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An ecological assessment of anthropogenic disturbance impact on regeneration and Importance value index of woody species in Katerniaghat Wildlife Sanctuary

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Abstract
The objective of present study was to assess the impact of human induced anthropogenic pressure on regeneration and Importance Value Index of woody species in the study area. The study was carried out in Katerniaghat Wildlife Sanctuary having an area of 400km^2 located in Bahraich district off Uttar Pradesh, India. The latitude and longitude of study area is 28^O 06' N & 28^O 24' N latitudes and 81^O 02' E & 81^O 19' E longitude. The sanctuary has moist deciduous type of forest and enriched with wide variety of flora and fauna. For methodology, a reconnaissance survey was carried out and area was stratified on the basis of presence of anthropogenic disturbance indicators into high, medium and low disturbed sites. Circular plot method was used for used for tree and regenerative species in each stratified sites. For data analysis, Importance value Index of woody species, density and Sorenson's similarity coefficient was calculated. The overall highest IVI is of *Lannea grandis* (75.45) in the study area. In low disturbed site, the highest is of *Scleichera oleosa* (28.52). The sapling and seedling density of *Mallotus phillipinensis* was found to be highest in low disturbed site (419.46/ha and 549.3/ha respectively). The Sorenson's similarity coefficient of seedling was found to be highest (46.67%) across high-medium disturbed site compared to tree and sapling layer. The family Fabaceae was represented by seedling layer in the study area with highest proportion (26.66%) compared with tree and sapling layer. In the present study, urgent conservation initiatives are required for species showing lower IVI in highest and least disturbed site. The rare regenerative species having lower densities also needs utmost consideration.

Keywords: Katerniaghat, human induced disturbance, regeneration, trees, IVI

Introduction

Trees are very important and useful to mankind and wildlife in various ways. Trees acts as a micro-habitat for birds and arboreal wild species. Trees also provide timber and non timber forests products to local community for their sustenance and livelihood activities. However, the forest resource extractions have ecological implications over the structure and dynamics of forest ecosystem (Ticktin 2004) [19]. The increase in forest resource dependency is causing conservation issues for the tree species despite of lot of efforts and initiatives worldwide.

For tree species, Importance Value Index (IVI) helps in determining which species needs high conservation effort. In ecological research, The IVI makes the conservation objectives easier by prioritizing the woody tree species with low values (Kacholi, 2014) [9]. The tree species with higher IVI depict its dominating existence in a forest ecosystem (Yirga *et al*., 2019) [20].

The seedling and sapling strata indicate the regeneration of plant species in a community (Manral *et al*., 2018) [14]. The three factors that govern the successful regeneration are: (i) capability to produce seedlings (ii) endurance of seedling and sapling (iii) growing capability of seedling and sapling (Good and Good, 1972) [5]. Regeneration is a cost effective natural process by which plants re-establish themselves and this strategy helps the plants to maintain their diversity and genetic identity (Hanief *et al*., 2016) [6]. The mode of regeneration determines survival through human disturbance and the plant growth after the disturbance (Kennard, 2002) [11]. The less number of seedlings in all the forests may be due to the low viability of seeds, disturbances brought by frequent fire incidence, erosion of soil and water, uncontrolled grazing by animals, cuttings of under canopy plant species by villagers for their domestic cattle etc (Kapkoti *et al*., 2016; Adhikari *et al*., 2017) [1].

The aim of the study was to know the IVI of tree species and status of regenerating species in the different magnitude of human disturbance. Hence, the status of trees species with respect to their IVI values will help in determining their conservation priorities in each site stratified on the basis of degree of human induced disturbance. Moreover, the population density of regenerative species was also calculated to depict health status of the forest due to anthropogenic disturbance in the study area.

Materials and Methods

Study area

Katerniaghat Wildlife Sanctuary is situated in Bahraich district of Uttar Pradesh. The geo-spatial coordinate of the sanctuary are: 28^O 06' N & 28^O 24' N latitudes and 81^O 02' E & 81^O 19' E longitude (Figure 1). The area encompassed by the sanctuary is 400km^2. The sanctuary is subjected to three climatic conditions: summer, monsoon and winter. Its main rivers are Girwa,

Kauriala, Ghaghra and Saryu. The sanctuary supports moist deciduous type of forest. The forest is divided into major three categories: Sal forest, miscellaneous forests and grasslands. The sanctuary is also rich in fauna with 20 identified species of mammals and 166 species of birds. The sanctuary is surrounded by large number of human settlements (Anonymous, 2000) [2].

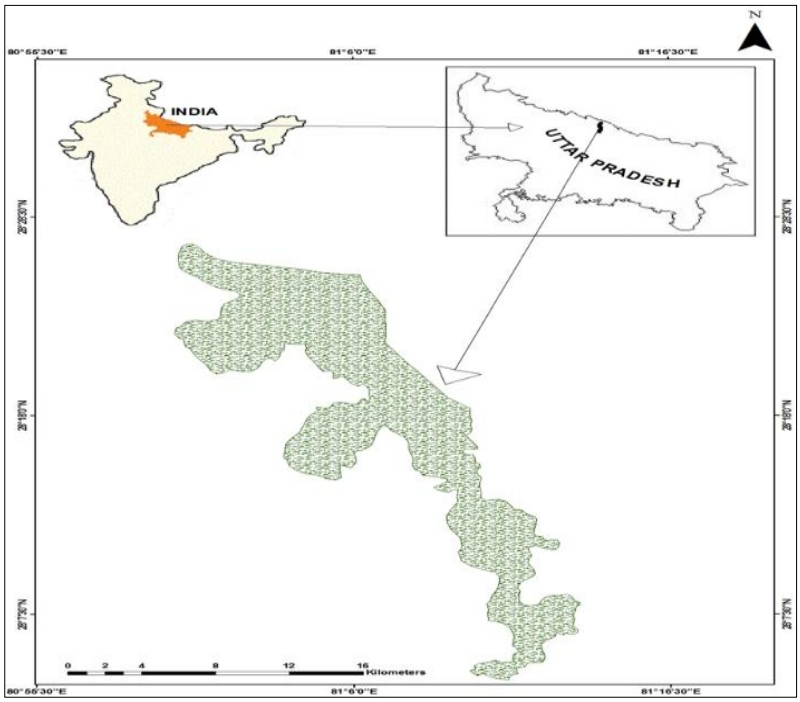

Fig 1: Map of Katerniaghat Wildlife Sanctuary (Tahoor, 2017) [18]

Methods

For sample site selection, study area was stratified into high, medium and low disturbed site through reconnaissance survey. The stratification was done on the basis of presence of human induced disturbance indicators (human trails, cattle dung, lopping and weed). Transects were established in each selected site having circular plot of 10m radius placed equally (at a distance of 200m). The distinct human disturbance indicators were recorded in each stratified site on a scale of 0-4. The value of each disturbance variables was added to get a common index value (CIV) in each circular plot. Then mean of common index value is calculated in each stratified site. That mean value helped us to stratify areas into high, medium and low disturbed sites.

For data collection, circular plot of 10 meter radius at every 200 m (statistically independent samples) was placed on the transect line. Tree layer was sampled within the 10 m radius of plot. The individuals of tree species with>30cm girth at breast height and >3m height was considered as trees (Mueller-Dombois and Ellenbergh, 1974). In each plot species, number of individuals and girth at breast height of each tree was recorded. A nested 5m circular plot was used to assess regeneration pattern. Species not branched from the base of the stem were included in recruitment class and their respective number of individuals were recorded.

For data analysis, Importance Value Index was calculated for tree species. It was done by adding the relative values of density, frequency and dominance (basal area) of each woody species in each stratified sites (Curtis & McIntosh 1950, Krebs 1989) [4, 12]. The density of seedling and sapling was calculated. Similarity index (community coefficient) to determine the similarity in plant species composition between the categorized sites was calculated with the help of following formula (Jaccard, 1912) [8]:

$$C_j = j / (a+b-j)$$

Where, C_j= Jaccard similarity coefficient, a = number of species in area A, b=number of species in area B and J= number of species common to both the area

$$\text{Index of similarity} = 1 - Cj$$

Results and Discussion

Trees: The Importance Value Index of woody species is shown in Table 1. The IVI of *Lannea grandis* is found to be highest (75.45) followed by Dalbergia sissoo (40.33) and *Syzizium cumunii* (39.01) in high disturbed site. The high disturbed site accompanied by highest values of dominance and density for *Lannea grandis* (64.5) and *Dalbergia sissoo* (20.53) respectively. In medium disturbed site, the highest IVI is of *Terminalia alata* (33.03) followed by *Lagerstroemia parviflora* (24.72) and *Sterculia vellusa* (22.72). The tree species showed maximum values for dominance, density and frequency are *Terminalia alata* (28.66), *Sterculia vellusa* (10.924) and *Holoptelia integrifolia* (10.924) respectively. The IVI of *Shleichera oleosa* was found to be highest (28.52) followed by *Shorea robusta* (28.40) and *Tectona grandis* (23.97) in low disturbed site of the study area. The highest values of dominance and density were presented by *Schleichera oleosa* (20.58) and *Tectona grandis* (9.885) respectively. The least IVI in high and medium disturbed site is of *Aegle marmelos* (3.71)

and *Albizzia lebbeck* (5.05) respectively. Whereas, two species (*Helicteris isora and Terminalia tomentosa*) showed least value for IVI in low disturbed site (6.147). The existence of high IVI values for tree species depicts their existence in the forest in terms of dominance, density and frequency of occurrence. In the present study, some species having lower IVI represents their rarity in the forest. In forest, most of the species are rare as compared to common ones (Magurran, 2004) [13]. The reason behind the rarity of the species area: strong density dependency in the forest, existence of resource gradient, poor dispersability of species, human disturbance and inter-species competition (Hubbell *et al*., 2001; Comita *et al*., 2007) [3]. The tree species with lower IVI is commonly used for prioritizing the species conservation initiatives. Most of the tree species were absent across all the three sites. For example, *Albizzia lebbeck, Bauhinia purpurea, Bridelia retusa, Chordia dichotoma, Ehretia laevis, Ficus benghalensis, Helicteris isora, Holoptelia integrifolia, Lagerstroemia parviflora, Shorea robusta, Sterculia vellusa, Streblus asper* and *Terminalia arjuna* were not recorded from the high disturbed site, whereas, found in either medium or low disturbed site.

Table 2 showed sapling density/ha in high, medium and low disturbed site of the study area. In high disturbed site, the maximum density is of *Lannea grandis* (235.75/ha) followed *by Acacia catechu* and *Shorea robusta* (209.82/ha and 181.53/ha respectively). The least sapling density is of Dalbergia sissoo (4.705/ha) in high disturbed site. The site suffering from medium level of disturbance has highest sapling density of *Murayya koenigii* followed by *Mallotus phillipinensis* and *Syzizium cumunii* (240.47/ha, 214.53/ha and 89.58/ha respectively). The same site has low density of *Ficus glomerata, Bridelia retusa* and *Terminalia arjuna* (2.35/ha). In low disturbed site the highest density is of *Murayya koenigii* and *Mallotus phillipinensis* (419.46/ha and 155.6/ha respectively). The lowest density recorded from the same site is of *Ficus hispida* (2.35/ha). Few species showed no individuals of sapling from the low disturbed site. For example; *Bridelia retusa, Dalbergia sissoo, Ehretia laevis, Ficus glomerata, Lagerstroemia parviflora, Lannea grandis, Schleichera oleosa, Terminalia alata and Terminalia arjuna*.

The species wise density/ha of seedling in high medium and low disturbed site is given in Table 3. A total number of twelve seedling species were recorded from the sampled plots of high disturbed site. Where; highest seedling density is of *Murayya koenigii* followed by *Mallotus phillipinensis* and *Lannea grandis* (207.46/ha, 188.6/ha and 148.5/ha respectively). From the same site; the lowest density is of *Aegle marmelos, Terminalia alata* and *Litsea sebifera* (2.37/ha). The species whose individuals were not recorded from the same sites were *Terminalia tomentosa, Chordia dichotoma, Tectona grandis, Ficus glomerata* and *Ficus hispida*. In medium disturbed site; the highest seedling density is of Syzizium cumunii followed by *Murayya keonigii* and Mallotus phillipinensis (483.29/ha, 462.08/ha and 61.23/ha respectively). The lowest seedling density is of *Chordia dichotoma* (2.35/ha). In low disturbed site, the highest seedling density is of *Murayya koenigii* followed by *Mallotus phillipinensis* and *Tectona grandis* (549.3/ha, 332.41/ha and 113.16/ha respectively). *Ficus glomerata* showed lowest seedling density from the low disturbed site (2.35/ha). Some species whose individuals were not present in the low disturbed site are *Terminalia alata, Lagerstroemia parviflora, Lannea grandis, Shorea robusta, Litsea sebifera, Terminalia tomentosa* and *Chordia dichotoma.*

In high disturbed site, *Lannea grandis* was dominant in tree and sapling layer but for seedling stage it occupied the third position. However, the species is represented by the three strata (tree, sapling and seedling). The magnitude of human pressure in coming future may suppress the population density of the species. It is because from the same site, highest population density is of *Murayya koenigii* as recruiting class individuals. In medium disturbed site, *Terminalia alata* was the dominant tree species. Whereas, it's regenerating individuals were not recorded from the site. It showed that the medium level of human disturbance is not favourable to regenerating individuals of *Terminalia alata*. However, few species can tolerate the medium level of human disturbance therefore were represented by recruiting individuals of *Murayya koenigii, Syzizium cumunii* and *Mallotus phillipinensis.* The dominating tree species *was Schleichera oleosa* in low disturbed site. Whereas, *Tectona grandis* showed its presence as third highest seedling species in the low disturbed site. The regeneration status is considered (a) good, if> saplings> adult trees; (b) fair, if seedlings >saplings d" adults; (c) poor, if the species survives only at sapling stage, but not seedlings (though saplings maybe less or equal to adults); (d) no regeneration, if a species is present only in adult form (absent both in seedling and sapling stages) and (e) new, if the species has no adults but is only represented by seedlings or saplings (Shankar, 2001) [17]. Therefore, the species need utmost support for its conservation as the seedling class are highly prone to human induced disturbances like grazing, fire and weed invasion. The seedling phase is the struggle period of that individual to sustain and survive despite of the entire obstacle (natural or manmade). Similar study was carried out by Parveen *et al*., 2017 [16], where, negligible effect of human disturbance was found on tree and its regenerating pattern in montane forests of Garhwal.

Table 4 showed details of Sorenson's similarity coefficient of tree, sapling and seedling in the high, medium and low disturbed site of the study area. For tree layer; the maximum similarity coefficient was found in high-medium followed by medium-low and low-high site (0.44, 0.41 and 0.375). It shows that maximum number of species similarity is present in high and medium disturbed site. The sapling layer, showed highest similarity index for medium-low followed by low-high site (0.40 and 0.25). In case of seedling layer, the highest similarity was recorded from medium-low followed by high-medium site (0.5 and 0.46 respectively). The similarity coefficient showed mixed findings for regenerating class, as medium and low disturbed site showed maximum similarity in species composition as compared to trees.

Table 5 showed overall percentage of families of tree, sapling and seedling in the sampled circular plots of study area. The tree layer is supported by seventeen families in the sampled plots of study area. The highest proportion is of Moraceae followed by Fabaceae and Diptherocarpaceae (13.36%, 12.12% and 9.09% respectively). The lowest proportion is comprised by Lyrthaceae and Rhamnaceae (1.52%). A total number of thirteen plant families supported the sapling strata in the study area, where, major proportion is of Rutaceae (12.5%). The seedling layer is represented by twelve families, where, Fabaceae showed the

highest proportion of (26.66). Few families were not recorded from the study sites for sapling and seedling but symbolized tree layer (for example: Euphorbiaceae, Lauraceae, Malvaceae, Moraceae, Phyllanthaceae and Rubiaceae).

Table 1: The Importance Value Index of woody species in high, medium and low disturbed site of Katerniaghat Wildlife Sanctuary

	High disturbed site				**Medium disturbed site**				**Low disturbed site**			
Tree Species	Dominance	Density	Frequency	IVI	Dominance	Density	Frequency	IVI	Dominance	Density	Frequency	IVI
Acacia catechu	0.078	1.866	3.567	5.512	1.152	4.916	4.916	10.984	2.000	3.844	3.730	9.575
Adina cordifolia	0.504	1.866	1.783	4.154	5.783	2.184	2.184	10.153	2.474	3.020	2.931	8.426
Aegle marmelos	0.060	1.866	1.783	3.710	3.841	2.184	2.184	8.211				
Albizzia lebbeck					0.683	2.184	2.184	5.053				
Bauhinia purpurea					1.093	2.184	2.18	5.463				
Bombax ceiba	1.077	6.618	6.323	14.02	6.1576	3.277	3.277	12.71	5.50	7.048	6.839	19.388
Bridelia retusa					0.027	4.057	4.057	8.142	4.1	3.452	3.34	10.902
Cassia tora					2.778	4.369	4.369	11.518				
Cassia fistula	0.675	2.986	2.853	6.516								
Cassia semiae									2.324	3.020	2.931	8.275
Chordia dichotoma									0.783	3.020	2.93	6.735
Dalbergia sissoo	0.178	20.534	19.619	40.332	5.493	2.184	2.184	9.863	3.400	3.02	2.931	9.352
Ehretia laevis									1.126	6.041	5.862	13.02
Ficus glomerata	0.358	2.800	5.350	8.508	19.163	2.731	2.731	24.62	2.631	6.041	5.862	14.534
Ficus hispida	0.236	4.200	4.0129	8.45	1.137	3.550	3.550	8.238	1.466	3.020	2.931	7.418
Ficus religiosa					0.031	2.731	2.731	5.493				
Helicteris isora									0.195	3.020	2.931	6.147
Holoptelia integrifolia					0.027	10.92	10.92	21.877				
Lagerstroemia parviflora					7.241	8.739	8.739	24.721				
Lannea grandis	64.5	5.600	5.350	75.45	3.787	3.8236	3.823	11.434	7.573	4.83	4.689	17.095
Litsea sebifera	0.516	10.163	9.710	20.390					1.066	3.0206	2.931	7.018
Mallotus phillipinenses	0.087	1.866	1.783	3.738	1.470	4.265	4.265	10.002	2.955	5.437	5.312	13.705
Murayya koenigii					1.604	2.184	2.184	5.973	2.324	3.020	2.931	8.275
Psidium guajava									0.698	3.020	2.931	6.650
Scleichera oleosa	0.123	6.533	6.242	12.899	0.012	3.641	3.641	7.295	20.584	4.027	3.908	28.519
Shorea robusta					0.912	4.916	4.91	10.74	19.52	3.020	5.862	28.408
Sterculia vellusa					0.875	10.924	10.9	22.724				
Streblus asper	0.178	1.866	1.783	3.828	3.108	2.184	2.18	7.478	1.530	5.28	5.129	11.94
Syzizium cumunii	29.779	4.721	4.511	39.012	3.480	3.823	3.823	11.127	2.29	3.020	2.931	8.242
Tectona grandis	1.276	3.266	3.121	7.664	1.563	5.826	5.826	13.216	4.49	9.885	9.592	23.972
Terminalia alata	0.104	4.882	4.664	9.651	28.669	2.184	2.184	33.039	10.127	4.833	4.689	19.649
Terminalia arjuna									0.628	3.020	2.931	6.580
Terminalia tomentosa									0.195	3.020	2.93	6.147
Toona ciliata	0.250	2.800	2.675	5.726								
Zizyphus mauritiana	0.012	15.556	14.86	30.43								

IVI=Importance Value Index, The dominance, density and frequency are in proportionate of their respective relative values

Table 2: Species wise density (ha) of tree in the different magnitude of human induced disturbance sites in Katerniaghat Wildlife Sanctuary

Species	**High**	**Medium**	**Low**
Acacia catechu	5.51	10.98	9.57
Adina cordifolia	4.15	10.15	8.42
Aegle marmelos	3.71	8.21	
Albizzia lebbek		5.05	
Azadirachta indica		5.46	
Bauhinia purpurea			8.27
Bombax ceiba	14.02	12.71	19.38
Bridelia retusa		8.14	10.90
Cassia tora		11.51	
Cassia fistula	6.51		
Chordia dichotoma			6.73
Toona ciliata	5.72		9.35
Dalbergia sissoo	40.33	9.86	
Ehretia laevis			13.03
Ficus benghalensis			8.27
Ficus glomerata	8.50	24.62	14.53
Ficus hispida	8.44	8.23	7.42

Ficus religiosa		5.49	
Helicteris isora			6.14
Holoptelia integrifolia		5.97	
Lagerstroemia parviflora		24.72	
Lannea grandis	75.45	11.43	17.09
Litsea sebifera	20.39		7.02
Mallotus phillipinensis	3.73	10.00	13.70
Mangifera indica		21.87	
Psidium guajava			6.65
Scleichera oleosa	12.89	7.29	28.52
Shorea robusta		10.74	28.40
Sterculia vellusa		22.72	
Streblus asper		7.47	11.94
Syzizium cumunii	39.01	11.12	8.24
Tectona grandis	7.66	13.21	23.97
Terminalia alata	9.65	33.03	19.64
Terminalia arjuna			6.58
Terminalia tomentosa	3.82		6.148
Zizyphus mauritiana	30.43		

Table 3: Species wise density (ha) of sapling in the different magnitude of human induced disturbance sites in Katerniaghat Wildlife Sanctuary

Species	High	Medium	Low
Acacia catechu	209.82		14.14
Bridelia retusa		2.35	
Dalbergia sissoo	4.705		
Ehretia laevis		11.78	
Ficus glomerata		2.35	
Ficus hispida			2.35
Lagerstroemia parviflora	129.66		
Lannea grandis	235.75		
Mallotus phillipinensis	4.715	214.53	155.59
Murayya koenigii	4.715	240.47	419.46
Scleichera oleosa	7.072		
Shorea robusta	181.53		
Syzizium cumunii		89.58	11.78
Tectona grandis		35.36	73.08
Terminalia alata	4.715		
Terminalia arjuna		2.35	
Zizyphus mauritiana	120.23		

Table 4: Species wise density (ha) of seedling in the different magnitude of human induced disturbance sites in Katerniaghat Wildlife Sanctuary

	High	Medium	Low
Acacia catechu	4.71	14.14	16.50
Aegle marmelos	2.35		
Chordia dichotoma		2.35	
Ficus glomerata			2.35
Ficus hispida			4.71
Lagerstroemia parviflora	59.94		
Lannea grandis	148.52		
Litsea sebifora	2.36	11.79	
Mallotus phillipinensis	188.60	61.23	332.41
Murayya koenigii	207.46	462.08	549.3
Scleichera oleosa	4.71		
Shorea robusta	16.50		
Syzizium cumunii	16.50	483.29	63.65
Tectona grandis		11.78	113.16
Terminalia alata	2.36	35.36	
Terminalia tomentosa		23.57	
Zizyphus mauritiana	14.145	18.86	9.43

Table 5: Sorenson's similarity coefficient and percentage of tree, seedling and sampling in the three disturbed categorized sites of Katerniaghat Wildlife Sanctuary

Area	Tree	Sapling	Seedling
High-medium	0.44 (44)	0.133 (13.33)	0.466 (46.67)
Medium-low	0.411 (41.1)	0.4 (40)	0.5 (50)
Low-high	0.375 (37.5)	0.25 (25)	0.33 (33.33)

*Values in parentheses are in percentage

Table 6: The overall percentage of family of tree, sapling and seedling in the sampled circular plot of Katerniaghat Wildlife Sanctuary

Family	Tree	Sapling	Seedling
Anacardiaceae	6.06	4.16	3.33
Boraginaceae	3.03	4.16	3.33
Combretaceae	10.6	8.3	10
Dipterocarpaceae	9.09	4.16	3.33
Euphorbiaceae	4.54		
Fabaceae	12.12	2.5	26.66
Lamiaceae	4.54	8.3	6.66
Lauraceae	3.03		6.66
Lytheraceae	1.52	4.16	3.33
Malvaceae	7.57		
Moraceae	13.36	8.3	
Myrtaceae	6.06	8.3	10
Phyllanthaceae	3.03	4.16	
Rhamnaceae	1.52	4.16	10
Rubiaceae	4.54		
Rutaceae	4.54	12.5	13.33
Sapindaceae	4.54	4.16	3.33

Conclusions

In the present study, it has been concluded some woody species needs urgent conservation initiatives because of low values of IVI. Some species from recruiting class needs consideration because of lower representation by their respective individuals. The stratification of sites on the basis of magnitude of human disturbance was highly supportive to prioritize the conservation objectives foremost needed by the woody species and their respective recruiting class. To increase the population and abundance of species, strict action is required to control the illegal activities inside the protected area. The local people participation for conservation should be encouraged. Conservation awareness education programs should be initiated on village level.

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