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Assessment of Human Disturbances in the Wildlife Corridor Forests of Terai Arc Landscape, Nepal

KEYWORDS: Terai Arc Landscape, Community based forest management, Human disturbances, Biodiversity Conservation

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ABSTRACT *Nepal has experienced enormous challenges in conserving its biodiversity in Terai region. The approach undertaken by Terai Arc Landscape (TAL) programme provides an opportunity to scale up conservation initiatives and address threats. This study a) identifies the types human disturbances present in TAL area; b) explores the pattern and trend of disturbances if that can be generalized quantitatively and c) identifies the performance and effect of management modes on the disturbances. The study was carried out in 2011 and 2012 in 128 forest units under four different management regimes. The disturbance parameters were determined aligning with quantitative tools of Community Forestry inventory. A total of 10 priority disturbance variables were identified and subjected to both parametric and non-parametric analysis. The result shows that the community based forest management has the positive consequences on conservation through prevention and mitigation of disturbances and will have to be dominant conservation strategy*

Introduction
Nepal has experienced enormous challenges in conserving its biodiversity particularly in the Terai region (NPC 2010). Over time, a high proportion of the forests of Terai has been modified by anthropogenic disturbances and the forestsare under threat (WWF, 2004 and Chakraborty, 1999). Recently, the landscape conservation approach has been adopted as an opportunity to scale up conservation initiatives and the Terai Arc Landscape (TAL) programme as an example (NPC, 2013).

The enormous exploitation of TAL forests by an array of disturbances driven by different scales of anthropogenic pressures, which vary in the degree and subject to which they can be detected by techniques ranging from local participatory process to advanced remote sensingtechniques. Unfortunately, many anthropogenic disturbances, except land-cover changes, deforestation, forest fragmentation and forest fire are almost undetectable using remote-sensing techniques (Carlos,et al., 2006; Carlos and Peters, 2005).Little has been known about the overall patterns of human disturbances within the forests in TAL. It has been also remained unclear whether resource exploitation is indeed expanding in general and to what extent different forests are already affected.Thus a maiden attempt has been made to study the anthropogenic disturbances in relation to forest management modes in TAL forests.

Objectives

This study a) identifies the types human disturbances present in TAL forests b) explore the pattern and trend of disturbances if that can be generalized quantitatively and c) identify the performance and effect of management modes on the disturbances.

Study sites
The TAL is a transboundary landscape area between Nepal and India; and within Nepal it consists of a total area of 23,199 Km2 with forest area of 14000 Km2. Outside the protected areas, TAL intervention consists of seven corridor and bottleneck areas, in which 341 forest management units (both community based and state managed governance)are established by the end of year 2012, of which 190 units are being used for wildlife habitat and movements. This study used the sample of 128 forest units (n) out of population (N) of 190 with 5% error based on Cochran's sample size formula.The sample sites were divided into four groups: (G1) – Community forests (CFM), n = 43; Group 2 (G2) – Government managed forests (GMF), n = 43; and Group 3 (G3)-Buffzone government forests (BGM), n=21; and Group 4 (G4) –Buffer-zone community forests (BCF),n = 21.(Table 1).

Table 1: Sample sites

Sites	Management types				Total
	G1	G2	G3	G4	
Barandabar	9	9	9	9	36
Basanta	10	10			20
Dovan	3	3			6
Khata	4	4	4	4	16
Laljhadhi	5	5	4	4	18
Lamahi	8	8			16
Mahadevpuri	4	4	4	4	16
Total	43	43	21	21	128

(Source: Field survey, 2011)

Materials and Methods
This study was carried out from January 2010 to March 2013 based on both literature review, open and structured interviews, discussion with local informants and field measurement (DoF 2004; Aryal,et al. 2012). The disturbance parameters were determined aligning with quantitative tools and methodology described in Community Forestry (CF) Inventory Guidelines, Government of Nepal (DoF 2004).For each forest, important disturbance factorswere identified and quantified using the systematic sampling method and in a series of plots of (50 m long and 10 m wide) along transect lines located systematically from the starting point. The starting point and direction of each transect line was recorded using a GPS (geo-referenced) and a compass respectively to allow transects to be relocated in the future.

Variables
The variables selected were as below (Table 2 and 3):

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Table 2: Independent variables

Name	Variables	Types*	Explanation
Site name	Name	N	Name of sites
Forest name	Name	N	Name of forests
Management types	Name	B/O	1= CFM; 2= GMF; 3= BGM; 4= BCF
Approach	Name	B/O	Community based forest management (CBM) = CFM + BCF) Government managed system (GMS) = GMF + BGM

(* N= Nominal; B= Binary; O= Ordinal; Unit= Number; Source: Office record)

Table 3: Dependent variables

Name	Variables	Types*	Explanation	Unit
LOG	Logging	C	Total volume removed, legally, illegally and naturally	Percent
ENC	Encroachment	C	Area encroached (past or present)	Percent
GRZ	Grazing	C	Grazing, area grazed (proportion in percent of area)	Percent
LVD	Livestock density	D	Number per unit area	Number
INV	Invasive species	B	Presence or absence of evidence recorded as 1 or 0	Yes or No
FFR	Forest fire	C	Area under fire by proportion or events	Percent
PCH	Poaching	C	Wildlife poaching events including birds per year	Number
FWD	Firewood extraction	C	Fuel wood extraction	Metric ton
DST	Distance to settlement	C	Settlement proximity in Km	Km
NRG	No Natural regeneration	C	Proportion of area under no regeneration	Proportion in percent

(*C = continuous; B = Binary; O= Ordinal; D=Discrete; Source: Office records, field verification with map and questionnaire: 2011-2013)

Both qualitative and quantitative comparison of threats between CBM and SMF were carried out. For each of the CFM included in the study, an area conventionally managed by state was selected for comparison based on proximity to each respective CF. T tests, Chi-square, Principal Component Analysis, and logistic regressions were performed using SPSS 20.

Data analysis and result

Analysis on comparison

Independent sample t tests was carried out to compare threat mean between: a) CFs and GMFs; b) BCF and BGM and c) CBM (both CFM and BCF) and GMS (GMFs and BGM.Table 4 shows that the mean valuesdisturbancesof LOG, FFR, DIST, NR between CFM and GMF are significantly different at p<0.000;GRZ is significant at p=0.023 and ENC, LVD, PCH and FWD are not significant (>0.05). Comparison of BCFwith their adjoining BGM forests in buffer-zone shows that threat variables are statistically significant (p=<0.05) except FWD (p=0.134). CBM and adjoining forests under government system (GMS) have significant different threat variables (p=<0.05) except FWD (p=0.269).

Table 4: Independent sample t test

Disturbance variables	Types	Between CFM (1) and GMF (2)				Type	Between BGM (3) and BCF (4)				Types	Between CBM (CFM and BCF), [illegible] and GMS (GMF and BGM), [illegible]			
		n = [illegible] each, df=[illegible]					n = [illegible] each, df=[illegible]					n = [illegible] each, df=[illegible]			
		Mean	SE	t	p		Mean	SE	t	p		Mean	SE	t	p
LOG	1	[illegible]	[illegible]	[illegible]	[illegible]	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	2	[illegible]	[illegible]			4	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]		
ENC	1	[illegible]	[illegible]	[illegible]	[illegible]	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	2	[illegible]	[illegible]			4	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]		
GRZ	1	[illegible]	[illegible]	[illegible]	[illegible]	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	2	[illegible]	[illegible]			4	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]		
LVD	1	[illegible]	[illegible]	[illegible]	[illegible]	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	2	[illegible]	[illegible]			4	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]		
FFR	1	[illegible]	[illegible]	[illegible]	[illegible]	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	2	[illegible]	[illegible]			4	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]		
PCH	1	[illegible]	[illegible]	[illegible]	[illegible]	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	2	[illegible]	[illegible]			4	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]		
FWD	1	[illegible]	[illegible]	[illegible]	[illegible]	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	2	[illegible]	[illegible]			4	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]		
DST	1	[illegible]	[illegible]	[illegible]	[illegible]	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	2	[illegible]	[illegible]			4	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]		
NRG	1	[illegible]	[illegible]	[illegible]	[illegible]	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	2	[illegible]	[illegible]			4	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]		

Similarly, invasive species such asMichaneamacrantha and Lanata camera have been threats inTerai forests. When asked to the prevalenceas a disturbance,67 forests (52.3 percent) experienced as a threat whereas 61 forests (47.7 percent) do not. However, this different has not been found statistically significant under Chi square test for contingency variables (X21 = 1.17; P=0.760).

Principal Component Analysis (PCA)

Principal Component Analysis (PCA) was used to extract factors using Varimax rotation. Before being submitted to PCA, the correlations were checked for multicollinearity problems.The results of analysis showed a significance level of 0.00 under KMO test, a value that is enough to reject the hypothesis. These diagnostic procedures indicate that factor analysis is appropriate for the data. (Table 5).

Table 5: KMO measure of sampling adequacy and Bartlett's test of sphericity

Management	KMO Measure of Sampling Adequacy	Bartlett's Test of Sphericity		
		Chi-Square	df	Sig
Both CBM and GMS	0.570	256.925	36	0.00
CBM	0.435	109.78	36	0.00
GMS	0.528	127.03	36	0.00

The nine variables were included in the factor analysis and only those factors with an eigenvalue of 1.0 or more were retained. Four factors accounted for 75.96 per cent of the total variance in overall threats, 75.53 percent of threats in CBM and 72.98 percent in GMS. The most influential variables for the first factor, labeled as "forest resource base", which explained 32.56% of the variation, with the highest with the highest loading of NRG followed GRZ, FFR and LOG; the second, "forest products" 17.42 percent, with the loading of ENC followed by PCH and logging, the third factor, "movements" 13.67 percent with the loading of DST and FWD and the fourth factor, "basic needs", 12.01 percent with the loading of LOG, INC and LVD of total variance.

In GMS, the first factor explained 28.38%, the second explained 18.43%, the third explained 14.35% and the fourth explained 11.83 %. Together the first four PCAs explained 72.98% of the variability in the disturbance variables. In CBM, the first factor accounted for 32.96 percent, the second 17.71 percent, the third factor 13.46 percent and the

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fourth factor 11.46 percent of total variance.

Table 6: Results of PCA: Varimax rotation factor matrix

Component	Overall management				GMS				CBM			
	1	2	3	4	1	2	3	4	1	2	3	4
NRG	0.83				0.77				0.74			
ENC	0.81								0.83			
FFR	0.58				0.64				0.53			
GRZ	0.54			-0.51	0.71				0.70		0.52	
LVD		0.80				0.60		-0.55			0.83	
LOG		0.77			0.55		0.51				0.66	0.57
PCH			0.91			0.51		0.51		0.80		
DST			0.83		-0.67					0.89		
FWD				0.91		-0.57	0.76					0.87
Eigen value	2.93	1.567	12.31	1.081	2.554	1.658	1.252	1.064	2.943	1.593	1.238	1.032
Variance explained	32.56	17.42	13.67	12.01	28.38	18.43	14.35	11.83	32.69	17.71	13.68	11.46
Total variance	75.66				72.98				75.55			

Extraction Method: Principal Component Analysis and factor loaded above 0.5
Rotation Method: Varimax with Kaiser Normalization

Comparing Factor Structure of CBM and GMF

Multivariate analysis of variance (MANOVA) was used to determine whether the threat reductions were related to their factor score (FS) variables and revealed the dimensions of overall threat reductions were differing by forest management modes (Wilks' Lambda, F=8, 8.22, 6.44, p=0.000).The dimensions of threats based on individual scores differed significantly by FS1 of GMS (Wilks' Lambda, F=1,38.58, p=0.000), FS1 (Wilks' Lambda, F=1, 33.33, p=0.000) and FS3 of CBM (Wilks' Lambda, F=1, 8.69, p < .01).See Table 7 fordetail on F and p values.

Table 7: Multivariate Tests: Between-Subjects Effects

Dependent Variable	SS	df	MS	F	p
GMS					
FS1	31.82	1	31.82	38.54	0.000
FS2	2.54	1	2.54	3.16	0.078
FS3	0.37	1	0.37	0.48	0.491
FS4	1.14	1	1.14	0.81	0.369
CBM					
FS1	36.30	1	36.30	33.33	0.000
FS2	0.69	1	0.69	0.96	0.330
FS3	11.80	1	11.80	8.69	0.004
FS4	4.28	1	4.28	2.89	0.091

Logistics regressions

A binary logistic regression analysis performed to assess the influence of forest management modes, CBM and GMS on conservation threats is shown in Table 8.The model contained nine independent variables. A test on the full model containing all nine predictors was statistically significant, with Chi-square (27, N=128) 269.27, P<0.000, indicating that the model was able to distinguish between threats and management modes between CBM and GMS. The model as a whole explained between 87.9% (Cox & Snell R^2) and 94.5% (Nagelkerke R^2) of the variance in the threats in relation to management modes.

Table 8: Model using binary statistics on CBM and GMS

		B	S.E.	Wald	Sig.	Exp(B)
Step 1a	LOG	0.451	0.28	2.584	0.108	0.637
	ENC	0.119	0.117	1.033	0.31	0.888
	GRZ	0.116	0.097	1.424	0.233	1.123
	LVD	0.01	0.09	0.012	0.914	1.01
	FFR	-0.029	0.061	0.22	0.639	0.972
	PCH	0.977	0.635	2.368	0.124	2.655
	FWD	0	0.003	0.024	0.877	0.999
	DST	-11.431	5.272	4.702	0.03	9.21
	NRG	0.409	0.212	3.74	0.053	1.506
	Constant	-42.116	21.541	3.823	0.051	0

a. Variable(s) entered on step 1: LOG, ENC, GRZ, LVD, FFR, PCH, FWD, DST, NRG; b. df = 1, Chi-square = 160.824, d.f. =9 , p = 0.000; -2 Log likelihood = 16.622; Cox & Snell R2 = 0.715; Nagelkerke R2 = 0.954;

LOG has positive regression coefficient (b) of 0.451with odds ratio (Exp b) of 0.637 which was not statistically significant at probability level of 5% (p = 0.108). In other words, increase in one unit of LOG increases the threat activities in the forest by a factor 0.637 and vice versa.This implies that an increase in LOG indicates that human activities have increased by a factor of 0.637.

ENC has a positive regression coefficient (b) of 0.119 with odds ratio (Exp b) of 0.888, with p value 0.31, meaning that a unit increase in ENC activity will increase the likelihood of threat by a factor 0.888 and vice versa. GRZ has a positive regression coefficient (b) of 0.116 with odds ratio of 1.123 which was statistically insignificant at probability level of 5% (p=0.233). This means that the chance of GRZ in TAL forests increases by a factor of 1.123 for a unit change in this variable.

LVD has a positive regression coefficient (β) of 0.01 with odds ratio (Exp β) of 1.01. This indicates disturbance in the forests increases by a factor of 1.01 for every unit change in this variable. FFR has a negative regression coefficient (β) of -0.031 with odds ratio (Exp β) of 0.972. This implies that an increase FFR indicate that human activities in the forests has decreased by a factor of 0.72.

PCH determines/influences human disturbance. PCH has a positive regression coefficient (β) of 0.977 and the odds ratio (Exp β) of 2.655. This implies that an increase in PCH, which was statistically insignificant at 5% (p=0.134), increases on human disturbances by a factor of 2.655. FWD has a positive regression coefficient (b) of 0 with odds ratio of 0.999 which was statistically insignificant at 5% (p=0.887). This means that the chance of human disturbances in the forest increases by a factor of 0.999 for a unit change in this variable.

DST has a negative regression coefficient (β) of -11.431 with odds ratio (Expβ) of 9.21. This implies that a unit increase in distance between the community and the forests will limit the likelihood of disturbances by a factor 9.21.The factor is statistically significant at probability level of 5% (p = 0.03). NRG has a positive regression coefficient (β) of 0.409 with odds ratio of 1.506 which was statistically significant at probability level of 5% (p=0.053). This means that the chance of human disturbances in the forest increases by a factor of 1.506 for a unit change in this variable

Conclusion

The present study was carried out to investigate the response of forest management modes to human disturbances to forest and biodiversity within seven sites of TAL. The study also analyzed on implication of the findings for biodiversity conservation.A total of 10 threats were identified and subjected to both parametric and non-parametric analysis. Based on the results of inferential statistics, factor analysis and regression analysis, a strategy for successful forest management can be derived. The change of forest ownership to communities posed the positive consequences overall biodiversity conservation through threat reduction. The study concludes that CBM still remains the dominant conservation strategy for prevention and mitigation of threats.

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