inter-annual trends): The landcover dynamics envisaged both progressive as well as the regressive trends in the region (Fig. 3a,b; Table 3). In general the Glaciers and Pastures did not show any significant trend. The regressive trends were most obvious in the locations where western Tragopan has been reported in lower portions of Neelam, and Kaghan valleys. The central portion of Palas seems to be affected by regressive evolution of landcover similarly the forested portions of Jalkot valley especially those located close to river Indus seem to indicate significant regressive trends in landcover. The Machiara National Park (Muzaffarabad) and its surroundings where the Tragopan has been reported show fairly stable trends in landcover.

In general, landcover class "Built-up/agriculture" had the highest mean Sen's slope value of 0.15% followed by Broadleaves (0.10%), Conifers and Shrubs (0.02% each). The regressive trends in landcover having localized impact can be attributed to small scale forest clearings, forest fires as well as landslides and slope failures (Fig. 3a, b). Interestingly, the areas representing borders of the sub-regions had negative slope values that can be attributed to the fact that these areas are accessed by the residents from either side and since the property rights are insecure (Puppim, 2008) the result is increased utilization pressure on the forest resources (Allan, 1986). As a matter of fact the borders are usually marked by means of some distinct geographical feature such as river or ridge, and rivers are easy way for transportation of logged timber (often illegal), therefore, regressive trends were obvious in comparative areas. The areas of both Muzaffarabad and Neelam valleys bordering the Indian occupied Kashmir showed a considerable recession in Sen's slope that can be interpreted as obvious result of trans-border conflict between India and Pakistan where the forest has been cleared to improve surveillance. The low lying areas of Battagram, Siran and Muzaffarabad showed progressive trends in vegetation/landcover that mainly consist of 'Built-up/agriculture' areas and can obviously due to the fact that these areas are well connected to rest of country thus resulting in enhanced trade followed by introduction of mechanized agriculture, new crops and crop varieties, pesticides and clearing of forested areas in favour of agriculture (Allan, 1986). Under the circumstances of growing population, the agroforestrial landuse becomes a necessity since it provides an opportunity for diversification in production to weaken the existential risks of losses and the basic food supplies are thus secured and farmers are not entirely tied to local conditions. The valleys of Allai, Siran and Battagram that form the watershed of Tarbela dam, were included in an environmental rehabilitation programme under Tarbela Watershed Management Project (TWMP) with objective to address soil erosion and land degradation issues for increasing the life of reservoir. The project started in 1964-65 that in its successive phases during 1982-83, 1992-93 and 2003 carried out aforestation campaigns in different parts of the watershed, thus the progressive landcover trends can be partly attributed to the efforts of TWMP (Swati, 2003). Since most of the aforestation efforts were carried out in the communal lands, where, people have opted to plant trees such as *Populus sp.* and *Eucalyptus* sp., that are fast growing and can be sold for cash but in the mean time, they could be detrimental for ecosystem due to their known issues of allelopathy and excessive water-use (Kohli, 1998).

Among all landcover classes, the conifers seemed to be most vulnerable to deterioration having greater than 7000 ha of significantly negative affected area in the region that can be directly related to their obvious commercial value as timber. The conifers provide core habitat to Western Tragopan, however, most degradation in the region was 37% for Neelam valley (concentrated in lower reaches), but the neighboring Muzaffarabad accounted for only 6% of the overall deteriorating conifers that can be attributed to conservation efforts by Machiara National Park administration (Table 3).

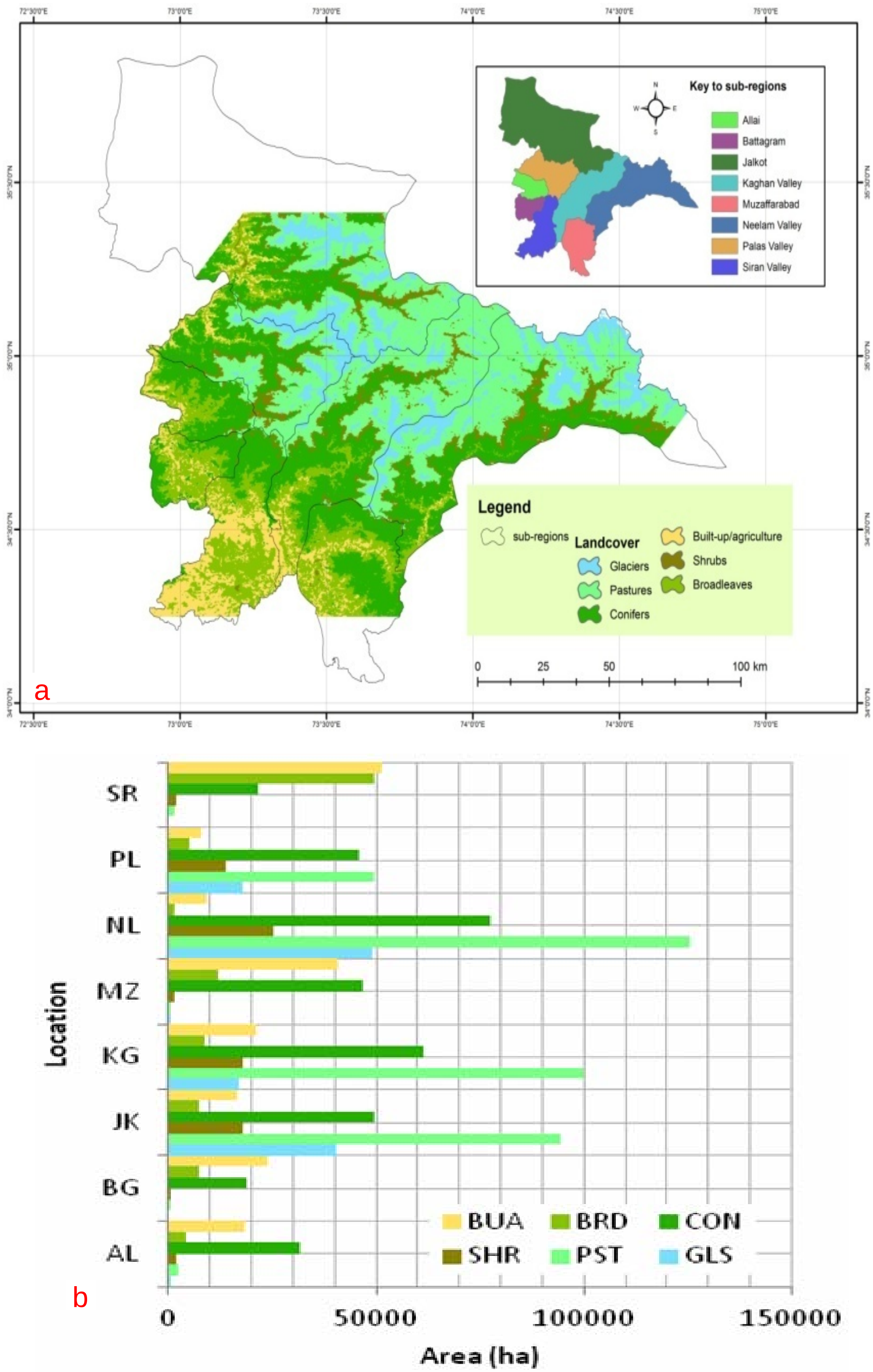


Fig. 2. (a) The spatial distribution of different landuse/landcover classes in the study region along with (b.) the sub-regional (AL=Allai; BG=Battagram; JK=Jalkot; KG=Kaghan; MZ=Muzaffarabad; NL=Neelam; PL=Palas; SR=Siran) details of area and proportionate area occupied by each landcover class (BRD=Broadleaves; BUA=Built-up/agriculture; CON=Conifer; GLS=Glacier; PST=Pasture; SHR=Shrubs).

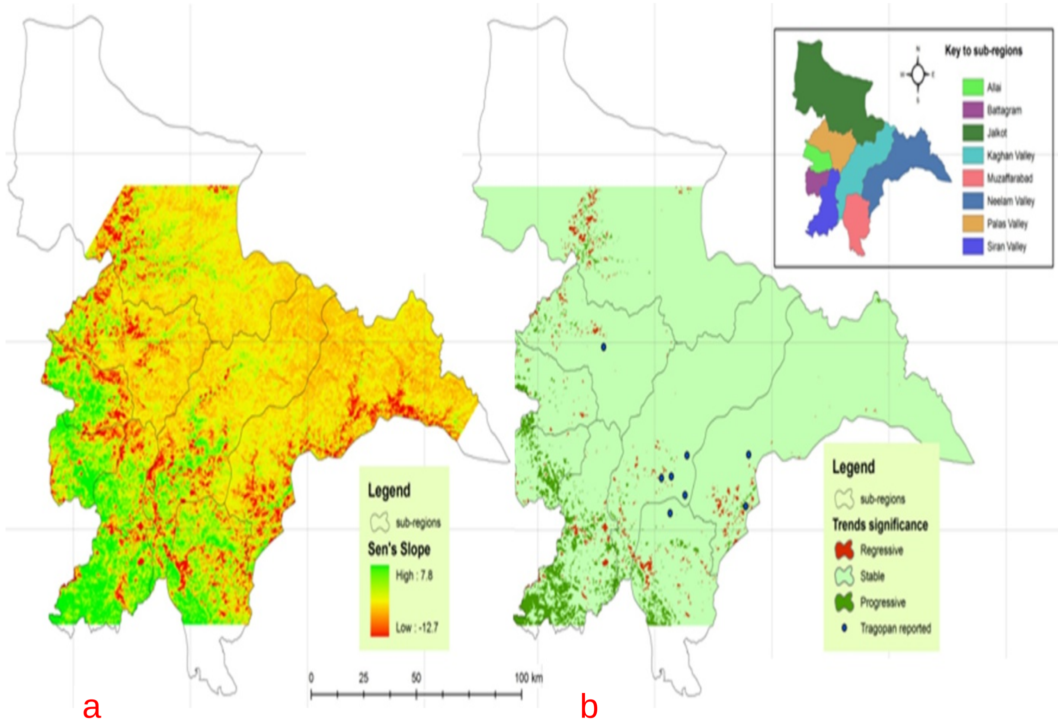
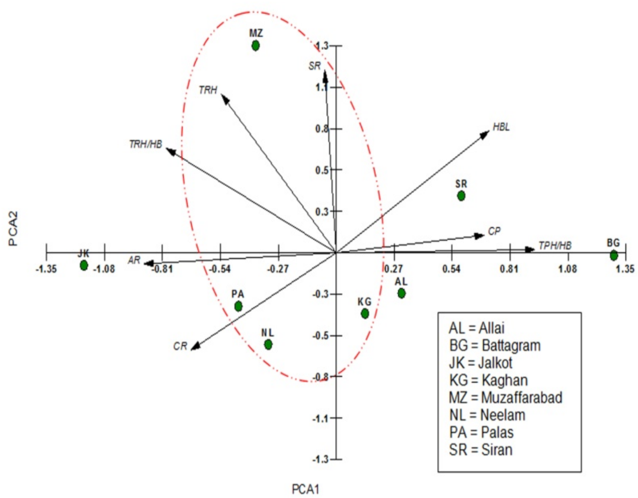


Fig. 3. (a.) Sen's slope % '*Q*' derived from NDVI time series data of forest vegetation (b.) The significance of vegetation activity trends based on Seasonal Mann-Kendall slope 'S' derived from.

Table 3. Extent of landcover (area hectares) that have gone under progressive or regressive evolution during 2000 – 2010 ('+'= progressive; '-'= regressive); (Sub-regions' coded as in Fig. 2.).

Trend	Landcover	Region	Sub-Region							
			AL	BG	JK	KG	MZ	NL	PL	SR
+	Overall	51066.8	2807.9	7851.8	2085.5	2618.7	6080.2	670.8	1333.0	27618.9
-	Overall	18051.4	860.0	399.9	4072.1	2021.0	2743.4	3022.9	1939.3	2992.8
+	Glaciers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Pastures	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Shrubs	81.7	4.3	0.0	73.1	0.0	0.0	4.3	0.0	0.0
	Conifers	3913.0	442.9	1290.0	339.7	249.4	301.0	68.8	692.3	528.9
	Broadleaves	31626.5	1328.7	2756.3	524.6	1806.0	2296.2	240.8	447.2	22226.7
	Built-up/agri	15445.6	1032.0	3805.5	1148.1	563.3	3483.0	356.9	193.5	4863.3
-	Glaciers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Pastures	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Shrubs	683.7	17.2	8.6	98.9	86.0	305.3	4.3	43.0	120.4
	Conifers	7133.7	490.2	279.5	1251.3	743.9	438.6	2691.8	954.6	283.8
	Broadleaves	4287.1	215.0	38.7	941.7	296.7	550.4	55.9	374.1	1814.6
	Built-up/agri	5946.9	137.6	73.1	1780.2	894.4	1449.1	270.9	567.6	774.0

Site groupings, human population and Tragopan abundance: The overall results obtained from principal component analysis (PCA) are shown in Fig. 4a,b. The analysis revealed that the first two components or PCA axis (PCA1 and PCA2) accounted for the major portion of the variation in the data (82.54%) with major contribution by PCA1 (49.2%). The variables loadings (VL) indicated their respective contribution to variance explained along each of the axis. The variables CP (VL=0.344) and TPH/HB (VL=0.462) had highest positive loadings against PCA1, showing that the PCA1 effectively represented a gradient where the progressive trends in landcover class conifers increase along the axis and reverse is the case of landcover class conifers showing regressive trends CR (VL=-0.338), ratio of total regressive habitat of tragopan to habitat available TRH/HB (VL=-0.395) and regressive trends in Built-up/agriculture landcover class AR (VL=-0.447). The variable tragopan habitat lost (HBL) that represented the proportion of montane agriculture maintain positive loadings for both PCA1 (VL=0.355) and PCA2 (VL=0.397) which means that the agriculture is more prominent in the sites differentiating positive to the centroid of the ordination biplot along both PCA axis. The PCA2 effectively represented the gradients of tragopan habitat lost HBL (VL=0.397), tragopan regressive habitat TRH (VL=0.517) and the shrub landcover showing regressive trends SR (VL=0.596) in increasing sequence.



a.

Axis ►	PCA1	PCA2	PCA3
Eigenvalues	3.936	2.667	0.723
Percentage	49.204	33.336	9.036
Cum. Percentage	49.204	82.54	91.576
PCA variable loadings (VL)			
HBL	0.355	0.397	0.158
TRH	-0.268	0.517	0.019
CP	0.344	0.057	0.833
SR	-0.027	0.596	-0.193
CR	-0.338	-0.317	0.21
AR	-0.447	-0.036	0.385
TPH/HB	0.462	0.01	-0.024
TRH/HB	-0.395	0.34	0.223
PCA case scores			
Allai (AL)	0.305	-0.266	-0.222
Battagram (BG)	1.292	-0.019	0.489
Jalkot (JK)	-1.172	-0.084	0.425
Kaghan (KG)	0.135	-0.397	-0.382
Muzaffarabad (MZ)	-0.373	1.347	-0.147
Neelam (NL)	-0.315	-0.599	-0.218
Palas (PA)	-0.454	-0.35	0.164
Siran (SR)	0.583	0.369	-0.109

b.

Fig. 4. (a.) PCA ordination biplot showing groupings of the sub-regions. The dotted ellipse shows locations with reported western tragopan. (b) The Eigenvalues, variable loadings and Site scores for the PCA.

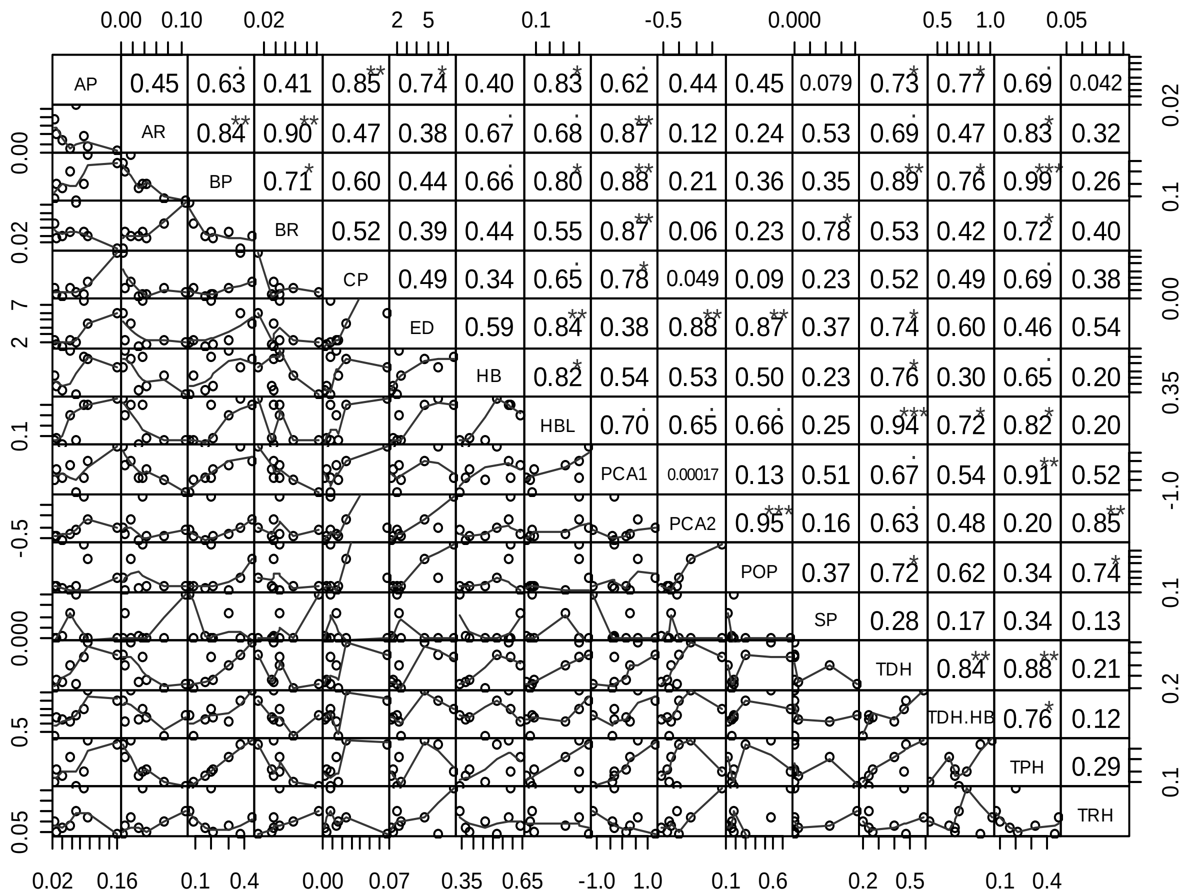


Fig. 5. The Correlogram showing the relationships between human population density, PCA ordination and landcover attributes; (AP =Built-up/agriculture progressive; AR= Built-up/agriculture regressive; BP= Broadleaves progressive; BR= Broadleaves regressive; CP= Conifers progressive; ED= Population (ecological) density; HB = Habitat (Tragopan); HBL= Habitat (Tragopan) lost; PCA1&2 = respective PCA axis score; POP=Population (human); SP= Shrubs progressive; TDH= Total dynamic habitat; TPH= Total progressive habitat; TRH = Total regressive habitat. (NB: Only attributes having at least one significant correlation with any other variable are shown. The tragopan abundance did not showed any significant relationship): Significance codes: "***" = 0.001; "**" = 0.01"*" = 0.05; "." = 0.1; " " = NS

The PCA site scores (Fig. 4-b) as well as visual inspection of ordination plot of PCA (Fig. 4-a) reflects that the majority of differentiation among the sites has occurred along the first axis (PCA1), particularly the Battagram (BG) and Siran valley (SR) distinctly segregate from the rest of sites, occupying the extreme right corner of the ordination diagram, similarly, the Jalkot sets aside at extreme left corner of the biplot. The areas with reported Tragopan i.e., Kaghan (KG), Neelam (NL), Palas (PA) and Muzaffarabad (MZ) occupy the centre of ordination biplot from where MZ departs from rest of Tragopan reported areas along PCA2. The Jalkot (JK) segregates from rest of sites by occupying extreme left position along PCA1 (Fig. 4).

One of the most significant aspects revealed by the analysis is that the sites representing western tragopan populations were located in the middle of ordination diagram (Fig. 4-a) along PCA1 that represents progressive landcover trends right to centroid and regressive landcover trends left to the centroid i.e., these sites contained a minimum disturbances in the landcover. Nevertheless, whether progressive or regressive trends were seen in the landcover evolution, both represent functional changes to ecosystem/landcover (Baldi *et al.*, 2008) thus it can be inferred that the presence of western tragopan in the middle sites relates to their relatively undisturbed conditions that are necessary for this shy bird and possibly certain other species (Anon., 2001). The role of increasing human population densities in modifying the status/trends in landcover dynamics of the region is further strengthened by its strong relationship with PCA2 (r=0.95).

The results of ordination can be further elaborated by correlation among PCA axis scores, landcover metrics, human demography and Tragopan abundance (Fig. 5). The PCA1 that accounted for about half of the variance explained has strong correlation with Tragopan's Habitat lost (HBL: r= 0.70) and progressive landcover dynamics in potential Tragopan habitat (TPH: r=0.91) conifers (CP: r= 0.78) and broadleaves (BAP: r=0.88), whereas, it correlates negatively with regressive dynamics of Broadleaves and Built-up/agriculture landcover. The PCA2 that accounted for 33.3% of the variance explained in the data was found positively correlated with the human demographic figures (Total population (POP) r=0.95; Population density (ED; r=0.88). The abundance of Tragopan, however, does not show any strong relationship with any of the ordination axis but still is negatively relates with PCA1 and PCA2 (r = 0.28 and -0.15 respectively) (Fig. 4-b).

It is important to note, however, that the Tragopan abundance could not be effectively related to the PCA as a weak correlation was found only with PCA1 and tragopan abundance (r=-0.28). This is due to the fact that the PCA1 represented a disturbance gradient with regressive landcover trends dominating at left hand side of the axis and progressive landcover trends on the right hand side with relatively undisturbed locations (noticed for tragopan occurrence) close to the centroid, so the axis scores behaved as a circular variable to the tragopan abundance resulting in lower correlation. This can be further supported through relatively stronger negative association of tragopan abundance with combined proportionate area showing trends (regressive or progressive) (TDH: r=-0.44) and proportion of dynamic habitat within the potential habitat of tragopan (r=-0.67; Fig. 5).

Conclusion

On the basis of overall statistics of Sen's slope it appeared that the Palas valley is being maintained in most pristine conditions (Q = 0.01±0.76) in the region and it can be generalized that the sites that represented western tragopan had relatively stable landcover. The Palas valley and Neelam valley can be identified as the most important sites for western tragopan due to their pristine landcover conditions and relatively uninfluenced by agricultural landscape (thus human population). The Palas valley has strict tribal culture and is not open for the tourists as eastern valleys in the region that has maintained the wilderness in the area and perhaps another important reason that the Palas valley has hosted the world's largest population of western tragopan.

References

Ahmad, S.S. 2012. Species response to environmental variables in Ayubia National Park, Pakistan using multivariate analysis. *Pak. J. Bot.*, 44(4), 1225-1228.

Alcaraz, D., J. Paruelo and J. Cabello. 2006. Identification of current ecosystem functional types in the Iberian Peninsula. *Global Ecol. Biogeogr.,* 15(2): 200-212.

Allan, N.J.R. 1986. Accessibility and altitudinal zonation models of mountains. *Mt. Res. Dev.,* 6(3): 185-194.

Anonymous. 2001. *Threatened birds of Asia: the Bird Life International Red Data Book*. Cambridge, UK: BirdLife International.

Ashraf, S., A. Daud, F. Moeen and R. Nawaz. 2004. *Mapping the habitat and distribution of western tragopan Tragopan melanocephalus in the Palas Valley, Pakistan using landcover, terrain and field survey data*. Paper presented at the International Galliformes Symposium.

Baldi, G., M. Nosetto, R. Aragón, F. Aversa, J. Paruelo and E. Jobbágy. 2008. Long-term satellite NDVI data sets: evaluating their ability to detect ecosystem functional changes in South America. *Sensors,* 8(9): 5397-5425.

Beck, P.S.A., C. Atzberger, K.A. Høgda, B. Johansen and A.K. Skidmore. 2006. Improved monitoring of vegetation dynamics at very high latitudes: A new method using MODIS NDVI. *Remote Sens. Environ.,* 100(3): 321-334.

Brady, N.C. and R.R. Weil. 1999. *The nature and properties of soils*. New Jersey: Prentice Hall.

Busetto, L., R. Colombo, M. Migliavacca, E. Cremonese, M. Meroni, M. Galvagno, M. Rossini, C. Siniscalco, U. Morra di Cella and E. Pari. 2010. Remote sensing of larch phenological cycle and analysis of relationships with climate in the Alpine region. *Glob. Change Biol.,* 16(9): 2504-2517.

Champion, H.G., S.K. Seth and G.M. Khattak. 1965. *Forest types of Pakistan*. Peshawar: Pakistan Forest Institute, Peshawar.

Chaudhry, A. 1992. Distribution and status of pheasants in Pakistan. In: *Pheasants in Asia*. (Ed.): D. Jenkins. Reading, U.K.: World Pheasant Association. pp. 7-14.

Clark, M.L., T.M. Aide, H.R. Grau and G. Riner. 2010. A scalable approach to mapping annual land cover at 250 m using MODIS time series data: A case study in the Dry Chaco ecoregion of South America. *Remote Sens. Environ.,* 114(11): 2816-2832.

Cleveland, R.B., W.S. Cleveland, J.E. McRae and I. Terpenning. 1990. STL: A seasonal-Trend Decomposition Procedure Based on Loess. JOS: 6(1): 3-73.

Congalton, R.G. 1991. A review of assessing the accuracy of classifications of remotely sensed data. *Remote Sens. Environ.,* 37(1): 35-46.

Coppin, P., I. Jonckheere, K. Nackaerts, B. Muys and E. Lambin. 2004. Review Article-Digital change detection methods in ecosystem monitoring: a review. *Int. J. of Remote Sens.,* 25(9): 1565-1596.

Duke., G. 1989. The world's largest population of Western Tragopans. Report to BirdLife International, Cambridge.

Anonymous. 2003. *ERDAS Field Guide* (7 ed.). St. Gallen: Leica Geosystems AG Heerbrugg, Switzerland.

Evrendilek, F. and O. Gulbeyaz. 2008. Deriving vegetation dynamics of natural terrestrial ecosystems from MODIS NDVI/EVI data over Turkey. *Sensors,* 8(9): 5270-5302.

Fraser, R.H., A. Abuelgasim and R. Latifovic. 2005. A method for detecting large-scale forest cover change using coarse spatial resolution imagery. *Remote Sens. Environ.,* 95(4): 414-427.

Gaston, A.J., K. Islam and J.A. Crawford. 1983. The current status of the western Tragopan *(Tragopan melanocephalus). WPA Journal,* 18: 40-49.

Gilbert, R.O. 1987. *Statistical Methods for Environmental Pollution Monitoring*. New York: Van Nostrand Reinhold.

Gu, Y., J. Brown, T. Miura, W.J. van Leeuwen and B. Reed. 2010. Phenological classification of the United States: A geographic framework for extending multi-sensor time-series data. *Remote Sensing,* 2(2): 526-544.

Huete, A., K. Didan, T. Miura, E. P. Rodriguez, X. Gao and L.G. Ferreira. 2002. Overview of the radiometric and biophysical performance of the MODIS vegetation indices. *Remote Sens. Environ.,* 83(1-2): 195-213.

Islam, K. 1982. *Status and distribution of the western tragopan in northeastern Pakistan.* Paper presented at the International Symposium on Pheasants in Asia.

Islam, K., and J.A. Crawford. 1987. Habitat use by western tragopans Tragopan melanocephalus (Gray) in Northeastern Pakistan. *Biol. Conserv.,* 40(2): 101-115.

Jacquin, A., D. Sheeren and J.P. Lacombe. 2010. Vegetation cover degradation assessment in Madagascar savanna based on trend analysis of MODIS NDVI time series. *Int. J. of Appl. Earth Obs.,* 12(Supplement 1): S3-S10.

Jönsson, P. and L. Eklundh. 2004. TIMESAT--a program for analyzing time-series of satellite sensor data. *Comput. Geosci.,* 30(8): 833-845.

Justice, C.O., J.R.G. Townshend, E.F. Vermote, E. Masuoka, R.E. Wolfe, N. Saleous, D.P. Roy and J.T. Morisette. 2002. An overview of MODIS land data processing and product status. *Remote Sens. Environ.,* 83(1-2): 3-15.

Kerr, J.T. and M. Ostrovsky. 2003. From space to species: ecological applications for remote sensing. *Trends Ecol. Evol.,* 18(6): 299-305.

Khan, S.M., D. Harper, S. Page and H. Ahmad. 2011. Species and community diversity of vascular flora along environmental gradient in Naran Valley: A multivariate approach through indicator species analysis. *Pak. J. Bot*., 43(5): 2337-2346.

Kohli, R.K. 1998. Allelopathic interactions in forestry systems. *For. Sci.,* 54: 269-284.

Mirza, Z. B., A. Aleem and M. Asghar. 1978. Pheasant Surveys in Pakistan. *J. Bombay Nat. Hist. Soc., 75*, 292-296.

Mkhabela, M.S., P. Bullock, S. Raj, S. Wang and Y. Yang. 2011. Crop yield forecasting on the Canadian prairies using MODIS NDVI data. *Agr. Forest Meteorol.,* 151(3): 385-393.

Puppim de Oliveira, J.A. 2008. Property rights, land conflicts and deforestation in the Eastern Amazon. *Forest Policy Econ.,* 10(5): 303-315.

Rafiq, R.A. 1996. Report on the botanical studies in Palas Valley (1992-1995). The flora of Palas valley and plant conservation priorities. Report prepared for: Himalayan Jungle Project, Palas Valley, Kohistan.

Redo, D.J. and A.C. Millington. 2011. A hybrid approach to mapping land-use modification and land-cover transition from MODIS time-series data: A case study from the Bolivian seasonal tropics. *Remote Sens. Environ.,* 115(2): 353-372.

Saqib, Z., R.N. Malik, M.I. Shinwari and Z.K. Shinwari. 2011. Species richness, ethnobotanical species richness and human settlements along a Himalayan altitudinal gradient: Prioritizing plant conservation in Palas valley, Pakistan. *Pak. J. Bot.,* 43(SI): 129-133.

Schickhoff, U. 1995. Himalayan forest-cover changes in historical perspective: A case study in the Kaghan valley, Northern Pakistan. *Mountain Research and Development,* 15(1): 3-18.

Schickhoff, U., G. Broll and B. Keplin. 2005. The upper timberline in the Himalayas, Hindu Kush and Karakorum: a review of geographical and ecological aspects. *Mountain ecosystems. Studies in Treeline Ecology*, 275-354.

Sen, P.K. 1968. Estimates of the regression coefficient based on Kendall’s tau. *Journal of the American Statistical Association,* 63: 1379-1389.

Spruce, J.P., S. Sader, R.E. Ryan, J. Smoot, P. Kuper, K. Ross, Prados, D., P., Jeffrey, R., Gerald, G, Rodney M. and W. Hargrove. 2011. Assessment of MODIS NDVI time series data products for detecting forest defoliation by gypsy moth outbreaks. *Remote Sens. Environ.,* 115(2): 427-437.

Swati, M.I. 2003. Tarbela watershed management project historical prospective, impact, lessons learnt. *Pak. J. For.,* 53.

Verbesselt, J., P. Jonsson, S. Lhermitte, J. van Aardt and P. Coppin. 2006. Evaluating satellite and climate data-derived indices as fire risk indicators in savanna ecosystems. *Geoscience and Remote Sensing, IEEE Transactions on,* 44(6): 1622-1632.

Wayre, P. 1971. Advisory report on the pheasants of the Kaghan valley with particular reference to the western Tragopan. Unpublished report to WWF Pakistan.

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