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Comparative assessment of floristic diversity in a buffer zone community forest and a community forest of Barandabhar Corridor, Chitwan, Nepal

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This research was carried out in the Bandevi buffer Zone Community Forest (BZCF) and Satkanya Community Forest (SCF) of Barandabhar corridor area in Chitwan district of Nepal to assess and compare the status of floristic diversity in buffer zone community forest and community forest in Barandabhar corridor in Chitwan district of Nepal, managed under different rules and regulations. Primary data were collected from reconnaissance survey, direct observation, forest inventory, interviews with forest user group members and key informant interview. Secondary data were collected from the forestry stakeholders working in community forestry and buffer zone sectors. The floral diversity was assessed by using Simpson's Diversity Index (SI), Shannon Weiner Diversity Index (WI) and Margalef Species Richness Index (MI). Information on management practices were assessed by field observation, key informant interview and review of operational plan of respective forests. Diversity index (SI=0.9367 and WI =3.3714) and species richness index of (MI=10) of BZCF were found higher than the diversity index (SI=0.8749 and WI =3.0099) and species richness index (MI=9.0491) of SCF. We conclude that floral diversity is higher in BZCF than the CF outside the buffer zone under similar edaphoclimatic conditions.

Key words: Community forest, buffer zone community forest, floristic diversity, diversity index, species richness index, Nepal.

INTRODUCTION

Nepal, a small Himalayan country of Asia represents one of the unique places of the world, which boasts of high bio-diversity is under continual disturbance by the local people. Plant species richness of Nepal comprises 465 species of lichens, 1,822 species of fungi, 687 species of algae, 853 species of bryophytes, 534 species of pteridophytes, 27 species of gymnosperms; and 5,856 species of angiosperms (GoN, 2009). The biological diversity contained in the Terai and Siwalik Hills (lowlands) ecosystems are of international importance both in view of the number of globally threatened species of fauna and flora as well as the diversity of ecosystems in these area. There are 1,885 species of angiosperms, 61 species of bryophytes and 81 species of pteridophytes from the Terai plain and Siwalik hill (BPP, 1995). The community forests are national forests handed over to the

forest user group (FUG) under section-25 of forest act for management and utilization for the collective benefit of the community (HMG, 1995). The buffer zone community forests are national forests handed over to the buffer zone user committee (BZUC) under section-21 of National park and wildlife conservation Act -1972, with amendment to manage, utilize the forest product and conserve the biodiversity for the collective benefit of the buffer zone community (HMG, 1999). Buffer zone community forest is one of the participatory forest management initiatives within the buffer zone management program which has a crucial role to improve the park-people relationships.

With the shift to active forest management in community forestry, several types of silvicultural operations such as cleaning and weeding, thinning, pruning, coppicing, selective felling, singling, collecting litter, grass, and dry twig, grazing, establishing and monitoring of trial plots, harvesting and removing dead and logged trees along with planting new species have been

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designed and undertaken by community forest user groups (CFUGs) (Dhital et al., 1998; Ojha and Bhattarai, 2001; Khadka and Schmidt-Vogt, 2008; Acharya, 2003). Practices such as seedling plantation, controlling wildlife hunting, forest fire and grazing, regulating forest encroachment, protecting soil erosion prone area and water resource area assist biodiversity conservation, paradoxically other practices such as species selection, removal of unwanted species during silvicultural activities, leaf litter collection, elite dominance in decision making, and traditional knowledge depletion have detrimental impact on biological diversity and ecosystem function of community managed forest (Shrestha et al., 2010). Silviculture affects these three attributes of forest ecosystem in different scale and intensity if not carried out with caution; it can threaten biodiversity.

The community forestry management approach offers an attainable means to conserve the biodiversity of Nepal. The programme is successful in rehabilitating degraded hills and thereby in increasing the biodiversity (Shrestha et al., 2010). However, the prevalent management approach in community forestry indicates increasing threats to the conservation of biodiversity. In addition, existing legal and administrative base favors for the management approach, which threats biodiversity and argued that the prevalent forest management approach in community forestry recognizes biodiversity conservation as secondary issue and there is evidences that biodiversity has been either decline or has been altered in community managed forest (Acharya, 2003).

On other hand, it is perceived that it has contributed to biodiversity conservation (Adhikari et al., 2004; Kijtewachakul et al., 2004). Maintaining compositional, structural and functional attributes of forest ecosystem is one of the important approaches of biodiversity conservation. Pokharel et al. (2005) claimed that community forests have improved overall forest conditions including biodiversity. Pandey (2007) found comparatively higher tree species diversity on community-managed forest stands than the national parks and government managed forests. However, more rigorous studies are necessary to understand whether the current management practices in community forests have been ameliorating or aggravating or bringing no change in the forest biodiversity. In this context, this study was carried out to find out and compare the current status of floral diversity in two forest categories: 1) a buffer zone community forest and 2) a community forest; managed under different management rules and regulations in Barandabhar corridor area of Terai region of Nepal.

MATERIALS AND METHODS

Study area

Two community forests of Barandabhar corridor area, Chitwan district of Nepal (Figure 1) were selected for the present study with a criterion: Satkanya community forest (SCF) is managed under Forest Act and Regulation (1993, 1995), and Bandevi Barandabhar buffer zone community forest (BZCF) is managed under National Parks and Wildlife Conservation Act and Regulation (1972, 1996). Both these forests are part of important Barandabhar corridor area of Nepal.

BZCF lies at 27°38' N latitude and 84°26' E longitude in the buffer zone area of Chitwan National Park. The area has alluvial soil with shallow ground water table with 5 to 15% gentle slope. The forest covers an area of 167 ha. There are 1500 households in the user's group of this buffer zone community forest. The forest was handed to local community in 1995. It is one part of Barandabhar corridor area of Nepal and an important place from biodiversity conservation point of view. This forest is dominated by Sal (*Shorea robusta)* associated with Asna (*Terminalia tomentosa*), Barro (*Terminalia belerica*), Kyamun (*Syzygium cerasoides)*, Jamun (*Syzygium cumini*) and Botdhanyero (*Lagerstroemia parviflora*). SCF lies at 27° 40' N latitude and 84°33' E longitude. The area has alluvial soil with shallow ground water table. The forest covers an area of 72 ha. There are 384 households in the user's group of this community forest. The forest was handed to local community in 1997. It is one part of Barandabhar corridor area of Nepal and an important place from biodiversity conservation point of view. This forest is dominated by Sal associated with Asna, Barro, Kyamun, Jamun and Botdhanyero.

Data collection and analysis

Management practices of both forests were studied from their operational plan, direct observation of practices on-site, reviewing the government rules and regulation for provisions on the management and utilization of the forest resources of respective forest types according to management authority and objective of management. Systematic random sampling with square nested sample plots was employed to collect quantitative information on floral diversity with 1% sampling intensity for tree species (≥30 cm diameter at breast height (DBH)), 0.5% for shrubs and saplings (≤10 cm DBH and more than 1 m height), 0.001% for herbs and seedlings (30 to 100 cm height) in each forest. The plot size for surveying tree and poles (pole has 10 to 29.9 cm DBH) was 10×10 m; 5×5 m for shrubs and sapling; and 1×1 m for herbs and seedling (Oosting, 1956; in Gysel and Lyon, 1980; in Sutherland, 1996; Rayamajhi, 1994). 18 sample plots were laid in SCF and 13 were located in BZCF. The number of species and their abundance with respect to their diameter were recorded in a standard data sheet. The plant species were identified with the help of standard literature of plant identification in Nepal and visual inspection by taxonomist and knowledgeable local informants.

Secondary data were gathered from published literatures, maps, and related line agencies such as District Forest Office, Terai Arc Landscape Programme Office, Chitwan National Park, Community Forest User Group Office, Federation of Community Forest User Groups in Nepal, Forest Action. These literatures were reviewed in order to have better understanding, interpretation and analysis for the present study. Formal and informal interviews were organized among community forest user groups, concerned buffer zone user committee, buffer zone community forest users, key informants, district forest officer, national park's warden and buffer zone management committee members about current management practices in respective forests and legal status of management.

Data collected from the field survey were processed to calculate species richness and diversity function of the study area, as well as density and relative density, frequency and relative frequency of the species, diversity indices and species richness index using the standard formulas in Magurran (2004). Secondary data were systematically reviewed and information on forest management practices; provisions of existing rules and regulations for management and utilization of forest resources in CF and BZCF;
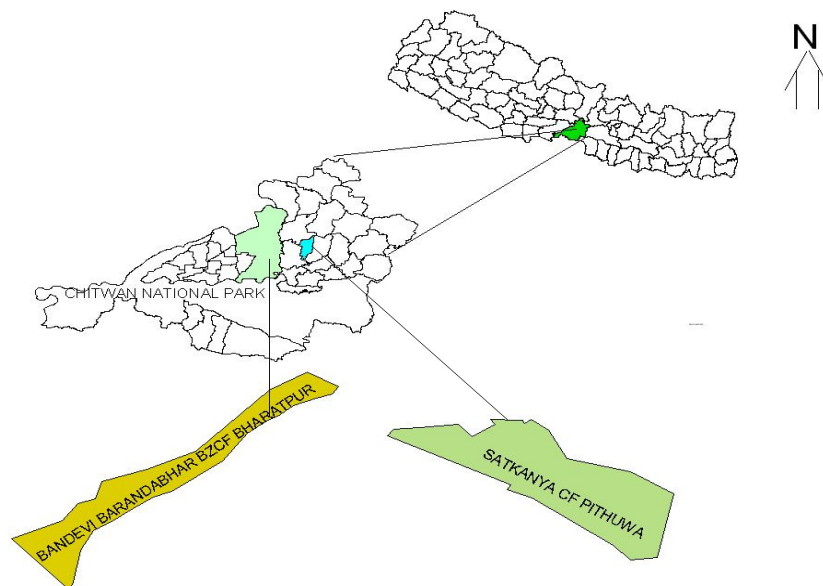
Figure 1. Map showing research sites: Study area.

and research methodology were extracted qualitatively.

RESULTS AND DISCUSSION

Historical perspectives on forest management

The review of operational plan of the community forest showed that until the early 1970s, Barandabhar forest was covered by dense vegetation and was a good habitat for Tiger, Rhino and other wildlife species. After 1972, a large number of people migrated to the study area from the adjacent hills. This resulted in clearing, degradation and fragmentation of the forest due to encroachment. During this time, the forest area was under the jurisdiction of the district forest office, and some conservation initiatives had already been initiated by the government. The degradation of forest continued till the early 1990s. The scarcity of forest resources became severe in the area and the pressure on the forest area increased. In the mean time some conservation initiatives were started, such as fencing around the forest, management of grasslands, plantation of fodder and timber species. After the declaration of the buffer zone, the area came under the jurisdiction of the authority of Chitwan National Park and was considered as a buffer zone forest and it was later handed over to the community as buffer zone community forest. Now, this corridor forest is being managed mainly in two types of management categories that is 1) government managed forest management type and 2) community managed forest management type. Community forests are also managed in two different ways under two acts and rules with different objectives.

Patrolling, forest fire control, control of encroachment,

illegal felling, grazing and hunting, and soil conservation and wildlife conservation are common forest protection and conservation practices in SCF and BZCF. BZCF is fenced along the boundary. Soil and water source conservation activities in wildlife habitat, wetland management, grass land management, species conservation, bird and insect conservation and conservation education, conservation awards and awareness are the major biodiversity conservation activities in BZCF. Cleaning, singling, pruning, thinning, retention of mother tree for regeneration, felling as silvicultural operation and dead wood removal are the common silvicultural operations in SCF and BZCF. In SCF, forest nursery development, plantation, check dam and forest road construction and NTFP identification and promotion also exist as forest development activities. Plot fixing, marking, tree felling, depot of timber, distribution and marketing of timber, pole extraction, firewood collection, leaf litter collection, long bole (lingo) collection, NTFP collection by users and supply of timber outside from user group boundary by bidding (tender) are the activities of forest product collection, utilization and distribution in SCF.

In BZCF, timber of only fallen trees were collected, poles were collected from branch and tending materials, firewood, leaf litter, charcoal and NTFPs were collected according to the collection plan. Forest products are not supplied outside the buffer zone area according to Buffer Zone Management Regulation. Agroforestry programme is promoted to fulfill the insufficient forest products demanded by local community. Road gravelling, construction of culvert, drinking water supply and support for schools are the activities of community development. Group empowerment, training, demonstration plot

Table 1. Summary of diversity and species richness index by forest management types.

Management types	Number of spp.	Maximum number of ind./ spp.	Minimum number of ind./spp.	Total number of ind. of all spp.	Richness index	Diversity index	
	S	Ni max	Ni min	N	MI	SI	WI
SCF	58	196	1	556	9.0491	0.8749	3.0099
BZCF	71	184	1	987	10.00	0.93675	3.3714

Ind. = Individuals, spp = Species, SI=Simpson's diversity index, WI=Shannon Weiner diversity index, MI=Margalef species richness.

establishment, forest based income generation (NTFP cultivation, broom grass farming, mushroom farming, goat farming, candle manufacturing training) are major pro-poor focused activities as forest management and livelihood enhancement practices in SCF and BZCF.

Overall budget of the SCF was allocated 20% in community development, 15% in administrative cost, 35% for livelihood programme, 25% for forest development programme and 5% as saving. Total budget allocated for different components in BZCF are: community development (23%), administrative cost (15%), income generation (5%), wildlife damage compensation (2%), institutional development (5%), forest conservation and management (35%), education and conservation education (5%), and eco-tourism management (10%).

Diversity and species richness of flora by forest management types

A total of 71 species of flora were recorded in BZCF and 58 in SCF. Shannon Weiner species diversity indices (WI) of BZCF and SCF were 3.3714 and 3.0099 respectively. Similarly, the Simpson's diversity indices (SI) of BZCF and SCF were 0.93675 and 0.8749 respectively. Jha and Acharya (2008) found the Shannon diversity index of 1.63 in some CFs of mid-hills of Nepal which were already handed over to CFUGs 5 years ago with a diversity index of 1.22.

Kharal (2000) found Shannon diversity index of 1.8 in rural farmlands of Chitwan district, which has similar physiography, elevation and climatic condition with Barandabhar area. Most of the tree species were represented by less number of individuals. The trend of species richness index (Margalef) in the study area was found almost similar to that of Shannon diversity index. The species richness index of whole BZCF (MI=10) was found higher than that of SCF (MI=9.0491) (Table 1).

Diversity and species richness of flora by plant life forms

Both Shannon and Simpson's diversity indices of tree/ pole sapling, tree seedling and herb were higher in BZCF than SCF while both diversity indices of seedlings of shrub and established shrubs were higher in SCF than BZCF. The species richness index of tree and shrub categories were lower in BZCF than that of SCF while species richness index of herb was found higher in BZCF than in SCF. The comparative diversity and species richness index are illustrated in Table 3.

Status of plant life forms and abundance

The number of trees and poles in the BZCF (711/ha) was higher than that of SCF (677/ha). Similarly, the number of tree seedlings (79444/ha), shrub (1444/ha) and herbs (228333/ha) in BZCF was also found higher than the SCF (70769/ha, 454/ha and 113846/ha respectively). The number of saplings (3844/ha) and shrub seedlings (40000/ha) in BZCF were lower than the saplings (4308/ha) and shrub seedlings (43846/ha) in SCF (Figure 2). It reflects that the BZCF is dense than SCF, in terms of the number of plant individuals.

Distribution of individuals of different plant life forms

The percentage of tree and shrub species in SCF is higher as compared to BZCF while percentage of herb species is less in SCF area. Regarding the whole area, number of individuals of tree species is more than that of shrub as well as herb species. It was found that the abundance of shrub species is lower than that of other plant categories in both BZCF and SCF. A total of 58 and 71 plant species were recorded in SCF and BZCF area respectively. The range of species richness found within a sample plot varied between 3 and 23 in BZCF; whereas, it was 2 and 18 species in SCF. The number of species of tree, shrub and herb was 22, 13 and 41 in BZCF respectively; whereas it was 21, 12 and 25 in SCF.

The proportion of herb species was higher in BZCF than in CF but proportion of tree and shrubs were higher in SCF than BZCF. Sigdel (2008) found a total of 147 species (36 trees, 37 shrubs and 74 herbs) in Shivapuri National Park in mid-hill of Nepal (1000 to 2000 m elevation) where the proportion of herbs were

Table 2. Abundance distribution of different life forms of plants in sampled area.

Plant life form	Category of forest									
	BZCF					SCF				
	No. of spp.	Total no. of individuals	% of ind.	Max. no.	Min. no.	No. of spp.	Total no. of individuals	% of ind.	Max. no.	Min. no.
Tree /Pole	14	128		14	1	9	88		4	1
Sapling	17	173	45	10	3	17	140	59	8	1
Seedling	14	143		9	2	10	92		7	1
Established shrub	8	65	14	6	1	6	18	14	5	1
Shrub seedling	6	72		4	1	10	57		9	2
Herb	39	411	41	15	3	25	148	27	13	5
Total	71	992	100	23	3	58	543	100	18	2

Ind. = Individuals, spp. = Species.

Table 3. Diversity and species richness index by plant life forms.

Plant life forms	Management type							
	BZCF				SCF			
	Diversity index		Richness index	No. of spp.	Diversity index		Richness index	No. of spp.
	SI	WI	MI	S	SI	WI	MI	S
Tree	0.7707	2.01639	2.6793	14	0.55878	1.23999	4.4773	9
Sapling	0.8248	2.1315	3.1048	17	0.62477	1.61557	3.2378	17
Tree seedling	0.7621	2.0006	2.4559	14	0.7396	1.45098	2.6538	10
Established shrub	0.7351	1.46825	1.6769	8	0.8497	1.69202	1.7299	6
Shrub seedling	0.2766	1.436193	1.1619	6	0.90226	2.229526	4.043	10
Herb	0.8939	2.79706	6.3138	39	0.8605	2.694898	4.6025	24
Total	0.9367	3.2126	10	71	0.8749	3.0099	9.0491	58

SI=Simpson's diversity index, WI=Shannon Weiner diversity index, MI=Margalef species richness, S=Total number of species.

higher as that of BZCF. The detailed information on growth form of plant species found in the study area is presented in Table 2.

Conclusion

Diversity of tree species, measured in terms of Shannon diversity index, Simpson's diversity index, Margalef species richness index in BZCF and SCF areas as a whole were found to be
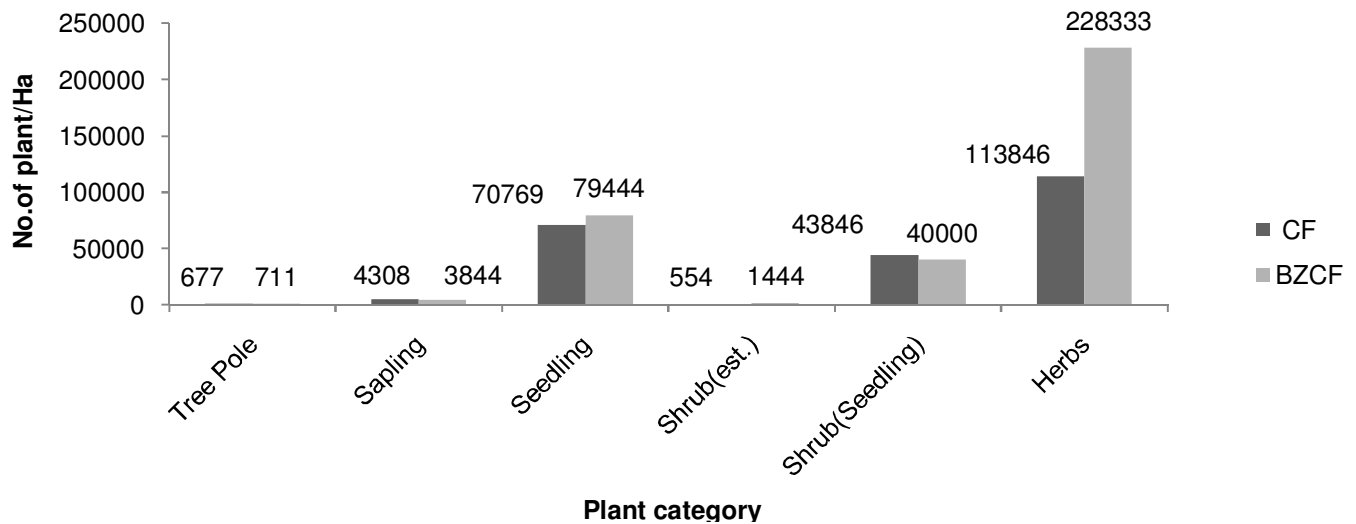
Figure 2. Abundance of plant categories.

higher than those values in CFs of mid-hills of Nepal and also to be higher than those in farmlands of similar geographical region of Nepal. The index values are found to be higher in BZCF than SCF area. The major cause influencing both index values in both management types was due to the higher abundance of individuals of single species especially *S. robusta*. A total of 71 plant species were found in BZCF area, while 58 species were recorded in SCF area. The distribution of individuals of herbs and seedlings was found more than 80% in both management types (CF and BZCF) while that of tree /pole forms were less than 1%.

The number of trees per ha and species number in community forest was found to be lower than that of BZCF. One of the major causes of that difference in number of individuals is management activities and silvicultural operation. Species preference, selection, ignorance and removal of lower plants, insufficient knowledge on biodiversity, overgrazing, forest fire and forest encroachment were mainly responsible for lowering more species in SCF of corridor area. The distribution of individuals of tree, shrub and herb forms in BZCF was found to be higher while those of shrub seedling and tree sapling forms were found too low than in CF. Similar trend was found for species diversity and species richness index in both management types. The diversity index of tree, tree sapling, seedling and herb forms were found to be higher in BZCF than of SCF but diversity index of shrub forms is high in SCF than in BZCF. Percentage of individual number of tree species in SCF sampled area was higher than the sampled area of BZCF.

Herb and shrub species were found higher in BZCF sampled area than the SCF sampled area. The Simpson's diversity index (SI) of seedling and shrub

seedling of SCF was found higher than in BZCF whereas the same index of tree; shrub and herb were found higher in BZCF than in SCF. Shannon Weiner diversity index (H') of shrub and shrub seedling of SCF was found higher than in BZCF whereas the same index of tree, sapling, seedling and herb shrub and herb were found higher in BZCF than in SCF. It is concluded that floral diversity and species richness was found higher in BZCF than in CF even though these areas have the same edhaphoclimatic condition. It gives general clue that community forest management practice under the NPWC Act 1972; was favorable for floral diversity conservation than the management practice under the Forest Act 1993; however this clue needs further research for deriving specific conclusion.

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