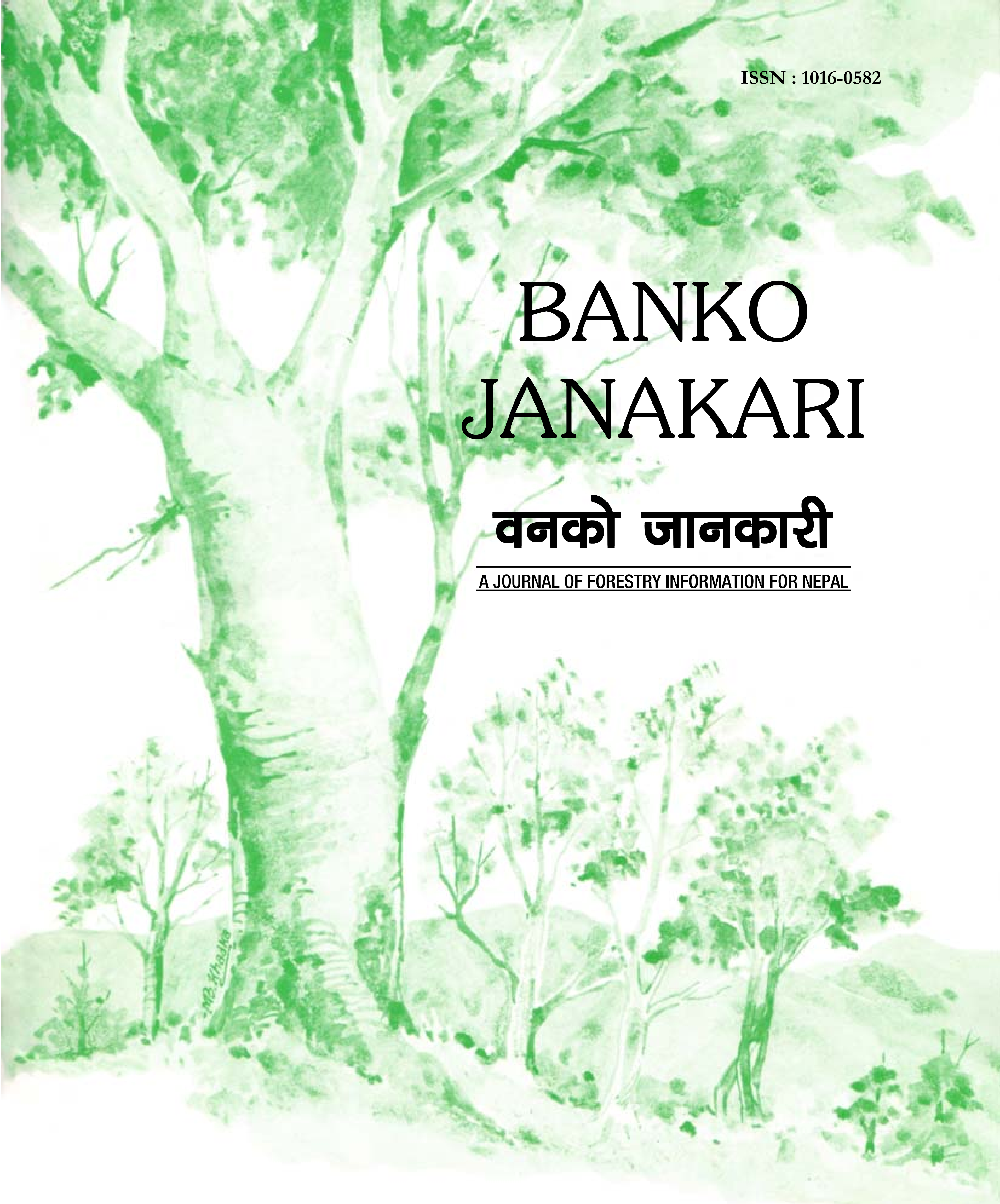
ISSN : 1016-0582

BANKO JANAKARI

वनको जानकारी

A JOURNAL OF FORESTRY INFORMATION FOR NEPAL



Vol. 19, No. 1 May 2009

Banko Janakari is published by the Department of Forest Research and Survey (DFRS), Ministry of Forests and Soil Conservation, Government of Nepal. Any opinions expressed in this publication are those of the authors and should not be taken to represent official policy.

Editorial policy is made by the Advisory Committee of the Department of Forest Research and Survey.

Mr. S. M. Shrestha, Director General

Editorial Board Members of the *Banko Janakari* are:

Mr. R. Shakya, Co-ordinator
Mr. H.B. Thapa, Member
Mr. S. K. Ojha, Member
Mr. R. Malla, Member Secretary

Contributions and correspondence should be addressed to:

Member Secretary
Department of Forest Research and Survey
PO Box 3339
Babar Mahal
Kathmandu, Nepal.
E-mail: bankojanakari@gmail.com

© Department of Forest Research and Survey, 1999
Produced by the Information Section of DFRS

Information regarding previous issues can be retrieved from, ***http://www.dfrs.gov.np***

Banko Janakari

A journal of forestry information for Nepal

Biodiversity Conservation

Nepal is rich in biological diversity (biodiversity) due to its varied climate and altitudinal ranges within short interval distance. Nepal comprises only about 0.1 percent of the terrestrial area of the earth but it harbors high share of biodiversity. A total of 118 ecosystems with 75 vegetation types and 35 forest types. Nepal has a global commitment to the Nepali people and its government for biodiversity conservation and sustainable development within broad framework of Convention on Biological Diversity (CBD). So, it is very crucial to conserve nature gifted biological resources to maintain diverse ecosystem of Nepal. Nepal has made lots of efforts to conserve biodiversity and in this regards, Nepal Biodiversity Strategy (NBS), 2002 and Nepal Biodiversity Strategy Implementation Plan (NBSIP), 2006 have also been prepared.

The NBS defines biodiversity as species diversity, ecological diversity and genetic diversity. The biological diversity in Nepal is closely linked to the livelihoods improvement, economic development, agricultural/ forest productivity and ecological sustainability. Furthermore, it relates to human health and nutrition, indigenous knowledge, gender equity, building materials, water resources, and the aesthetic and cultural well being of the society.

Conserving biodiversity cannot be achieved successfully under single sector approach. It needs proper co-ordination and co-operation from multi sectors and cross sectors whereby several cross sectoral issues can be addressed.

The paradigm of conservation of biological resources in Nepal is shifting from species level to ecosystem level and finally to landscape level. This effort of landscape level conservation is being carried out in some parts, especially focusing on Protected Areas, of the nation only. However, most of the forests such as community forest, leasehold forest, national forest, private forest still have not received much concern about biodiversity conservation.

There is a need of effective implementation of the Nepal Biodiversity Strategy in all sectors for the protection and wise use of the biologically diverse resources of the country, the protection of ecological processes and systems, and the equitable sharing of all ensuing benefits on a sustainable basis.

At present context, climate change and its impacts on environment as a whole is a burning issue. The impacts on biodiversity due to climate change need to be addressed to conserve biodiversity. There are biodoversity hotspots which are vulnerable to climate change because they are rich in endemic species with restricted distribution. If we talk about species level conservation, which species will be lost if climate change takes place?

Biodiversity conservation in situ contribute towards carbon sequestration which could be another benefit through carbon financing on one hand while carbon financing mechanism that conserve forest and promote sustainable land use could have a adverse impact on biodiversity conservation on other hand.

The rich biodiversity of the country has to be conserved by proper implementation of Nepal Biodiversity Strategy Implementation Plan, and a high priority must be given for conservation and sustainable forest management. Research in forests and flora, scientific forest management for conservation of biodiversity are areas of research for conservation of biodiversity. The focus on species level conservation should also be given at least for key stone species at present context.

Diversity of vascular plant communities along a disturbance gradient in a central mid-hill community forest of Nepal

S. K. Baral[1] and K. Katzensteiner[2]

The 'Community Forestry Program' has been considered successful in improving the environmental situation in the hills of Nepal by enhancing the vegetation coverage of degraded sites and by improving the supply of forest products to farmers. The restoration measures are considered sustainable if the ecosystems are self-supporting and resilient against perturbation. A community forest (CF) in the mid-hills of Nepal has been assessed for restoration success based on the comparison of vegetation structure and species diversity along a disturbance gradient, using a semi-protected natural forest as a reference site. In general, the community forest management (CFM) was able to re-establish forests on formerly severely degraded sites. Forest operations carried out during CFM have altered plant community composition, species richness and distribution, age class distribution of trees and vegetation structure. As a result, the CF was being transformed into a less diverse regular forest although the overall vascular plant diversity was retained with sufficient niches within the understorey vegetation.

Keywords: Central mid-hills, community forest, disturbance regimes, Nepal, plant diversity

Community Forestry (CF) has proved to be an efficient approach in the forestry sector of Nepal. In the mid-hills, it is credited with improving people's livelihoods and conserving natural landscapes (Satyal, 2004). Also the CF program is noted for in increasing the vegetation coverage (greenery) of degraded sites, fostering local level institutions for resource management, improving the supply of forest products to farmers, and correcting the environmental situation in the hills of Nepal (Acharya, 2003).

The agricultural system in Nepal relies on the interdependence of arable land and livestock with forests (Satyal, 2004). In the hills of Nepal, farmers rely heavily on forest litter that is collected for animal bedding and then enriched with animal excrement to be incorporated as compost into the agricultural system. In this kind of interlinked hill farming system, CF has strived to supply forest products to local users and while conserving biodiversity with silvicultural techniques such as cleaning, weeding, thinning and pruning.

Padma (2007) reported that CF had positive impacts on biodiversity conservation by increasing the vegetation cover and the number of wildlife species, thereby averting the local extinction of species. However, his study revealed that CFUGs tended to conserve only "useful" species i.e. low-quality timber trees, shrubs, climbers, grasses and herbs were removed, a practice that could have undesirable implications on biodiversity. Such implications include a changed community structure, a reduction of understorey species, and even age stands with low biodiversities. The present case study tests a methodological approach for comparing and analyzing the impacts of silvicultural techniques and biomass extraction from community forests on vascular plant diversity. The investigations were carried out along a disturbance gradient in a CF in the central mid-hills of Nepal.

Materials and methods

Study site

The study was carried out in Dhulikhel, the district headquarter of the Kavrepalanchowk District, 30 km east of Kathmandu. The district covers an area of 140, 486 hectares and stretches between 85° 24' - 85° 49' E longitude and 27° 20' - 27° 85' N latitude in the central mid-hill region. It has been one of the

[1] Assistant Research Officer, Department of Forest Research and Survey, Babarmahal, Kathmandu, Nepal
e-mail: sharadbaral@gmail.com
[2] Assoc.Prof., Institute of Forest Ecology, Department of Forest and Soil Science, University of Natural Resources and Applied Life Sciences, Vienna, Austria

pioneer districts for the implementation of the community forestry program (Sharma 2000), a fact that provides an opportunity to interact with experienced forest user groups who have been involved for over 15 years in community forestry management activities (Humagain 2003). Moreover, the impacts of forest management activities on vascular plant diversity can be pronounced. The 'Gaukhureshwar Community Forest' (hereafter CF) and an adjoining semi-protected natural forest (Thulo ban) owned by the Dhulikhel Municipality (hereafter MF) have been selected for the study. The forests share similar climatic conditions, topographic features and belong to the same vegetation zone (Webb and Gautam, 2001).

History of the forests

Historically, the study site was a dense forest till 1933. Afterwards, the forest was gradually exploited. A series of natural calamities (earth quake, heavy rainfall) had disturbed the forest. Additional pressures from population growth and urbanization have led to severe degradation. Apparently, both the CF and MF were subjected to exploitation after 1934 to 1962. However, it is not clear which one of the two was more exploited in terms of resources (Webb and Gautam, 2001). Although the forests were classified as CF and MF based on the rights of management and utilization, the land ownership of both forests remained with the Government of Nepal, according to the Forest Act 1993.

Gaukhureshwar community forest (CF)

By 1981 the forest had been almost cleared for grazing pasture and only a few trees and bushes remained. In 1985 the local people made an effort to restore their forest by applying for support from the District Forest Office, Kabhre for enrichment planting with *Pinus roxburghii* and to employ a forest watcher. Later on, the District Forest Office, Kabhre formally handed over 21 ha of this forest to the local people, thereby formulating a forest user group in 1992. Subsequently, secondary succession ensued (Webb and Gautam, 2001) and *Pinus roxburghii* was outcompeted. The stands were about 20 years old by 2007. Now the forest user group is managing this forest as a community forest and applying silvicultural techniques, according to their operational plan (Personal communication with the head of the CFUG Badri Jangam, 2007).

Dhulikhel municipality owned forest (MF)

The remaining patch of the forest (Thulo Ban) has been protected by the residents of Dhulikhel city since 1962 in order to conserve the watershed. After the establishment of the Dhulikhel Municipality in 1986, an important contribution to the protection of MF was the deployment of watchmen. No utilization activities had taken place since then (Webb and Gautam, 2001).

Data collection

Sampling design

A CF and a MF were selected for the field survey in comparable topographic positions. The diversity status of vascular plants and forest structure were compared between forest areas facing a high pressure of biomass extraction through the community forest management activities (CF) and the better protected municipality owned forest, facing little anthropogenic pressure (MF) as a reference site. Cleaning, thinning, pruning and litter raking activities had been carried out in the CF. Although the collection of forest products in MF had not been allowed, there had been some illegal collection of forest products (such as dry branches, tree stumps and litter in some plots).

A transect survey from the base to the top of the hill was conducted systematically to collect the primary data of each forest (CF and MF). In this transect, the survey was carried out in 8 systematically placed square-shaped composite plots of 10m×10m for poles, 5m×5m for shrubs and regeneration, and 1m×1m for herbs, a design which is a standard for contemporary community forest inventory in Nepal. The sample plots were located at least 50 m apart and at least 20 m interior from the edges or roads. After conducting a rapid forest survey, the required number of sample plots to reach a confidence interval for the average weight of biomass in the CF of 10 % was calculated by using the following formula:

Number of plots (n) = $(t * 100 * S_x / W * e \%)^2$

Whereby

- t = tabulated value of student $t_{DF\text{-}n\text{-}1}$, p=0.05,
- DF = degrees of freedom
- S_x = standard deviation of biomass
- W = Average weight of biomass
- e = required accuracy [%]

Forest inventory

Tree height, diameter at breast height (DBH) and crown width were measured for each plot. A clinometer was used for measuring tree height, and a D-tape and a measuring tape were used for the determination of DBH and crown width (diameter), respectively. The number of species in the understorey was recorded. The amount of litter left on the forest floor was estimated from 30 cm × 30 cm plots. By interviewing the FUG members, the quantity of litter collected from the CF was estimated.

Scaling the disturbance

To compute the simple plant community-based indices (plant diversity indices) of forest disturbance, the level of disturbance was scaled from 1-4 in an ordinal scale, where 1 is the lowest and 4 is the highest level of disturbance, based on the visual observation of sample plots on the basis of the amount of litter left on the forest floor, trampling and tree lopping and felling (Table 1).

Secondary data

Records of the forest management activities and the data related to the amount of forest products harvested/collected were drawn from the community forest user group's office and District Forest Office records.

Data analysis

Calculation of above ground biomass, basal area and diversity indices

The total above ground tree biomass was calculated by using the biomass table prepared by Tamrakar (1999). Basal area was calculated by using equation 4 below. Three biodiversity indices for the vascular plant diversity were calculated from the information of the forest inventory. Shannon Wiener Index was used as the index affected by both the number of species and the evenness of their population. This index increases as both values (number of species and evenness) increase. On the other hand, the Simpson's index was used as a dominance index. It is weighted towards the abundance of the most common species and measures the probability of two individuals randomly selected from a sample belonging to the same category. In this measure, as the index goes up, so does diversity.

The following formulae were used to calculate the diversity indices (Timberline Forest Inventory Consultants Ltd, 2003).

Shannon-Wiener index **H =** $-\sum_{i=1}^{s} p_i \times \log p_i$ **....1**

Simpson's diversity **D =** $1-\sum_{i=1}^{s} p_i^{\,2}$ **.................. 2**

Evenness **E = H / log (N 3**

BA = $\pi DBH^2/4$. **.. 4**

Where:

s = number of species

p_i = proportion of the i^{th} species in a community

N = total number of species

DBH = diameter at breast height (1.3 m) from the ground level

Statistical analysis

Descriptive statistics was used to describe stand structure, forest composition and forest management activities. The differences between diversity indices of the different forest types were subjected to a Mann-Whitney U test because these parameters were not normally distributed. Basal area per hectare, number of plants in the understorey per hectare and estimated above ground biomass were subjected to independent sample t-tests. The level of significance used was $\alpha = 0.05$.

Results and discussions

Forest management history, forest structure and diversity of vascular plants

Forest type and management activities

The forest vegetation type belonged to the boundary line between the sub-tropical Schima-Castanopsis

Table 1: Criteria for scaling the disturbance

S.N.	Criteria	Score				Overall score
		1	2	3	4	
1	Amount of litter left on the forest floor (Litter raking)	>70%	50-70%	30-50%	<30%	The overall score of the plot is: if the total scores
2	Trampling	Low	Medium	High	Very high	
3	Tree lopping and felling	Few	Medium	High	Very High	9-12=4, 6-9=3, 3-6=2 and <3=1.

forest and the lower temperate forest. Major species found in the forest were: *Castanopsis tribuloides*, *Quercus glauca*, *Rhododendron arboreum, Myrica esculenta, Myrsinia rivularis* and *Schima wallichii etc.*

Litter raking was the dominant method of biomass extraction activities from the forest. Cleaning (removal of unwanted shrubs and weeds and singling of desired species) and thinning/pruning were the other silvicultural operations undertaken after the forest was handed over to the community. The intensity of thinning entirely depended on traditional knowledge. In this system, only the dead, dying, crooked, malformed and weak trees were preferentially removed. On average, 30% of pole-sized trees were removed in the thinning operations and the branches were pruned up to 50% of tree height. During winter, litter raking has been free for the users. Grazing and illegal collection of forest products were totally prohibited. Table 2 displays the record of quantity of biomass extracted at different time periods from the community forest.

Forest structure

The MF had a higher stem density per hectare. However, the understorey density was higher in CF. In the MF, basal area was almost double that of CF, and the estimated above ground biomass was also slightly higher. Similarly, both the maximum tree height (13.5 m) and the maximum DBH (29.5 cm) were significantly higher in MF (Table 4).

A larger part of the basal area in the MF was occupied by the trees with higher diameters but in the CF the larger part of the basal area was contributed by trees with 5-15 cm DBH since there were no trees thicker than 20 cm DBH (Fig 1).

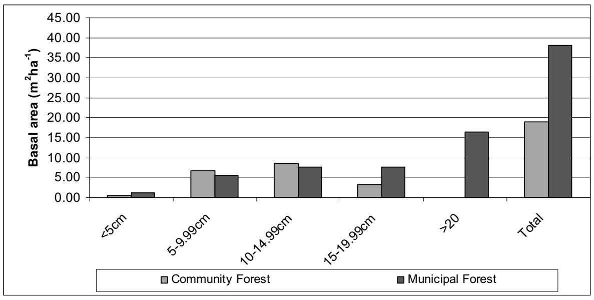


Figure 1: Basal area distribution in different DBH classes

Castanopsis tribuloides and *Quercus glauca* were the major dominating tree species in CF occupying the higher share (almost 80%) of the total basal area, whereas the basal area was distributed rather fairly among all the species that were found in the site in MF (Fig 2).

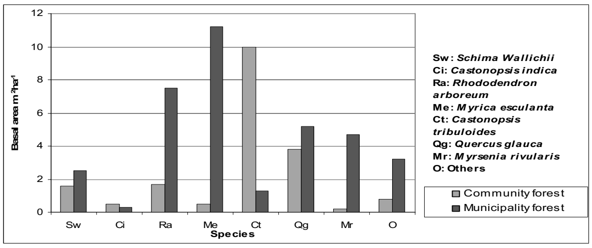


Figure 2: Basal area distribution of tree species in the CF and MF

The average biomass in the MF was 17.61 kg m^{-2}, SE = 0.91, a sum significantly higher than the average biomass of the CF (12.08 kg m^{-2}, SE = 0.86). In the CF, almost 85% of the biomass was contributed by two major tree species *Castanopsis tribuloides* and

Table 2: Community forest management activities and quantity of forest biomass extracted

S.N.	Year	Management activities	Forest product extraction		
			Product	Unit*	Quantity
1	1993	Cleaning	Fuelwood with green foliage	Mg ha^{-1}	3.7
2	1994	Cleaning	Fuelwood with green foliage	Mg ha^{-1}	2.8
3	1997	Thinning/pruning	Fuel-wood	m^3 ha^{-1}	1.2
		(Average thinning intensity = 30%)	Timber	m^3 ha^{-1}	0.4
			Foliage	Mg ha^{-1}	0.3
4	1999	Cleaning	Fuelwood with green foliage	Mg ha^{-1}	6.8
5	Annually	Litter raking (82% of the total litter)	Litter	Mg ha^{-1}	3.2

***** The unit was calculated considering 1 bhari = 40 kg for green foliage and fire wood and 1 bhari litter = 25 kg of litter

Table 3: Density, basal area and estimated above ground biomass in different forest types

Forest type	Basal area m^2ha^{-1}	No. of stems ha^{-1}	No. of plants in the understorey ha^{-1}	Max. tree height (m)	Max DBH (cm)	Estimated above ground biomass (kg m^{-2})
CF	19.03[a]	2525	7050[a]	12.5	16.5	12.18[a]
MF	38.19[a]	2725	4850[a]	13.5	29.5	17.72[a]

[a] Significant difference between CF and MF in independent samples t-test at á=0.05.

Quercus glauca but in the MF the biomass was distributed among the wider species composition typical to this forest type (Fig 3). This observation suggests a tendency for species preference among forest users in community forest management. They probably preserved preferred species (*Castanopsis tribuloides* and *Quercus glauca)* and removed others. In the CF, they had also removed bigger and older trees during silvicultural operations to provide space for a future crop of younger trees of the preferred species.

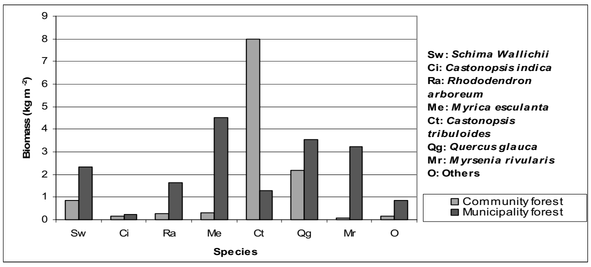


Figure 3: Biomass distribution of tree species in the CF and MF

Species richness, abundance and diversity indices

The cumulative tree species number increased with the increasing number of plots. The number of understorey species rapidly increased in the initial plots but the increase declined after the fifth plot for both forests. The slope of the curve for understorey flattened after five to six plots (Fig 4).

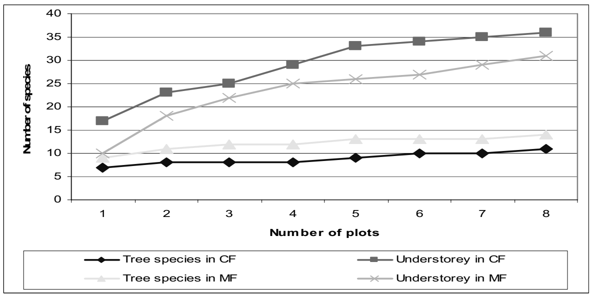


Figure 4: Cumulative number of species

From this pattern it can be concluded that the number of plots was sufficient to describe the diversity within the two forest types.

There were 40 vascular plant species of 30 families found in the CF but in the MF only 36 species of 25 families were recorded. The number of tree species was slightly higher in the MF (14 species of 10 families) than that of the CF (11 species of 8 families) (Annex 1). The diversity index for the tree layer in the CF was 0.96 for Shannon Wiener, 0.48 for Simpson and 0.6 for Evenness, as opposed to 1.6 for Shannon Wiener, 0.75 for Simpson and 0.85 for Evenness in the MF. This result underscored the higher tree species richness and their more even distribution within the MF than in the CF (Table 4).

While the tree layer diversity was significantly higher in the MF than in the CF, the understorey vegetation diversity was slightly higher in the CF, although this difference was insignificant (Table 4).

Castanopsis tribuloides and *Quercus glauca* were the most abundant tree species found in the CF, whereas *Myrsinia rivularis*, *Quercus glauca*, *Rhododendron arboreum* and *Myrica esculenta* were the species having a higher abundance in the MF (Fig 5).

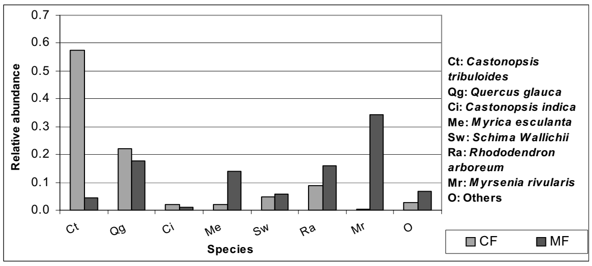


Figure 5: Abundance of different tree species in CF and MF

Table 4: Number of families and species in forest, Shannon Wiener diversity index, Simpson's index and Evenness at study sites

Forest type / Layer	Number of species	Total number of families	Shannon-Wiener Index (H)	Simpson's Index (D)	Evenness (E)	Remarks
CF						
Tree layer	11	8	0.96[a]	0.48 [a]	0.60 [a]	
Under storey	36	30	1.96	0.84	0.91	
Total	40	30				
MF						
Tree layer	14	10	1.6 [a]	0.75 [a]	0.85 [a]	
Under storey	32	25	1.87	0.8	0.88	
Total	36	25				

[a] denotes the significant difference between CF and MF in the Mann Whitney U test at α=0.05.

Tree diversity indices according to different scale of disturbance

The value of Shannon Wiener index and Simpson's index were plotted against the scale of disturbance in the plots. Fig 6 shows that when the intensity of disturbance increased from 1 to 2, the tree diversity in the forest slightly increased but heavy disturbance (categories>2) was associated rapid decrease in diversity.

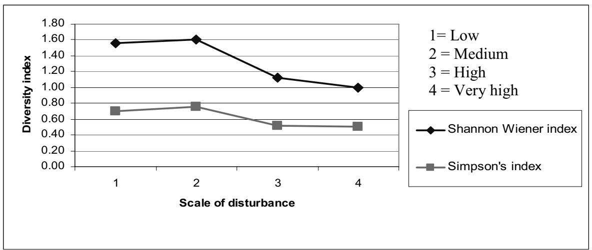


Figure 6: Value of diversity indices with respect to different scale of disturbance

This study indicated that the basal area per hectare, biomass and tree density were higher in the forest that was better protected (MF) than in the community forest. Species diversity in the tree layer was also higher in the MF. Forest biodiversity depends on even age class distribution, presence of various tree species and proper distribution of these species in the forest stand (HMG/N 2002). However, the number of plant species in the understorey vegetation (tree species<5cm DBH and other shrubby species) was found to be higher in the CF. This finding was similar to the findings of Webb and Gautam (2001) who observed that the mature, semi-protected forest had a substantially greater basal area while the community forest exhibited a higher density of small diameter trees, which was typical of a young successional forest.

Managed forests were more diverse in plant species than primary forests, and were also more heterogeneous in a study of Sebastia et al. (2005) conducted in Southern Europe. Research carried out in the boreal forests of Canada had suggested that vascular plant species diversity peaked on moderately treated sites (Heusler et al., 2002). Likewise, diversity was rapidly restored through succession in community forests of Nepal although the forest structure was not complex (Webb and Gautam, 2001). However, in this study, tree species were found to be less diverse in the CF than in the MF although the understorey was more diverse. This might be due to the silvicultural activities carried out by CFUGs based on local knowledge and skills that focused on the promotion of preferred tree density (Acharya, 2003) for economic benefits from tree species useful for timber (Pandey, 2007). The most abundant species in the CF (*Castanopsis tribuloides* and *Quercus glauca*) were highly valued by farmers for their high yield of leaves, and as multipurpose trees usable for fodder, fuelwood, agricultural implements and timber (Jackson, 1994).

Silvicultural activities change the tree species composition (Schelhas and Greenberg, 1996) and if they are not carried out with caution, they can jeopardize biodiversity (Putz and Blate, 2001). These findings confirmed that the tree diversity decreased in the CF. There were 40 species of 30 families in the CF while in the MF, there were only 36 species of 25 families. However, a contradictory finding of this study was the higher vascular plant species richness in the CF. Low impact management mimicking natural disturbances enhances plant diversity (Sebastia et al., 2005) and, therefore, the management that mirrors natural disturbances is recommended to sustain biodiversity (Harvey et al., 2002).

Conclusions

Silvicultural techniques applied in CF affect forests by altering plant community composition, species richness and distribution, and age class distribution of the trees. From the study it can be concluded that the CF was changing into less diverse, uniform stands with a low number of species in the tree layer compared to a regular semi-protected forest. However, the overall diversity of vascular plants was maintained by providing proper niches for a rich understorey vegetation. From a biodiversity conservation point of view, special attention must be paid to the maintenance of species diversity in the forest composition when executing silvicultural operations in the community forest. To keep disturbance at an intermediate level would be an appropriate strategy for CF management to achieve the paradoxical twin objectives of i) supplying the basic needs for forest products to the forest users and ii) for maintaining the vascular plant diversity in forest ecosystems.

Acknowledgements

The authors would like to thank the Gaukhureshwar Community Forest User Group Dhulikhel-1, Kabhrepalanchok. We acknowledge the ITTO

Fellowship Program, Japan for providing financial support to conduct this study. We also would like to thank Mr. Bimal Acharya, Assistant Research Officer, Department of Forest Research and Survey, Babarmahal, Kathmandu and Mr. Dil Bahadur Purja Pun, Ranger, Department of Forest, Babarmahal, Kathmandu, Nepal for their support during data collection.

References

Acharya, K.P. 2003. Conserving biodiversity and improving livelihoods: The case of community forestry in Nepal. Paper presented at The International Conference on Rural Livelihoods, Forests and Biodiversity 19-23 May 2003, Bonn, Germany.

HMG/N 2002. **Nepal Biodiversity Strategy**. Ministry of Forest and Soil Conservation, His Majesty's Government of Nepal.

Haeussler, S., Bedford, L., Leduc, A., Bergeron, Y. & Kranabetter, J.M. 2002. Silvicultural disturbance severity and plant communities of the southern Canadian boreal forest. *Silva Fennica* **36(1):** 307–327.

Harvey, B. D., Leduc, A., Gauthier, S. and Bergeron, Y. 2002. Stand landscape integration in natural disturbance-based management of the southern boreal forest. *Forest Ecology and Management* **155(1-3):** 369-385.

Humagain, K. H. 2003. Sustainability of community forest in terms of operational plan implementation: multiple case studies from central and western Nepal. Dissertation submitted to the Institute of Forestry, Trbhuvan University, Nepal for the partial fulfilment of the requirement of the Master of Science in Forestry.

Jackson, J. K. 1994. **Manual of Afforestation in Nepal**. Forest Research and Survey Centre, Ministry of Forest and Soil Conservation, Nepal Second edition. Volume 2. 824pp.

Padma, T. V. 2007. Community forestry: the regreening of the Himalayas. www.SciDev.Net Accessed on 20th April 2008.

Pandey, S. S. 2007. Tree species diversity in existing community based forest management systems in Mid-hills of Nepal. Master thesis, No. 44, Uppsala 2007, ISSN:1653-834X.

Putz, F.E. and Blate, G.M. 2001. Tropical forest management. *Conservation Biology* **15(1):** 7-20

Satyal, P. P. 2004. **Country Profile Report- Forestry Sector in Nepal**, Forests Monitor, Cambridge (UK).

Schelhas, J. and Greenberg, R. 1996. Introduction: the value of forest patches, In *Forest patches in tropical landscapes*: J. Schelhas and R. Greenberg (eds.). Island Press, Washington, DC, pp. 15-35.

Sebastia, M. T., Casals, P., Vojnickvick, S., Bogunic, F. and Beus, V. 2005. Plant diversity and soil properties in pristine and managed stands from Bosnian mixed forests. *Forestry* **78 (3):** 297-303.

Sharma, S. K. 2000. Management of *Pinus patula* stands by the forest user groups in Nepal. A thesis submitted to Georg-August University Goettingen, Germany for the partial fulfillment of the Master in Tropical Forestry.

Tamrakar, P. R. 1999. Biomass Tables for Katus-Chilaune Forest Type. Department of Forest Research and Survey, Kathmandu, Nepal. Research Leaflet No. 8.

Timberline Forest Inventory Consultants Ltd. 2003. Monitoring plant diversity: Simpson's index and species richness assessment. Canadian Forest Products Ltd. 5162 Northwood Pulp mill Road, Prince George, Canada.

Webb, E. L. and Gautam, A. P. 2001. Effects of community forest management on the structure and diversity of a successional broadleaf forest in Nepal. *International Forestry Review* **3(2):**146-157.

Annex 1: List of plant species found in the forest at study sites

Family	Species	Habit	Occurrence	
			Community forest	Municipality forest
Acanthaceae	*Thungbergia coccinea*	climber		√
Ampelidaceae	*Leea robusta*	Shrub	√	
Anacardaceae	*Rhus succedanea*	Small tree	√	√
Asteraceae	*Inula cappa*	Shrub	√	√
Asteraceae	*Eupatorium adenophorum*	Shrub	√	
Betulaceae	*Betula alnoides*	Tree	√	
Campanulaceae	*Lobelia alsinoides*	Small tree		√
Caprifoliceae	*Viburnum coriaceum*	Shrub	√	√
Cyperaceae	*Cyperus cyperoides*	Herb/grass		√
Cyperaceae	*Cyperus rotundus*	Herb/grass	√	√
Dryopteridaceae	*Dryopteris atrata*	Herb/Fern	√	√
Ericaceae	*Rhododendron arboreum*	Tree	√	√
Ericaceae	*Lyonia ovalifolia*	Tree		√
Fabaceae	*Indigofera cylindracea*	Shrub	√	
Fagaceae	*Castanopsis tribuloides*	Tree	√	√
Fagaceae	*Quercus glauca*	Tree	√	√
Fagaceae	*Castanopsis indica*	Tree	√	√
Gleicheniaceae	*Gleichenia glauca*	Herb/Fern	√	√
Lamiaceae	*Scuttelaria discolor*	Herb/grass	√	√
Lauraceae	*Litsea citrate*	Tree	√	
Loranthaceae	*Maesa chisia*	Shrub	√	√
Melastomataceae	*Osbeckia stellata*	Herb	√	√
Melastomataceae	*Melastoma normale*	Shrub	√	√
Meliaceae	*Walsura trijuga*	Tree	√	
Myricacea	*Myrica esculenta*	Tree	√	√
Myrseniceae	*Myrsenia rivularis*	Tree	√	√
Myrseniceae	*Myrsenia semiserrata*	Tree	√	√
Oleaceae	*Fraxinus floribunda*	Tree	√	√
Oleandraceae	*Nephrolepsis cordifolia*	Fern	√	
Phyllanthaceae	*Phyllanthus parvifolius*	Shrub	√	
Poyaceae	*Digitaria sanguinalis*	Herb/grass	√	√
Poyaceae	*Eragrostis tenella*	Herb/grass	√	√
Poyaceae	*Athraxon lancifolius*	Herb/grass	√	√
Poyaceae	*Arundinaria intermedia*	Grass/bamboo		√
Ranunculaceae	*Clematis buchananiana*	Herb	√	√
Rosaceae	*Syzygium cumini*	Tree	√	
Rosaceae	*Robus ellipticus*	Shrub	√	√
Rubiaceae	*Loranthus spps.*	Tree	√	√
Smilacaceae	*Smilax menispermoides*	climber	√	√
Symplocaceae	*Symplococus ramosissima*	Shrub	√	√
Thaeceae	*Schima wallichii*	Tree	√	√
Thaeceae	*Eurya cerasifolia*	Tree	√	√
Thaeceae	*Cleyera ochnacea*	Herb	√	√
Thaeceae	*Camellia kissi*	Shrub	√	√
Orchids	species not determined	Epiphytes	√	√

Scores for Effective Forest Conservation: A Village-to-Village Approach

R. K. Pokharel[1] and H. O. Larsen[2]

Community forestry in Nepal strives for forest conservation and sustainable forest management. Evaluating progress towards this end requires periodic measurements, and currently there are no standard tools for undertaking evaluations in a participatory way. The purpose of this paper is to suggest a standardized way for measuring effective forest conservation through the use of locally set scores. A village-to-village approach was used to assign scores on criteria and indicators developed earlier for forest conservation. A total of eight small meetings with forest users were conducted to elicit their perspectives and quantify their progress towards conservation by means of scores. For the 14 criteria specified, local forest users assigned higher scores to four criteria: two for social and one each for socio-economic and environmental spheres. This paper argues that a score of 59 or above is an effective cut off for determining "effective" forest conservation.

Keywords: Community forest, criteria, forest management, indicator, village,

This paper attempts to address the issue about how to compare the performance of community forest management in terms of effective forest conservation. We use the criteria and indicators developed by Pokharel and Larsen (2007) as a basis for assigning scores to evaluate effective forest conservation. The criteria and indicators were developed to determine whether CFUGs conserved forests effectively. Indeed, effective forest conservation is expected to lead to a sustainable forest management, the ultimate goal of community forestry program (Acharya, 2002), and that of Nepal's forest policy (HMG, 2000). The government has instituted a forest conservation award at the national level to recognize and encourage CFUGs to manage their forests sustainably. Every year, the government recognizes the three most successful CFUGs according to a set of guidelines (MFSC, 2004) for this award. As one of the foundations of Nepal's community forestry is the participation of local forest users in the planning, implementation and general decision making (HMG, 2000; Springate-Baginski et al., 2003), arguably, the local perspectives on the performance indicators should also be accorded due recognition. In line with this thinking, some exploration of local perspectives have started (Smith et al., 2003; Shrestha and Khanal, 2004; Pokharel and Larsen, 2007; Pokharel and Suvedi, 2007). However, none of the studies of comparison, proposed so far, have incorporated local priorities. Local scoring of criteria and indicators is one way of providing some means for comparison that will take into account the local perspectives in the evaluation. A set of agreed criteria will furthermore allow evaluation to be highly transparent. Transparency is important to motivate forest users, because in Nepal, people often manipulate things in favor of *afno manche* (ones own people, friends or relatives) once in power. In this context, this paper is expected to contribute to the development of a transparent evaluation system for Nepal's community forests. Furthermore, it is also expected to assist the villagers to examine the effectiveness of their forest conservation.

Materials and Methods

This paper uses the criteria and indicators developed by Pokharel and Larsen (2007) for evaluating effective forest conservation. Scores are assigned by local people on their assessment of the criteria and indicators developed by the CFUGs they visit. We chose village to village approach as this permits researchers to cross check the information, and to acquire the perspectives from males, females, and from different castes and so on, to foster a feeling of local ownership of the process. Village to village approach requires visiting rural areas and offering

[1] Institute of Forestry Tribhuvan University, PO Box 43, Pokhara, Nepal; e-mail: ridishp@gmail.com
[2] Forest & Landscape, Copenhagen University, Denmark; e-mail: hol@life.ku.dk

local people a chance to reflect on and analyze their experiences. In this study, we used a village-to-village approach by visiting CFUGs and holding 20-30 minutes informal discussions for assigning the score along the given criteria and indicators.

A total of eight small group meetings were conducted with CFUG members separately (one meeting each in Jaykot, Kankali, Rani, and Malatimahila CFUGs and two meetings each in Thanimia and Simalchaur CFUGs). Since only one individual attended the first meeting of Thanimai and Simalchaur CFUGs, we decided to conduct additional meetings with these CFUGs. Locating individuals interested in participating in the discussion was relatively easy as good rapport had been nurtured through earlier visits and the researcher was also familiar with the local situation. We directly approached forest users for small group meetings since the first author was familiar with the local situation and CFUGs. We first contacted a random individual in the field and then requested him or her to invite a few more individuals to a small group meeting. The meeting was conducted at *chautaras* (communal meeting/resting places under specific tree shades in a village) or at one of the respondents' home, depending on the convenience of the respondents. The data was recorded in September 2006.

Results and discussions

The meetings were conducted with an air of informal ambience. Working together with small groups as indicated by Schusler et al (2003) provided an opportunity for dialog among participants. At each meeting, we explained the purpose and objective of our visit and about the criteria and indicators. Then, with a flip chart, the list of the criteria and indicators was expounded. We invited the participants to assign a score, between 1 and 10, for each application of the criterion and indicator in forest conservation in their own situations. Ascribing a quantitative number or value for each of the criteria and indicators was not easy for forest users, and at first they could hardly agree on a common, assessed value. After discussing among themselves they finally reached consensus. So by applying the criteria and indicators to their own situations and assigning the scores accordingly, they were able to compare the effectiveness of forest conservation for different CFUGs. Each score was recorded onto the flip chart and read aloud so everyone could confirm what number was agreed on for a given set of criterion and indicator. After the recitation of the scores, the participants sometimes revised the scores for some criteria or indicators.

Table 1 lists the average scores and adjusted scores for the given criteria and indicators used in this study. The average scores and the adjusted scores are the sum of all scores divided by the number of meetings and the final score for each criterion and indicator, respectively. We computed the average score as the sum of the scores for each criterion and indicator assigned by local people divided by number of meetings. Similarly, we computed the adjusted score by converting the total score into 100.

Pokharel and Larsen (2007) identified two types of indicators – cumulative and non-cumulative. Cumulative indicators meant more than one indicator could be assigned to a given CFUG, but only one non-cumulative indicator could be assigned. As values for criteria could be assigned from 1 to 10 to calculate the total score of a CFUG indicator, values proportionate to the value of the relevant criterion are summed. For example, if an area at the time of handover to a CFUG was naked or barren the score value would be 9. When adjusted for the relative importance of the criterion, this value would be 7.63 out of 10, and this score is adjusted to 6.86. For cumulative indicators, the maximum total value that could be assigned was the value of the corresponding criterion. The indicator values assigned are reduced proportionately. For example, if community forest management had resulted in increased greenery and improved water quality, a score of 15.51 was assigned. The average criterion score was 8.38, the total assigned score of indicators was 32.25, and the adjusted score, therefore, came to be 4.03. The maximum total value of a CFUG was 94.06, while the minimum was 23.84, with the average score being 58.95.

The results indicate that local forest users perceived attendance of all users in the general assembly and development of healthy environment as the most important inputs for sustainable community forest management, whereas the size of the CFUG fund and composition of the forest management committee were perceived as less important. The criteria and scores indicate that community forest users envision conservation as requiring a holistic perspective, assigning high scores to criteria on environmental, social and socio-economic spheres such as the use of CFUG funds.

Table 1: Average score on criteria and indicators as perceived by local people

Criteria	Indicators	Average criteria score	Average indicator Score	Adjusted score
Attendance of all users in general assembly*		8.38		7.76
	Up to 50%		5.13	3.95
	51 – 75%		7.63	5.89
	Above 75%		9.38	7.21
Development of healthy environment		8.38		7.76
	Increased greenery		8.63	2.14
	Increasing availability of water source		8.38	2.07
	Reduced soil erosion/landslides		8.38	2.07
	Improved drinking water quality		6.88	1.70
Forest management practices		8.25		7.64
	Block division in the forests		8.75	2.93
	Construction of fire line		7.63	2.55
	Regular silvicultural operation		7.5	2.51
State of forests at time of evaluation		8.25		7.64
	Presence of good shape trees		8.75	1.86
	Reappearance of spp. that were lost		8.25	1.75
	Appearance of wildlife		8	1.70
	Community access to fuel wood		7.88	1.67
Financial transparency of CFUG committee		8.13		7.53
	Presentation of financial report in GA**		8.75	2.14
	Access of all users to financial report		8.75	2.14
	Presentation of financial report in PH		8.13	1.99
	Formation of sub-committee for FM		7	1.71
Use of CFUG funds		8		7.41
	Community development works		7.88	1.56
	Forest improvement activity		7.88	1.56
	Self-employment skill development		7.63	1.51
	Literacy programs for forest users		6.13	1.21
	Soft loan for income generating		5.63	1.12
Proportion of women in general assembly*		8		7.41
	Up to 25%		4.88	3.55
	26 – 50%		7.25	5.33
	51 – 75%		7.88	5.77
	Above 75%		8.63	6.37
Performance of CFUG committee		7.75		7.18
	Preparation of yearly CFUG report		8.75	1.47
	Meetings are conducted regularly		8.63	1.45
	Effective information sharing		8.13	1.37
	Formation of sub-committee for MA		8	1.35
	Assessment of users' needs		8	1.35
State of forest before hand over*		7.63		7.07
	Naked and barren hills		9	6.36
	Plantation areas		7.25	5.09
	Natural forests		6.5	4.59
Forest protection system*		7.63		7.07
	Self-disciplines		9	6.36
	Users on rotational basis		7.38	5.16
	Hiring forest watchers		5	3.53
Awareness of forest importance among users		7.38		6.84
	CFUG organizes tree planting activity		7.25	2.58
	Illegal cutting from forest is reduced		6.88	2.45
	Informal class on forestry issues		5.5	1.96
Forest products distribution system*		7		6.48
	Equity – needy get more		7.75	4.98
	Equal – all get equal share		5	3.24
CFUG fund size*		6.88		6.37
	Below Nrs15,000		4.88	3.05
	Nrs15,000 – 24,999		6.13	3.88
	Nrs25,000 – 49,000		7.25	4.58
	Nrs50,000 and above		8.63	5.47
Composition of CFUG committee*		6.75		6.25
	Proportional representation of sexes		8.5	5.31
	Equal ratio of male and female		7.88	4.87
	50% or more are women		7.25	4.50
	Domination of one group		4	2.50
	Only men		3.13	1.93

*Indicators under the criteria are non-cumulative

**PH meaning public hearing; FM meaning financial monitoring; GA meaning general assembly; MA meaning monitoring activities

Interestingly, the participants were reluctant to assign full scores to neither criteria nor indicators. This may be the acculturation spill over from experiences with the Nepalese education system wherein students are rarely awarded a hundred per cent score on a test. This tendency introduces methodological problems for the interpretation of the evaluation.

Generally, criteria are assigned higher scores when they reflect current problems, for example, with regards to the distribution of forest products and gender inequality (Agrawal, 2001; Malla et al., 2003), financial transparency, and environmental aspects. The community forestry program is regarded as environmentally beneficial (Gautam et al., 2002; Karna et al., 2004).

At this point an evaluation of CFUGs according to the presented criteria and indicators would yield comparative quantitative information about the success of forest conservation. We propose that, for now, CFUGs earning average or more of the possible score (score with 59 and higher) be designated as demonstrating "effective" forest conservation.

The number of CFUGs visited for this study was small. To develop a national list of criteria and indicators truly representing the views of forest users would call for more observations. In terms of methods, the village to village visit approach was found to be effective for fostering interaction with the local people and for gathering information. This approach allowed us to observe a village, get a sense of what was going on, and to compare the information with field reality. Moreover, it was relatively easy to establish rapport with local people by demonstrating respect and interest. Indeed, local people felt happy when their work was acclaimed and cited as one of the reasons for choosing the area. The village to village approach requires building trust with local people which is not an easy task. Several visits and positive discussions regarding the local work would facilitate the build-up of trust.

Conclusions

Developing and scoring criteria and indicators for forest conservation assists local people to evaluate their own performances. They can use it as a transparent tool to evaluate themselves independently – whereas central evaluations are perceived to be opaque and often invite controversy and illegitimacy. This study has demonstrated that forest users can develop and score criteria and indicators for forest conservation, and that their perceptions of conservation are more holistic than narrow. Some conceptual challenges were encountered regarding the reluctance to assign absolute maximum and minimum scores of 100 or 0 to indicators. In general, though, this experience has shown that forest users were able to discuss the evaluation of forest management competently and that the village to village visit approach was effective for gathering reliable information.

References

Acharya, K. P. 2002. Twenty five years of community forestry in Nepal, *International Forestry Review* **4 (2):** 149 – 156.

Agrawal, B. 2001. Participatory exclusions, community forestry, and gender: An analysis for South Asia and a conceptual framework, *World Development* **29:** 1623 – 1648.

Springate-Baginski, O., Dev, O. P., Yadav, N. P. and Soussan, J. 2003. Community forestry management in the Middle Hills of Nepal: the changing context, *Journal of Forests and Livelihoods* **3 (1):** 5 – 20.

Gautam, A.P., Webb, E.L., and Elumnoh, A. 2002. GIS assessment of land use/land cover changes associated with community forestry implementation in the Middle Hills of Nepal, *Mountain Research and Development* **22:** 63 – 69.

His Majesty's Government of Nepal (HMG) 2000. **Revised Forestry Sector Policy,** HMG, Ministry of Forests and Soil Conservation, Kathmandu/ Nepal

Karna, B.K., Gyawali, S. and Karmacharya, M.B. 2004. Forest condition change: Evidence from five revisited community forests. In K. R. Kanel, P. Mathema, B. R. Kanel, D. R. Niraula and M. Gautam (eds.), *Twenty five years of community forestry, Proceedings of the fourth national workshop on community forestry,* Community Forest Division, Department of Forests, Kathmandu: 118 – 123.

Malla, Y.B., Neupane, H.R., and Branney, P. 2003. Why aren't poor people benefiting more from community forestry? *Journal of Forests and Livelihoods* **3 (1):** 78 – 93.

MFSC, 2004. *2059 salko ganeshman singh bansanrakchan puraskar 2054 kolagi 059/7/13ko chhalfalbata chhanaut samitile prastab gareko abedan faram (*proposed application guidelines 2059 for Ganesh Man Singh forest conservation award 2054 by selection committee meeting held on 2059/7/13), Ministry of Forests and Soil Conservation, Kathmandu.

Pokharel, Ridish K. and Larsen, Helle O. 2007. Local versus official criteria and indicators for evaluating community forest management, *Forestry: An International Journal of Forest Research* **80 (2):** 183 – 192.

Pokharel, Ridish K. and Suvedi, Murari 2007. Indicators for measuring the success of Nepal's community forestry program: A local perspective, *Human Ecology Review* **14 (1):** 68 – 75.

Schusler, T.M., Decker, D.J. And Pfeffer, M.J. 2003. Social learning for collaborative natural resource management, *Society and Natural Resources* **16 (4):** 309 – 326.

Shrestha, K. and Khanal, P.N. 2004 **Forest Certification: Experiences from Parbat District.** Seed Tree Nepal, Integrated Human Ecology Project, Parbat. UNDP/GEF Small grants Programme, Kathmandu.

Smith, P.D., Chhetri, B.B.K. and Regmi, B. 2003 Meeting the needs of Nepal's poor: creating local criteria and indicators of community forestry. *Journal of Forestry* **101 (5):** 24 – 30.

Medicinal plants of Nepal: Distribution pattern along an elevational gradient and effectiveness of existing protected areas for their conservation

K. P. Acharya[1], R. P. Chaudhary[2] and O. R. Vetaas[3]

This study explores patterns of medicinal plant species richness along an elevational gradient in Nepal and the effectiveness of existing protected areas for their conservation. We used published data on the distribution of medicinal plants. The number of medicinal plants and the number of protected areas present in each 100 m elevation band were collated by interpolation. We tested the number of protected areas and the number of species as the response variables against elevation as a predictor variable. To explain the relationship between the total medicinal plant richness and their different life forms with elevation and protected areas, we used generalized additive models (GAMs) and scatter plots. The elevational distribution of medicinal plants as a whole and disaggregated into different life forms revealed hump-shaped patterns. The maximum richness of medicinal plants was found at an elevation of 1100 m a.s.l. but the maximum numbers of protected areas were found at elevations between 3000-3500 m a.s.l. There was negative correlation between the altitudinal distribution of protected areas and medicinal plants in Nepal. This study suggests that the protected areas of Nepal were less concentrated where medicinal plants diversity was rich.

Key words: Elevation gradient, generalized additive model, medicinal plants, species richness

With a wide range of topographic features and climatic conditions in Nepal, one can find large environmental variation (from the humid lowland forests to glaciated mountain tops). This variation has resulted in isolated localities that host a large number of plant species. So far, around 7000 species of flowering plants have been documented for Nepal (DPR, 2001). Of these, around 1792 species (including lichens and fungi) were used for medicinal purposes (Baral and Khurmi, 2006). However, the number of medicinal plants in Nepal is still uncertain. Almost 60% of the world population and 80% of the population in the developing countries rely on traditional medicines (Shrestha and Dillion, 2003).

In a developing country like Nepal, the majority of the people in the rural areas rely mostly on plants and plant products for their traditional "medicines" or drugs and primary health care needs. Demand for medicinal plants have been increasing due to their having no side-effects, easy availabilities at affordable prices and sometimes being the only source of health care available to the poor. The source of medicinal plant is usually the nearby forest which is being depleted because of forest clearing for agriculture, land for settlement of the growing population, developmental activities and demand for forest based raw materials (Manandhar, 1995; Chaudhary, 1998) so many species are already threatened due to collection pressures (Ghimire *et al.*, 2005).

The majority of the studies till date have focused on systematic documentation of useful plants but there is a lack of quantitative studies on the distribution pattern on medicinal plants, especially within existing protected areas. The study of the relationship between species richness and elevation is important for conservation and management of species diversity (Grytnes, 2003) because the lack of detailed knowledge about distribution patterns of species and ecosystems leads to problems in conserving species (Hunter and Yonzon, 1993).

Relationship between species richness and elevation have been determined using different methods for variety of taxa in different parts of the world (*see*

[1] P.O.Box 15142 KPC 676, Kathmandu, Nepal. Email: acharya.kamal@gmail.com
[2] Central Department of Botany, Tribhuvan University, Kirtipur, Nepal
[3] UNIFOB-Global, University of Bergen, Nygaardsgt. 5, N-5015 Bergen, Norway

Rahbek, 2005; Garu *et al.*, 2007) and along the Himalayan elevational gradient (Vetaas and Grytnes, 2002; Bhattarai *et al.*, 2004; Carpenter, 2005; Grau *et al.*, 2007; Acharya, 2008). But, studies on elevational pattern of medicinal plants and its relationship with protected areas have not been carried out. Medicinal plants represent all life forms and taxonomic groups of plants.

So, this study might document the patterns for the medicinal plants with different life forms. The main objectives of this study are: 1) to find out the distribution patterns of medicinal plants along the elevational gradients in the Nepal Himalaya, 2) to compare these patterns with patterns found for plants and plants groups from the same area, so as 3) to ascertain any relationship between the elevational distribution of protected areas and the elevational distribution of medicinal plants of Nepal.

Materials and Methods

Biogeographical location and climate of study area

Nepal (26^0 22' N to 30^0 27' N latitude, 80^0 40' E to 88^0 12' E longitude), the central Himalaya is a narrow Himalayan strip that consists of five east-west running ranges: Terai, Siwaliks, Mahabharat, High mountains and High Himalaya (LRMP, 1986). Across this short North South distance, the elevation ranges from about 60 m to 8848 m (highest peak of the world) and comprises tropical to alpine climatic zones. The medicinal plants are distributed from 100 m to 6,000 m a.s.l. (DPR, 2007).

Nepal harbours a wide range of climatic conditions. However, the climatic conditions can be broadly divided into two types: dry winter period and wet summer period (Shankar and Shrestha, 1999). The climatic condition of Nepal is dominated by the precipitation from the Bay of Bengal summer monsoon. The amount and distribution of this precipitation, the duration and altitudes of cloudiness vary considerably in different parts. The amount of rainfall gradually decreases from east to west, but increases from the plains to certain elevations between 800 to 2000 m a.s.l. to the north and then decreases.

Data Source and Interpolation

We collected information of medicinal plants from secondary sources. The elevation ranges of medicinal plants were collected from DPR (2007). Information on sixty species assigned to various risk categories: critically endangered, endangered, insufficiently known, nearly threatened, vulnerable, rare, threatened and data deficient were collected from DPR (2006). This was the latest book on medicinal plants of Nepal with the information on their elevational distribution. The medicinal plants were distributed from 100 m to 6000 m a.s.l. To examine the relationship between species richness and elevation, the overall elevation range between 100 and 6000 m was divided into 60, 100-m elevation interval, vertical elevation bands. The number of species present in each elevation band was estimated by interpolation (Vetaas and Grytnes, 2002; Bhattarai *et al.*, 2004). A species was determined to being "present" in every 100-m intervals of its upper and lower elevation limits. For example, *Dactylorhiza hatagirea* with its elevation limit between 2800 and 4000 m, was assumed to be present in each elevation band of 2800, 2900, 3000, 3100, 3200, and so on up to 4000 m (*see* Bhattarai *et al.,* 2004). We used the term species richness for the total number of medicinal plant species present in each 100-m elevation band. To find the number of protected areas occurring in each 100-m elevation band, the altitudinal range of each protected areas was determined from *Nepal Biodiversity Strategy* (HMGN/MFSC, 2002). The interpolated elevation range was converted to dummy variable by ascribing "1" for presence and "0" for absence and the number of conservation sites per 100 m elevation band was estimated (Crawley, 2005).

Statistical analysis

This is an exploratory study with elevation (meters above sea level) as the main predictor variable, so we used Generalized Additive Models (GAMs) (Hastie and Tibshirani, 1990) with up to four degrees of freedom to explore the overall pattern of species richness with elevation. We used elevation as an explanatory variable and species richness and the number of conservation sites as response variables. Species richness data were considered to follow a Poisson distribution as it is a count (discrete) data (Crawley, 2005) which requires a logarithmic link. However, because of overdispersion, a quasi-Poisson model was used (Crawley, 2005) with a logarithmic link. We used an *F*-test to check the significance of models because this is more robust when there is overdispersion (Crawley, 2005). We used $R_{2.8.1}$ (R Development Core Team, 2008) for regression analysis and graphical representations.

Results and discussions

Life form spectrum of medicinal plants of Nepal

The latest report on the total number of medicinal plants and their elevational range counted 697 species (DPR, 2007). These medicinal plants belonged to different life forms: trees, shrubs, herbaceous, climbers and some were lichens and mushrooms (Figure 1).

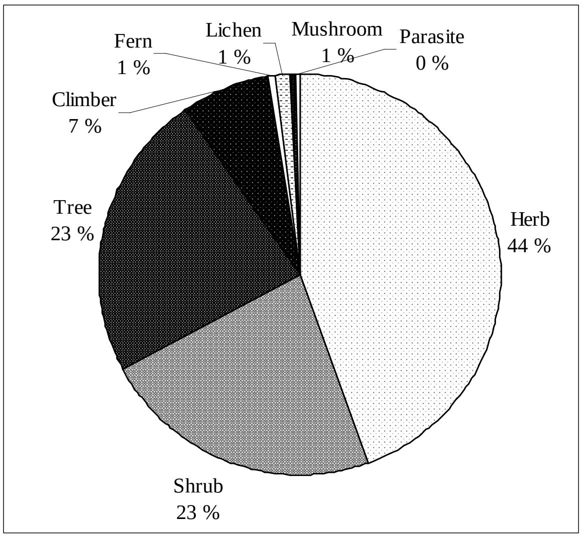


Figure 1: Different life forms of medicinal plants.

Distribution of medicinal plants in different ecological regions and along the elevation gradients

The medicinal plants were found growing between the elevations of 100 m to 6,000 m a.s.l. The distribution of medicinal plants along different ecological regions of Nepal is tabulated in Figure 2.

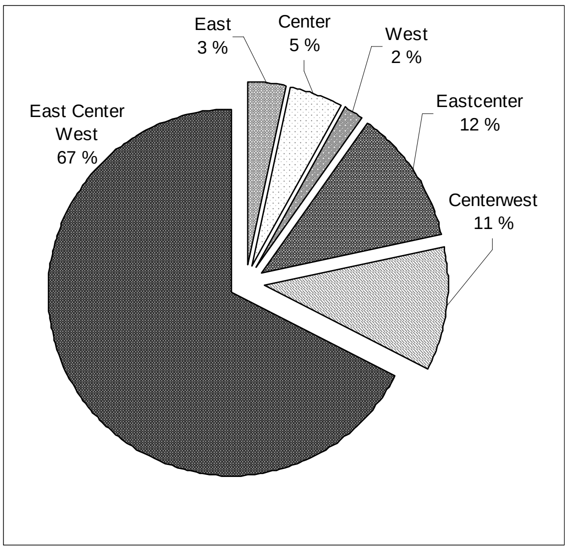


Figure 2: Distribution of medicinal plants in different regions of Nepal

The variation in species richness of total and of different life forms of medicinal plants along the elevation gradient is presented in Figure 3. The uppermost elevations for the growth of different life forms of medicinal plants were different. The uppermost elevation for the growth of trees, shrubs, herbaceous forms and climbers were 4500 m, 5000 m, 6000 m and 3300 m a.s.l, respectively. The total and different life forms of species showed hump-shaped patterns of distribution along the elevation gradient of Nepal. The optimum richness of different life forms was also different. The maximum richness of total medicinal plants was observed at an elevation of 1100 m a.s.l. Similarly the maximum richness of trees, shrubs, herbaceous forms and climbers were found at elevations of 1000 m, 1000 m, 1300 m and 900 m a.s.l, respectively (Figure 3). Because of overexploitation, sixty species have been assigned to various conservation risk categories: critically endangered, endangered, insufficiently known, nearly threatened, vulnerable, rare, threatened and data deficient. The maximum richness or concentration of these threatened medicinal plants peaked at 3500 m a.s.l. (Figure 3f).

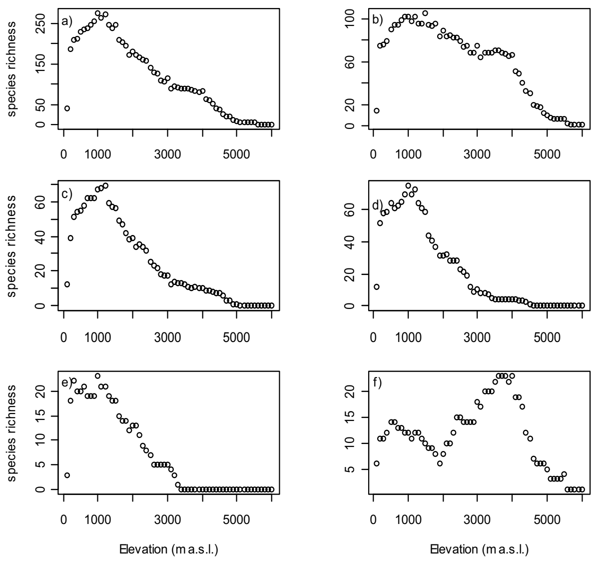


Figure 3: Relationship between different life forms a) total b) herbs c) shrub d) tree e) climber f) threatened of medicinal plants of Nepal with elevation (m a.s.l.). (Note: Vertical axis has different scales).

Species richness

We found hump-shaped patterns of medicinal plant species richness along the elevation gradient in Nepal Himalaya (Figure 3a) peaking at 1100 m a.s.l, which was about 400 m below the prediction made by Vetaas and Grytnes (2002) for flowering plants.

Similar unimodal patterns have been observed for flowering plants (Grytnes and Vetaas, 2002), ferns (Bhattarai *et al.,* 2004), liverworts and mosses (Grau *et al.,* 2007) and orchids (Acharya, 2008). This suggests that hump-shaped pattern is the common pattern (Rahbek, 2005). This result also supports the findings made by Malla and Shakya (1999), Hamilton and Radford (2007) and Ghimire (2008) that maximum numbers of medicinal plants were found within the elevation of 1000-2000 m a.s.l.

Medicinal plants included plants of different life forms (trees, shrubs, herbs, climber etc.). When analyzed for different life forms of medicinal plants, the present study did not find results similar to Bhattarai and Ghimire (2006). The maximum richness of medicinal plants with different life forms: shrub, herbaceous and climber were found at lower elevations than those obtained from the analysis of Bhattarai and Ghimire (2006). This might be because they had included smaller numbers of species in their analysis (143 species vs 647 in this investigation). However, there was consistency in the maximum richness of medicinal plants ascribed to tree life forms as in the result of Bhattarai and Ghimire (2006).

To explain the causes of these patterns, many hypotheses have been proposed; however, climatic variables seem to be the most important for explaining species-richness patterns with elevation, especially in broad-scale studies (Odland and Birks, 1999; Bhattarai and Vetaas, 2003; Sanders *et al.,* 2007). The maximum richness of species will occur at locations with maximum rainfall and optimum energy conditions. So, the maximum richness of medicinal plants at the elevation of 1100 m a.s.l. was due to the optimum water energy dynamics (Bhattarai and Vetaas, 2003).

Mid-elevation peak in species richness may be the result of large scale mass effect (Shmida and Wilson, 1985). The mid elevation receives inputs from both the lower elevations and higher elevations. So, mass effect or source sink dynamics may be important in influencing variation in species richness within an elevation gradient (Grytnes and Vetaas, 2002). This is the first comprehensive and quantitative study on medicinal plants of Nepal where the maximum richness of plant species was observed at the elevation of 1100 m a.s.l. The peak of maximum richness of medicinal plants contrast with the richness peak of ferns at 1900 m and of vascular plants, which had a maximum richness between the elevations of 1500 to 2500 m a.s.l.

Medicinal Plants vs Conservation areas

There are nine national parks, three wildlife reserves, one hunting reserve, three conservation areas and nine buffer zones covering a total area of about 19.42% of total area of Nepal (Table 1). The protected areas in Nepal are distributed from 75 m to 8848 m a.s.l. Maximum numbers of protected areas were found between 3000 m to 3500 m a.s.l (Fig. 4).

Table 1: Conservation areas of Nepal and their altitudinal range in Nepal

S.N.	Protected areas of Nepal	Elevation (m a.s.l.)	
		low	high
1	Annapurna Conservation Area	1000	8092
2	Dhorpatan Hunting Reserve	2850	7000
3	Kanchanjunga Conservation Area	1200	8598
4	Khaptad National Park	1000	3276
5	Koshi Tapu Wildlife Reserve	90	90
6	Langtang National Park	792	7245
7	Makalu Barun National Park	435	8463
8	Manaslu Conservation Area	1360	8163
9	Parsa Wildlife Reserve	150	815
10	Rara National Park	1800	4048
11	Bardia National Park	152	1494
12	Chitwan National Park	150	815
13	Shuklaphanta Wildlife Reserve	90	270
14	Sagarmatha National Park	2800	8848
15	Shey Phoksundo National Park	2000	6885
16	Shivapuri National Park	1366	2732

Source: HMGN/MFSC (2002)

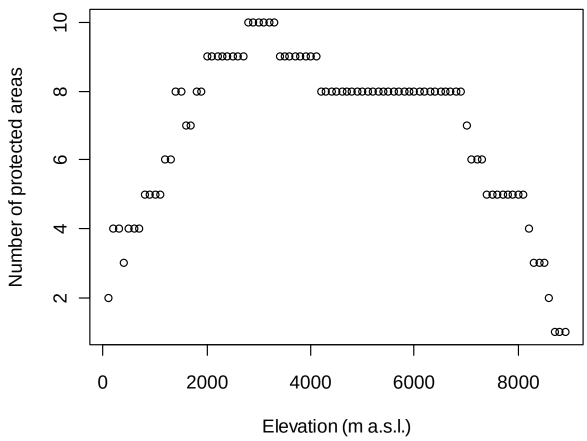


Figure 4: Relationship between numbers of protected area with elevation along an elevation gradient in Nepal.

The number of protected areas increased up to 3000 m and then gradually decreased after 3500 m a.s.l.

There was a strong negative correlation between the total number of medicinal plants and the number of protected areas (r= - 0.46) (Fig. 5a). However, there is a positive correlation between the total number of threatened medicinal plants and the number of protected areas (r= 0.224) (Fig. 5b).

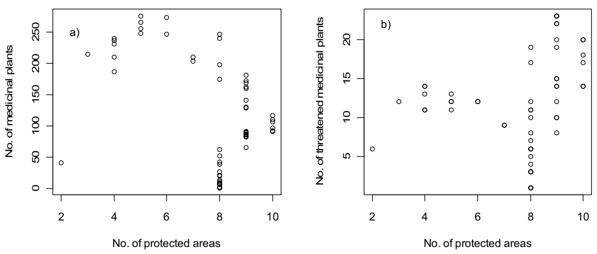


Figure 5: Scatter plot showing the relationship between a) no. of medicinal plants b) no. of threatened medicinal plants with number of protected areas of Nepal.

Protected area and medicinal plant species richness

Till date, there are nine national parks, three wildlife reserves, one hunting reserve, three conservation areas and nine buffer zones covering a total area of about 19.42% of total area of Nepal (Table 1). These protected areas were distributed from 75 m to 8848 m a.s.l. and the maximum numbers of these areas were found between 3000 m to 3500 m a.s.l. But the maximum peak of plant species was found below this elevational range. There was a negative correlation between number of protected areas and number of medicinal plants (Figure 5a). This shows that our conservation efforts are less focused towards plant diversity. Protected areas were located at higher elevations where diversity of plants was less. However, there was a positive correlation between number of threatened medicinal plants and the number of protected areas (Figure 5b). Ghimire *et al.* (2006) also found that the elevations between 3000 m to 4500 m a.s.l. harbour potential medicinal plants for national and international trade and these species are threatened.

Large numbers of medicinal plants in wild are being depleted due to the continuous and haphazard harvesting, without any plans to regenerate and sustain them (Sharma *et al.,* 2004). In Nepal, medicinal plants were collected by people from rural areas; the majority of them do not possess adequate knowledge of natural regeneration and plant habitats. Not only this, the collectors extracted even those medicinal plants which were banned for collection and transportation. According to local traders, the numbers of medicinal plants in their localities had declined in recent years (Acharya and Rokaya, 2005). Some of the high value herbs were threatened with extinction. These included *Dactylorhiza hatagirea, Nardostachys grandiflora, Rauvolfia serpentina, Valeriana jatamansi* (Chaudhary, 1999). The Government of Nepal had banned the collection and transportation of some species; however, these types of ban and restriction have not been effective in the conservation of species and the reduction of the collection amount.

Medicinal plants occur in good densities in national parks and reserves where harvest has been prohibited or restricted (Sharma *et al.,* 2004). However, Ghimire *et al.* (2005) reported the collection of two threatened species, *N. grandiflora* and *Neopicrorhiza scrophulariiflora* even from national parks and buffer zones. A complete checklist of flora present in each protected area of Nepal has not yet been prepared (Bhattarai and Ghimire, 2006). If the species is distributed across a large number of middle hill districts, collection and trade of medicinal plants is too high from lowland districts or Terai districts (Olsen, 2005). If this collection situation continues, then a large number of medicinal plants will be threatened from lower belts where the diversity has been high. Another reason for higher extraction of medicinal plants from lower belts is because these areas are easily accessible.

For the solution for sustainable management, the Government of Nepal has given top priority to 12 rare and high priced plant species (out of total 30 medicinal plant species prioritized for research and development) (DPR, 2006). Farming of these medicinal plants will help ease the supply problems, regularize their trade, provide certifiable products of uniform quality and offer a new source of income to the rural poor. The establishments of herbal farms in the Royal botanical garden (Godavari) and Daman Botanical Garden (Daman) have been successful in conserving medicinal plants found in the respective localities. However, these *ex-situ* conservation efforts are insignificant compared to the vast resources available to the country. Besides, their methods of documentation are poor: the accession of conserved plants has not been maintained properly and methods of propagation have not been properly documented (Sharma *et al.,* 2004). The community forest program, one of the priority programs, aims to produce a wide range of forest products including medicinal plants. In community forestry, people specify their use rights to the management, development and utilization of forest resources. In order to collect more revenue from community forests, community forest user groups are running silvicultural and harvesting activities (Acharya *et al.,* 2006). Instead of growing all plant species in their forests, people are now focusing on a few selected fast growing species. The practice of using a few selected species for fuelwood and the absolute conservation of dominant species in community managed forests may affect the regeneration process and community structure of forests and may also destroy the habitat of valuable medicinal plants. So, community user groups should be well trained about the medicinal plants.

Conclusions

As indicated by the distribution pattern of medicinal plants, the maximum richness of these was observed at the elevation of 1100 m a.s.l. but the maximum protected areas were found at elevations between 3000 to 3500 m a.s.l. The distribution pattern of protected areas did not correspond well with the distribution pattern of medicinal plants. If the medicinal plants of Nepal are to be well protected, it is important that the elevational range where maximum richness of medicinal plants is found should be prioritized for conservation activities.

References

Acharya, K.P. 2008. Orchid Species Richness along a Himalayan Elevation Gradient. MS Thesis, Department of Biology, Faculty of Mathematics and Natural Sciences, University of Bergen, Bergen, Norway. 42p.

Acharya K.P. and Rokaya, M.B. 2005. Ethnobotanical survey of medicinal plants traded in the streets of Kathmandu valley. *Scientific World.* **3(3):** 44-48.

Acharya, K.P., Gautam, K.R., Nepal, B.K. and Gautam, G. 2006. Participatory assessment of biodiversity conservation in community forestry in Nepal. *Banko Janakari.* **16(1):** 46-56.

Baral, S.R. and Khurmi P.P. 2006. *A Compendium of Medicinal Plants in Nepal.* Mrs. Rachana Sharma, Kathmandu, Nepal.

Bhattarai, K.R. and Ghimire, M. 2006. Commercially important medicinal and aromatic plants of Nepal and their distribution pattern and conservation measure along the elevation gradient of the Himalayas. *Banko Janakari* **16(1):**3-13.

Bhattarai, K.R. and Vetaas, O.R. 2003. Variation of plant species richness of different life forms along a subtropical elevation gradient in the Himalayas, east Nepal. *Global Ecology and Biogeography* **12:** 327-340.

Bhattarai, K.R., Vetaas, O.R. and Grytnes, J.A. 2004. Fern species richness along a central Himalayan elevation gradient, Nepal. *Journal of Biogeography* **31:** 389-400.

Carpenter, C. 2005. The environmental control of plant species diversity on a Himalayan elevation gradient. *Journal of Biogeography* **32:** 999-1018.

Chaudhary, R.P. 1998. **Biodiversity in Nepal (Status and Conservation).** S. Devi, Saharanpur (U.P.), India and Tecpress Books, Bangkok, Thailand.

Crawley, M.J. 2005. **Statistics: An Introduction using R.** John Wiley & Sons Ltd., England.

DPR, 2001. **Flowering Plants of Nepal (Phanerogams).** His Majesty's Government, Ministry of Forest and Soil Conservation, Department of Plant Resources, Kathmandu, Nepal.

DPR, 2006. **Plants of Nepal: Fact Sheet.** Ministry of Forest and Soil Conservation, Government of Nepal, Thapathali, Kathmandu, Nepal.

DPR, 2007 Bulletin of the Department of Plant Resources No. 28 Medicinal Plants of Nepal (Revised). Department of Plant Resources, Ministry of Forest and Soil Conservation, Government of Nepal, Thapathali, Kathmandu, Nepal.

Ghimire,S.K. 2008. Medicinal plants in the Nepal Himalaya: Current issues, sustainable harvesting, knowledge gaps and research priorities. In: *Medicinal Plants in Nepal: an Analogy of Contemporary Research* (eds.) Jha, P.K., Karmacharya, S.B., Chhetri, M.K., Thapa, C.B. and Shrestha, B.B., Ecology Society (ECOS), Nepal, pp. 25-44.

Ghimire, S.K., Maskey, D. and Yildiz, A.T. 2005 Conservation of Himalayan medicinal plants: Harvesting patterns and ecology of two threatened species, *Nardostachys grandiflora* DC. and *Neopicrorhiza scrophulariiflora* (Pennell) Hong. *Biological Conservation* **124:** 463-475.

Ghimire, S.K., McKey, D. and Aumeeruddy-Thomas, A. 2006. Himalayan medicinal plant diversity in an ecologically complex high altitude anthropogenic landscape, Dolpo, Nepal. *Environmental Conservation*. **33(2):** 128-140.

Grau, O., Grytnes, J.A. and Birks, H.J.B. 2007. A comparison of altitudinal species richness patterns of bryophytes with other plant groups in Nepal, Central Himalaya. *Journal of Biogeography*. **34**: 1907-1915.

Grytnes, J.A. 2003. Species-richness patterns of vascular plants along seven altitudinal transects in Norway. *Ecography*. **26:** 291-300.

Grytnes, J.A. and Vetaas. O.R. 2002. Species richness and altitude: A comparison between null models and interpolated plant species richness along the Himalayan altitudinal gradient, Nepal. *The American Naturalist*. **159:** 294-304.

Hamilton, A.C. and Radford, E.A. 2007. **Identification and Conservation of Important Plant Areas for Medicinal Plants in the Himalaya.** Plant life International, Salisbury, UK and Ethnobotanical Society, Kathmandu, Nepal.

Hastie, T.J. and Tibshirani, R.J. 1990. **Generalized Additive Models.** Chapman & Hall, London.

HMGN/MFSC, 2002. **Nepal Biodiversity Strategy.** Ministry of Forest and Soil Conservation, HMG, Nepal.

Hunter, M.L. and Yonzon, P. 1993. Altitudinal Distributions of Birds, Mammals, People, Forests and parks in Nepal. *Conservation Biology* **7(2):** 420-423.

LRMP, 1986. **Land System Report.** Land Resource Mapping Project, HMG/N and Government of Canada, Kathmandu, Nepal.

Malla S.B. and Shakya, P.R. 1999. Medicinal Plants. In *Nepal Nature's Paradise* (ed.) Majupuria, T.C. and Majupuria, R.K., M. Devi, Gwalior, India, pp. 261-297.

Manandhar, N.P. 1995. A survey of medicinal plants of Jajarkot district, Nepal. *Journal of Ethnopharmacology*. **48:** 1-6.

Odland, A. and Birks, H.J.B. 1999. The altitudinal gradient of vascular plant richness in Aurland, western Norway. *Ecography*. **22:** 548-566.

Olsen, C.S. 2005. Valuation of commercial central Himalayan medicinal plants. *Ambio*. **34:** 607-610.

R Development Core Team, 2008 **R: A Language and Environment for Statistical Computing.** R Foundation for Statistical Computing, Vienna.

Rahbek, C. 2005. The role of spatial scale and the perception of large-scale species richness patterns. *Ecology Letters*. **8:** 224-239.

Sanders, N.J., Lessard, J.P., Fitzpatrick, M.C. and Dunn, R.R. 2007. Temperature, but not productivity or geometry, predicts elevational diversity gradients in ants across spatial grains. *Global Ecology and Biogeography*. **16:** 640-649.

Shankar, K. and Shrestha, P.B. 1999. Climate. In *Nepal Nature's Paradise* (ed) Majupuria, T.C. and Majupuria, R.K., M. Devi, Gwalior, India, 39-44.

Sharma, U.R., Malla, K.J. and Uprety, R.K. 2004. Conservation and management efforts of medicinal and aromatic plants in Nepal. *Banko Janakari*. **14(2):** 3-11.

Shrestha, P.M. and Dhillion 2003. Medicinal plant diversity and use in the highlands of Dolakha district, Nepal. *Journal of Ethnopharmacology* **86:** 81-96.

Shmida, A. and Wilson, M.W. 1985. Biological determinants of species diversity. *Journal of Biogeography* **12:** 1-20.

Vetaas, O.R. and Grytnes, J.A. 2002. Distribution of vascular plant species richness and endemic richness along the Himalayan elevation gradient in Nepal. *Global Ecology and Biogeography*. **11:** 291-301.

Consumption Pattern of Timber and Fuelwood in Community Forests: a case study from Sindhupalchok District

D. Lamichhane[1]

The study was carried out in four community forest user groups (CFUGs) of Sindhupalchok district of Nepal with a view to find out the consumption pattern of forest products especially timber and fuelwood from the community forests (CFs). A set of structured questionnaires was used to collect data from the respondents of the selected CFUGs. Four CFUGs were randomly selected from among those meeting the predetermined criteria such as: more than 5 years old, regularly harvesting timber and fuelwood, and active in forest management. With a 20% sampling intensity, 103 respondents were identified from the groups for household visit and personal interview. Records of forest product distribution together with a checklist of secondary data were obtained from the District Forestry Office (DFO) and the CFUG records. This data were analyzed using both descriptive and inferential statistical analysis. Results indicated that there was no significant difference in the use of timber and fuelwood among the users. Similarly, there was no correlation between the number of livestock and use of firewood. However, there was a strong relationship between the number of livestock and fodder trees on their farmland. There was a higher demand for fuelwood than timber but the pine-dominant community forests were found to be producing more timber, thereby creating a big gap between the demand and supply of firewood. However, the supply of timber was comparatively consistent with demand.

Keywords: Community forest user group, demand and supply, farmland, fuelwood, timber

One of the long-term objectives of Community Forestry Programme was to regularize supply of the people's basic needs for timber, fuelwood, fodder and other forest products (MFSC, 1988). Considering the rural population of Nepal, 67 percent of the energy requirement was met through firewood (DoF, 1995). Community forestry was clearly contributing to rural peoples' livelihoods, through the acquisition of resources from forest products and other sources (Pearce *et al.* 2003). Our future challenge is to enhance the productivity of CF, and to ensure the equitable distribution of its benefits through the transformation of natural resources into assets that can address the livelihood priorities of CFUGs, particularly those of the poorest (Allison *et al.*, 2004). The user groups receiving official support have substantially improved the condition of their CFs, for example by way of reducing forest fire occurrence (Tachibana & Adhikari, 2009).

Nevertheless, the current practices of community forest management have, to some extent, negative impacts on the rural poor that lack the provisions for addressing equitable system of benefit distribution and cost sharing among the forest user groups and households. If community forestry is to be rural poor-friendly, poor-income households should be able to realize the full value of the share of unused forest products either by way of transferable rights or from access to markets (Dahal, 2006). According to Dahal (2006), the net benefit and benefit-cost (B-C) ratios for the three income groups were calculated with the help of summary statistics of gross benefits and costs. The net benefit and B-C ratios for poor, medium and rich households were found to be -3, 0.85, and 0; 1, 4, and 1.08, respectively. In his study, eight major types of forest products from CFs were considered as material values. The total costs of forest use and management were broken down into labor costs, transaction costs and membership fees.

The access of poor people to resources and capital has been reduced, with consequent negative impacts on their livelihoods (Ostrom, 1990). This reduced

[1] Asst. Research Officer, Department of Forest Research and Survey, Kathmandu, Nepal Email: dlamichhane@gmail.com

access has forced the poorest to enter nearby forests (other than CFs) which in turn has increased travel time for them to collect the forest products and induced negative impact on the condition of government forests in the neighboring areas. On the other hand, this situation reflects weak CFUG-level governance (Pokharel & Niraula, 2004). Increased growing stock of CF does not necessarily mean that there is increased access to either timber or fuelwood. Although the operational plans require a complex exercise of calculating the growing stock, annual increment and annual allowable cut as part of the operational plan preparation. Currently, even under CF-management practices, the only timber and fuel that can be harvested are from trees that have fallen down from natural causes or from allowable forest practices, such as thinning.

This study was intended to carry out a district-level survey regarding the utilization pattern of timber and fuelwood collected from the CFs. The specific objectives of the study were to: (i) collect the socioeconomic information of the forest users using forest products; (ii) estimate the annual extraction of timber and fuelwood from the community forests of the district; and (iii) identify the household consumption and sale and the main uses of the forest products.

Four community forests of Sindhupalchok district of the Central Development Region of Nepal (Figure 1) were selected. The forests here were mostly pine-dominated, consisting of the plantations done by the then Nepal-Australia Community Forestry Project.

This study has helped elaborate the utilization pattern of forest products such as timber and fuelwood extracted from the CFs in Sindhupalchok district of the Central Development Region of Nepal. The utilization pattern includes the data on the demand and supply condition of timber and fuelwood in the district and quantitative basis for comparison with other community forests.

Materials and Methods

The study area covered four CFUGs viz. Bhagwati, Gaurati, Jogikhoriya and Sunkoshi. Using the CFUG-database available in the District Forest Office (DFO), the aforementioned four CFs were selected randomly among those meeting some predetermined criteria such as the CFs with trees more than 5 years old, the CFs producing timber and fuelwood, and the CFs active in forest management. Altogether, 103 sets of questionnaire and 80 sets of checklist were used for primary data collection.

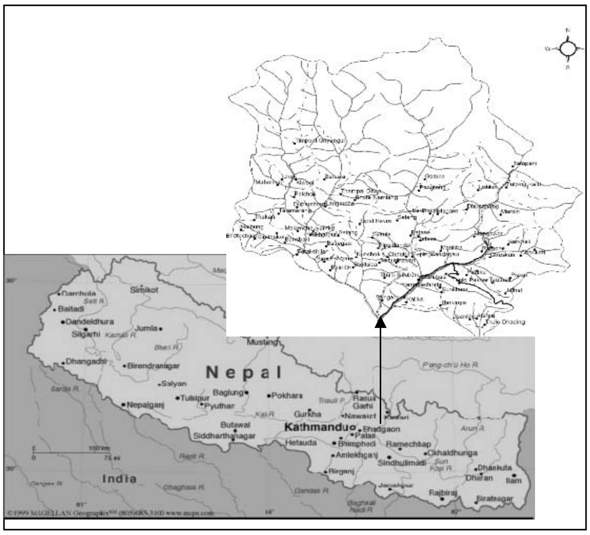


Figure1: Map of the study Area

With 20 percent sampling intensity, 103 respondents were selected from the groups for household visit and personal interview. 20 percent of these respondents were female. Primary data were collected using a number of techniques namely, household survey, focus-group discussion using PRA/RRA method, and a checklist for key informants. On the other hand, District and CFUG records of forest products distribution and a checklist for committee member were used for the collection of secondary data which included database of the DFO, operational plan and records of the CFUGs and other published and unpublished sources relevant to the survey. Both primary and secondary data were organized and entered into a computer program for statistical analysis. The data were analyzed with the help of both descriptive and inferential statistical analysis such as tables, graphs, correlation analysis and Chi-square (Ç2) test. The demand and supply of forest products and their consumption was assessed using socioeconomic data.

Results and Discussions

Existing demand & supply situation of timber and fuelwood

According to the DFO record of the Fiscal Year 063/64 (2006-07), the consumption quantities within the selected four CFUGs were: fuelwood - 102,064 metric tons, timber - 1,013,580 cubic feet and others - 122,438 metric tons. Similarly, timber and fuelwood sale outside the CFUGs was 13,359.39 cubic feet and 1,200 kilograms respectively. The consumption pattern within the CFUGs was determined by multiplying the average household consumption figure with the total number of households surveyed (DFO, 2006).

The supply curve for timber and fuelwood harvested from any CF is normally vertical because both the quantity supplied as well as the price are generally fixed. The harvests of the forest products from the mentioned CFs will be also have a vertical supply curve. No matter how much someone would be willing to pay for additional products; extra timber/ fuelwood cannot be produced as the annual allowable harvest is set by the operational plan. Also, even if no one wants the products, the allowable cut will still be made. Since the supply S and price (P_1) are fixed for timber & fuelwood, any shift in demand will only create gap between D_1 and D_2 (Figure 2).

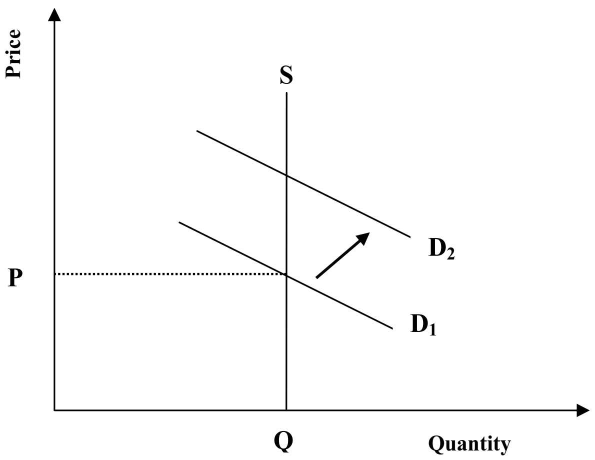


Figure 2: Theoretical Demand & Supply curve

When the demand D_1 is in effect, the price will be P_1. Similarly, when the demand D_2 occurs, the price should go up but because of the fixed price, it will still remain at P_1. Notice that at both values, the quantity is Q. Here, Q = forest products available for annual harvest as per the annual allowable harvest prescribed in the operational plan. Demand of fuelwood/timber generally increases because of population growth, separation of family/household, poverty and so on.

Production and distribution of timber & fuelwood

There was higher demand of fuelwood than timber (figure 3). The main forest products of these pine-dominated forests were fuelwood and timber. Harvesting of the products was done according to

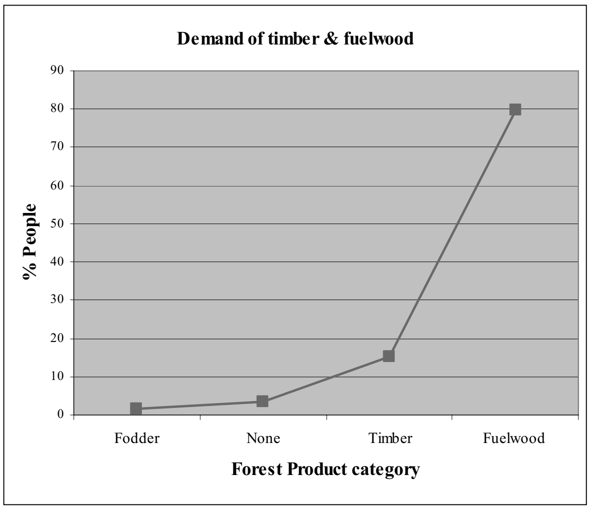


Figure 3: Demand status of forest products

the operational plan, i.e. taking out the forest products from 1-2 blocks rotationally. Generally, the CFUGs have prioritized the distribution of timber to the users in the case of: (i) construction of house for the households affected from natural hazards (flood, landslide and fire); (ii) making agricultural tools (plow, yoke, and handles of various tools); (iii) building new house in the case of separation within families; (iv) repairing the houses; (v) building and repairing cattle sheds; and (vi) public construction and developmental activities. In all these cases, poor and disadvantaged groups were said to have preference. Timber to make charcoal was free for blacksmith during harvesting period. In some cases, transportation cost of forest products was so high that users were unwilling to collect fuelwood.

Consumption of fuelwood and its utility

Fuelwood was mostly utilized for brewing local alcohol readily saleable in the market; the users did not hesitate to use even timber as fuelwood. This indicates the users' preference for fuelwood over timber and their higher utility. For making local wine, they bought timber at high price and used it as fuelwood. So there was the provision in the rule that ensured the use of timber only as timber and not as fuelwood. The timber from CFUGs was not allowed to be sold at local sawmills. Timber species most in demand were Chilaune (*Schima wallichii*) followed by Sallo (*Pinus spp.*). Therefore, the CFUGs wanted to convert their pine forests to broadleaved ones. However, fuelwood was adequate for those users who did not brew local alcohol.

Some of the measures to reduce fuelwood consumption included use of improved stove, biogas

Table 1: Measures taken to reduce fuelwood consumption

CFUG	Yes (%)		Both (%)	No (%)
	Improved Stove	Kerosene and Gas		
Bhagwati	28	6	34	66
Gaurati	40	15	55	45
Jogikhoriya	15	25	40	60
Sunkoshi	30	60	90	10

Table 2: Measures to substitute insufficient timber & fuelwood from CF (n=103, *p*=0.05)

CFUG	Percentage of users using timber/fuelwood			Percentage of people using kerosene and gas	χ2 value	Significance
	CF	Farmland	Buying			
Bhagwati	16	72	12	0	88.38	Significant
Gaurati	34	66	0	0		
Jogikhoriya	40	60	0	0		
Sunkoshi	0	0	66	34		

plant, raising fewer quality-cattle than more quantity cattle, grass production on risers, terrace and marginal lands. According to the users, the production of timber and fuelwood from their CFs was insufficient for their needs and so, additional timber and fuelwood had to be purchased from other CFs and outside to meet their demands. Sometimes, they even fetched forest products illegally from other CFs and government forests.

Apart from the CFs, there were 48 private forests registered at the District

Forest Office (DFO). The CFUGs did not have any program for reducing fuelwood consumption. The trees included in agroforestry practices on farmlands were mainly Kutmiro (*Litsea monopetala*), Chilaune along with Sal (*Shorea robusta*) and Sallo. Initially, the consumption of Chilaune for fuelwood was high but with their declining availability, the fuelwood demand has shifted to pines. Now pines are thinned to promote succession by Chilaune to a broadleaf forest again. Pines continue to grow faster on gentle slopes while Uttis and Chilaune were grown on eroded areas.

To make up for the insufficient forest products, the users had to depend mostly on their own farmlands. Possibility of biogas for fuel energy was unlikely due to the lack of livestock (sheep/goat, cattle and buffalo). The Ç2 test demostrated the significant differences on the sources of fuel energy used to make up for declining timber and fuelwood from the CFs (Table 2).

The major species grown in the farmlands include Kutmiro, Utis, Tooni (*Cedrela toona*), Kyamun (*Syzizium cumini*), Badahar (*Artocarpus lakoocha*), Khanyu (*Ficus semicordata*), Lapsi (*Choerospondias axillaris*), Aamp (*Mangifera indica*) and Sallo. The main timber species on the farmlands was Chilaune.

The average livestock per households was 4 (Table 3). Similarly, the average number of trees per household was found to be 27.25 whereas average number of fodder trees in the farmland was 9.25. Table 3 indicates the correlation between the number of livestock and fodder trees in private land.

Since, $|r| > 6 \times$ P.E., there is significant relationship between number of livestock and number of fodder trees in their farmland.

Table 3: Correlation between the number of livestock and fodder trees

CFUG	Average no. of livestock/household	Average no. of trees/households	Average no. of fodder trees/households	Correlation Coefficient
Bhagwati	6	39	13	**(r) = 0.98**
Gaurati	5	34	12	
Jogikhoriya	3	22	7	
Sunkoshi	2	14	5	
Av./household	**4**	**27.25**	**9.25**	

Probable Error (P.E) = 0.6745 × Standard Error (SE), where SE = $(1-r^2)/\sqrt{N}$ and N = 103

Consumption pattern of timber and fuelwood in CFUG

Timber was a major product of the CFs since the plantation-forests of pines were grown to produce enough timber. Timber was mainly used for constructional activities, but most of the users also burned timber due to the scarcity of fuelwood. Although the CFUGs had accorded priority to the needy users for the maintenance and construction of their houses and cowsheds, a substantial number of users had no need for timber. The Ç2 value revealed that use of timber was not significantly different among the CFUGs (Table 4).

Similarly, fuelwood was mostly used for cooking food, followed by large amounts of fuelwood used to brew local alcohol. Local alcohol was one of the main sources of income as it was readily saleable. The use of fuelwood for different purposes was found to be insignificant among the CFUGs, according to Chi square test below (Table 5).

Conclusions

Fuelwood and timber were found to be the major forest products in the study area. Results revealed that the forest product most in demand was fuelwood and that its supply was insuffniceint for many users since additional fuelwood was needed to brew alcohol as a source of ready cash income. The CFUGs did not have many measures to meet their shortfall in fuelwood demands. Trees on farmlands were relatively few and other fuel energies such as biogas were not viable due to inadequate livestock numbers. Users with insufficient fuelwood from small CF or their farm trees had to buy them from elsewhere, or fetch them from other CFs or government forests. Participation of users in forest management activities was poor because of the lack of time as labour was the main source of income for many users. Therefore, most activities of CF management were carried out on wage basis. The consumption patterns for timber and fuelwood by the users were not significant among the CFUGs but the measures taken by the users to complement the under-supplied fuelwood were significantly different.

Table 4: Consumption pattern of timber

CFUG	Percentage of users vs. consumption pattern of timber				$\chi 2$ value	Significance
	House construction	Cowshed construction	Both	No use		
Bhagwati	64	16	12	8	15.53	Not significant
Gaurati	58	12	30	0		
Jogikhoriya	40	15	15	30		
Sunkoshi	35	10	30	25		

n = 103 and *p* = 0.05

Table 5: Use of fuelwood (n = 103, *p*=0.05)

CFUG	Use of Firewood (% people)				$\chi 2$ value	Significance
	Cooking and making coal	Cooking and making alcohol	Cooking food only	Cooking food and *kundo**		
Bhagwati	24	4	44	28	13.47	Not significant
Gaurati	8	27	27	38		
Jogikhoriya	20	20	10	50		
Sunkoshi	15	20	35	30		

* *Kundo* is a foodstuff cooked for cattle using maize, millet, rice etc.

References

Allison, G., Bampton, J., Kandel B.R., Shrestha, M.L. and Shrestha N.K. 2004. Community Forestry and Livelihoods: How can Community Forestry Better Contribute to the Millennium Development Goals? In *Twenty-five Years of Community Forestry*. Proceedings of the Fourth National Workshop on Community Forestry, 4-6 August, 2004, Kathmandu, Nepal. (eds.) Kanel, K. R. *et al.* Department of Forest, December 2004, 171-179.

Dahal, Mahesh R. 2006. Benefit-cost analysis of community forest and its distributional impact on rural poor. *Economic Journal of Nepal,* **29 (2):** 93-107.

DoF. 1995**. Community Forestry Manual**. Department of Forest, Kathmandu, Nepal.

MFSC. 1988. **Master Plan for the Forestry Sector of Nepal.** Ministry of Forests and Soil Conservation, His Majesty's Government of Nepal, Kathmandu.

Ostrom, E. 1990. **Governing the Commons: The Evolution of Institutions for Collective Action.** Cambridge University Press.

Pearce, D., Putz, F.E. and Vanclay, J.K. 2003. Sustainable forestry in the tropics: panacea or folly? *Forest Ecology and Management*, **172 (2-3):** 229-247.

Pokharel, B.K. and Niraula D.R. 2004. Community forestry governance in Nepal: achievements, challenges and options for the future, 2004. In *Twenty-five years of Community Forestry*. Proceedings of the fourth national workshop on community forestry, 4-6 August, 2004, Kathmandu, Nepal. (eds.) Kanel, K. R., *et al.* Department of Forest, December 2004, 298-316.

Tachibana, T. and Adhikari, S. 2009. Does community-based management improve natural resource condition? Evidence from the Forests in Nepal. *Land Economics*, **85(1)**:107-131.

The frequency and relationship of flowering plants on the distribution pattern of *Ophiocordyceps sinensis* (Yarchagunbu) in the highlands of Dolpa district, Nepal

S. Devkota[1]

Ophiocordyceps sinensis (Berk.) G.H. Sung, J.M. Sung, Hywell-Jones & Spatafora is a highly valuable medicinal fungus. Biologically it is an entomopathogenic, entomophagous or entomophilous fungus. In order to investigate different floral associations with *O. sinensis*, and to know different threats to pasture biodiversity, research was conducted in three pastures of Raha and Majphal Village Development Committees of Dolpa district. The study revealed that *Juncus thomsonii* and *Bistorta macrophylla* were the principal plant associates with *O. sinensis* as they dominated the alpine pasture vegetation. This research also highlighted the need for some proactive solutions along with conservation awareness program as important management initiatives to ensure ecological balance of *O. sinensis.*

Key words: Alpine zone, flora, *Ophiocordyceps sinensis*, pasture management, Yarsagumba

Ophiocordyceps sinensis is a genus of entomophagous fungi (Pyrenomycetes, Ascomycotina) in the family Ophiocordycipitaceae. This parasitic fungus is variously known as Yarsagumba, Yarchagunbu, Kira, Jeevanbuti, Chyau, Chyau kira and Jara in Nepali, Yartsa gunbu in Tibetan, Dong chong xia cao in Chinese, Caterpillar fungus in English and *Cordyceps* in botanical term (Devkota, 2006, 2008a). Sherpas call them walking herb (Adhikari, 2000). There are about 300-400 species of *Cordyceps* distributed all over the world (Kobayasi, 1982; Sung, 1996). About 68 species have been reported from China and 33 species have been recognized in the Tibetan Plateau and Himalayan region (Zang & Kinjo, 1998). Kobayasi & Shimizu (1960, 1963) have worked on monographic study on *Cordyceps* and its allied species. From Nepal, 21 species of Cordycepioid fungi (*Cordyceps* and its allied species) have been reported (Adhikari, 2008b).

Zang & Kinjo (1998) have described distinct, closely related species (*Cordyceps gansuensis* K. Zhang, C. Wang & M. Yan, *C. kangdingensis* M. Zang & Kinjo, and *C. nepalensis* M. Zang & Kinjo) that in the past had been mistaken for *C. sinensis*. On the basis of molecular phylogenetic analysis Sung *et al.*, (2007) made taxonomic revision of Clavicipataceous fungal group. According to them, the taxa fall in 3 monophyletic (clades) family. The family Clavicipataceae (Lindeu) Earle ex Rogerson (Clade A) includes *Metacordyceps* Sung, Sung, Hywell-Jones & Spatafora; Ophiocordycepitaceae Sung, Sung, Hywell-Jones & Spatafora (Clade B) includes *Elaphocordyceps* Sung & Spatafora and Ophiocordyceps Petch. and Cordycipitaceae Kreisel ex Sung, Sung, Hywell-Jones & Spatafora (Clade C) includes *Cordyceps* Fr.

Ophiocordyceps sinensis fungus is endemic to the Tibetan Plateau including the adjoining high altitude areas of the Central and Eastern Himalayas (Nepal, Bhutan and the Indian states of Uttaranchal, Sikkim, Himanchal Pradesh and Arunachal Pradesh). The significance of the contribution of wild this edible fungus to rural livelihoods is acknowledged, but remains largely unexplored (Christensen *et al.,* 2008). *O. sinensis*, famous as the gold rush of Nepal, has its niche in the alpine meadows/pastures between the altitudinal range of 3540 and 5050m (Devkota, 2008a, 2008b). Its distribution is limited to areas where precipitation is below 300mm per annum (Winkler, 2008).

Ophiocordyceps sinensis is found mostly in Dolpa, Darchula, Jumla, Bajura, Kalikot, Mugu, Humla, Rukum, Bajhang, Manang, Mustang, Gorkha, Lamjung, Dhading, Rasuwa, Dolakha, Sindhupalchowk, Solukhumbu, Sankhuwasabha, and Taplejung districts of Nepal (Adhikari, 2008a,

[1] Asst. Lecturer, Central Department of Botany, Tribhuvan University, Kirtipur, Kathmandu, Nepal
E-mail: devkotashiva@yahoo.com

Devkota, 2008a). Relative to Mustang district, Manang is far richer in the occurrence and distribution of *O. sinensis* within the Annapurna Conservation Area (Sherchan *et al.,* 2005). Some of the other eastern Himalayan districts of Nepal stricken with acute poverty may also harbour the potential for commercial harvesting of *O. sinensis*; however, detailed exploration of the availability of this species is still warranted.

In the Tibetan plateau, the grasslands providing habitat for *Hepialus* moths and thus for *Ophiocordyceps sinensis* are associated with *Kobresia* sedges. The caterpillar of the moth lives in underground tunnels, emerging out at night to feed upon plant roots (Winkler, 2008). Among the sedges and grasses, *Kobresia setchwanensis*, *Poa elanata*, *Festuca rubra* are common. While among forbs, *Potentilla anserina*, *Anemone rivularis*, *Primula sikkimensis*, *Aconitum rockii*, *Gentiana veitchiorum*, *Polygonum viviparum*, *Rheum alexandrae, Nardostachys chinensis, Pedicularis* spp., *Anaphalis flavescens*, *Meconopsis horridula* are common (Wu, 1997; Zang & Kinjo, 1998). Larvae of *Hepialus* also prefer to feed on young roots of plant species of the families of Polygonaceae, Fabaceae, Cyperaceae, and Poaceae (Chen *et al.*, 2000).

Although few studies on the wild status of some medicinal plants have been carried out, several others, particularly at the high altitude species, are yet to be evaluated (Shrestha & Joshi, 1996; IUCN, 2000; Lama *et al.*, 2001). In this paper, floral associations of *Ophiocordyceps sinensis*, threats to *O. sinensis* in three different pastures and the impacts on the occurrence of this Himalayan treasure due to over grazing in Dolpa, Western Nepal have been analyzed. This research will be useful to know and manage the floral associations of *O. sinensis* in the high altitude areas of Dolpa.

Materials and Methods

Study Area

The study was confined to two Village Development Committees (VDCs), viz. Raha and Majphal of Dolpa district. The district is located between 28° 24'-29° 43' N Latitude to 82° 24'-83° 38' E Longitude. Shey-Phoksundo National Park, the largest national park of Nepal (core park area of 3555 km^2) covers a large part of this district. The first site is the village of Raha located in the buffer zone of Shey Phoksundo National Park (SPNP) and its associated pastures. Some principal *Ophiocordyceps sinensis* collection sites in this village are Palma Ramana, Patauti, Duna, Matey, Sunsey, and Gyalbara. Among these, Palma Ramana was selected for the study. It is located at an altitude of 4260 to 4810m. The main *O. sinensis* sites in Majphal VDC are Ruppatan, Majghari, Saiquarry, Pokeypani and Chinarangshi. Among them, Pokeypani and Saiquarry were selected for this study (Fig. 1).

Methods

Based on Participatory Research Appraisal (PRA) techniques and drawings of participatory resource maps, 80 permanent monitoring plots of size 10x10m were established at different pastures of Raha and Majphal VDCs. The field study was conducted from May 25 to July 15, 2006. A stratified random sampling technique was adopted for inventory of the product. The sample plots were laid at 100m distances along transects. Each individual

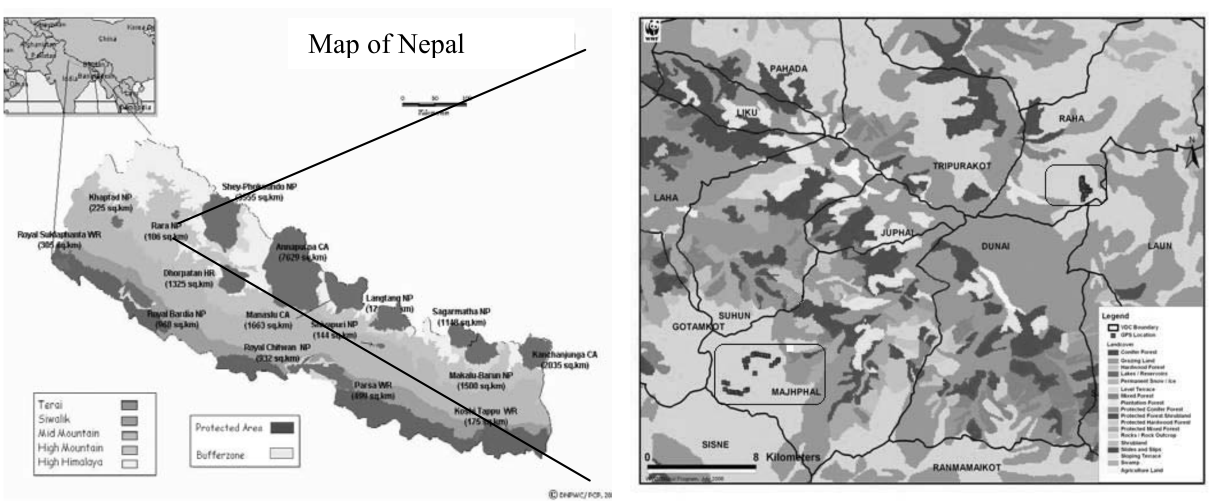


Figure 1: Showing study areas of Raha and Majphal VDCs of Dolpa district.

plot was marked permanently with enamels and stones. Forty plots were established at Palma Ramana pasture of Raha VDC, 10 at Pokeypani and 30 at Saiquarry of Majphal VDCs were established. The plots were established between the altitudinal range of 3905m to 4894m. The floral specimens collected from each permanent plot were recorded. Total numbers of *Ophiocordyceps sinensis* extracted by the collectors from the plots in the entire collection period were recorded.

Herbariums of collected plant specimens were prepared following the standard techniques (Martin, 1995; Lawrence, 1967). The collected plant specimens were identified with the help of standard literatures (Polunin & Stainton, 1984; Stainton, 1972; Lama *et al.*, 2001). All the herbariums were deposited in the Tribhuvan University Central Herbarium (TUCH).

Results and Discussions

The frequency and relationship of flowering plants on the distribution pattern of *Ophiocordyceps sinensis* during the collection period were recorded from the permanent plots of Raha and Majphal VDCs. The diverse groups of taxa are given in the Table 1. Altogether fifteen plant specimens belonging to ten families (Primulaceae, Ranunculaceae, Polygonaceae, Juncaceae, Compositae, Ericaceae, Euphorbiaceae, Rosaceae, Scrophulariaceae, Valerianaceae) were recorded from the study area.

The grasslands providing habitat for *Ophiocordyceps sinensis* were found to be predominantly of *Juncus thomsonii* and *Bistorta macrophylla* pastures. *J. thomsonii* covered most of the grasslands between the altitudinal range from 3000m to nearly 5200m, gradually rising from the southeast to the northwest of the pastures. Chen *et al.,* (2000) had also reported a similar distribution for Tibetan *O. sinensis.* Among the associated taxa, the top three plants with the highest frequencies were *J. thomsonii*, B. *macrophylla* and R*hododendron anthopogon*. These were observed in 79, 68, and 40 plots, respectively. Within the 80 permanent plots, the least frequently associated plants were *Androsace robusta*, *Primula macrophylla*, *Aconitum sp.* and R*umex nepalensis,* since they cropped up in only one, three, and four plots, respectively. The tender shoot of *B. macrophylla* resembled the fungal part of *O. sinensis* so the collectors were often confused.

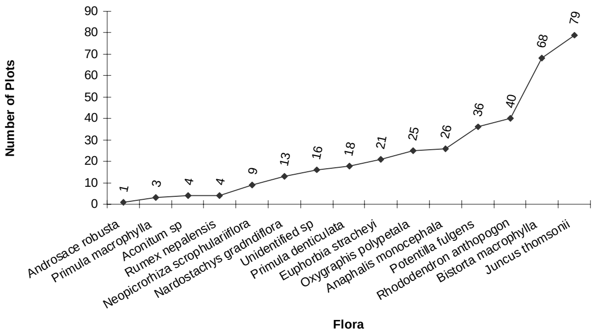


Figure 2: Number of sample plots and frequency of flowering plants.

Caterpillar fungus thrives in subalpine and alpine grasslands or meadows as well as open dwarf scrublands. In the study area, it was found naturally distributed from an altitudinal range of 3540 to 5050m asl. Since the current actual tree line has been strongly influenced by human activities; wide swathes of forests in study areas have been replaced by pastures. Similar phenomenon was also reported from the Tibetan plateau (Winkler, 2000)

In the case of Dolpa, no clear difference was found in the distribution pattern of *Ophiocordyceps sinensis* on different aspects. Collectors extracted from all sunny aspects. According to Boesi (2003), in Lithang China, caterpillar fungus was mostly found on north-facing slopes. However Winkler (2008) reported its distribution in China on well-drained sunny slopes with lush grass vegetation. In Dolpa, *O. sinensis* was confined to rich pastures and sites which were too wet or waterlogged did not harbor populations of *O. sinensis.*

Over grazing vs Distribution of *Ophiocordyceps sinensis*

Animal husbandry is a vital part of the economy of the local peoples. Almost every household usually maintained a large herd of animals for manure, milk, meat and to plough their fields. These herds included mainly sheep, goats, horses, ponies, ass and zomo (hybrid of yak and cow) that foraged on pastures. People graze their livestock freely in the forest and on grasslands based on customary systems (Ghimire, 2005). Overgrazing leads to the loss of forest regeneration and the loss of grassland vegetation thereby inducing soil erosion (Singh, 2001; Jha, 2006). The animals destroy *O. sinensis* during grazing because they also feed on the host plants. The livestock annually brought onto the pastures by the local collectors destroy the ecological niche of *O. sinensis.*

The collectors also reported that sites with less grazing effect had higher abundances of *O. sinensis*. *Juncus thomsonii, Bistorta macrophylla, Anaphalis monocephala, Potentilla fulgens,* were the plant species most affected by direct grazing and trampling effects. Similar views were also testified by collectors from Darchula district (Chettri & Lodhiyal 2008). This study also confirmed that the permanent plots affected by grazing impact had poorer densities of *O. sinensis* than the plots far from grazing areas.

Threats to the *Ophiocordyceps sinensis* in growing pastures in Dolpa

A number of threats are annually posed to the habitat of *Ophiocordyceps sinensis* growing pastures in Dolpa and these threats are mainly of anthropogenic nature. It was found that more than 50,000 collectors romped around 25 or more pastures of Dolpa during 2006. The major threats were haphazard and unscientific collection of *O. sinensis*; soil and water pollution, excessive use of fuel wood, hunting of wildlife, and intentional fires burns to procure fuelwood and better grass production for cattle.

The collectors burn intentional fires for clearing the sites to facilitate the collection of *O. sinensis* and also to extract fuelwood for the next season. They have figured out that burned areas harbored more *O. sinensis* in the following year. The accidental and intentional fires have, however, had adverse effects on the forest biodiversity in the past. The plant species mainly used for fuel wood by the collectors were *Rhododendron lepidotum, R. anthopogon, Juniperus* sp.*, Betula utilis,* and *Quercus* sp. Almost 100% of their energy resources were met from the nearby forests.

The majority of respondents (collectors/users = 74, traders = 25 and local healers = 3) surveyed in this study also complained that thousands of collectors posed negative impacts to the soil of pastures after leaving lots of non-degradable materials like plastics and batteries. Similarly, increasing numbers of foot trails in the pastures were perceived to be deteriorating the virginity of the green pastures.

Illegal hunting of local fauna was also a common practice throughout the collection areas and had become one of the major threats for faunal biodiversity conservation. According to the respondents in 2005, some of the professional hunters hunted the wild animals to exchange the flesh or trophy for *Ophiocordyceps sinensis*. *Pseudois nayaur* (Naur) was the species most targeted for hunting.

Maoists and Pastures Management

The collection and trade of *Ophiocordyceps sinensis* in Dolpa was totally controlled by the Maoist in the study year. Realizing the potential destruction of *O. sinensis*, the local Maoists had drawn up 17 points "Code of Conduct" regarding different aspects, including pasture management. Some of the major codes related to pasture management were a) not to cut green trees for fuel; b) not to make a big hole in the pastures during collection c) not to release cattle in the pastures before collection (there was provision to allow cattle a week after the collection starts); d) not to discard plastics and batteries in the pastures; and e) not to hunt wild animals. Though they have attempted to implement these strict regulations, there was no alternative to fuel except to cut more trees.

Conclusion

From the study it can be concluded that *Juncus thomsonii* and *Bistorta macrophylla* exhibited a wide range of distribution in the pastures of Dolpa during the *Ophiocordyceps sinensis* collection period. It can be speculated that a healthy grassland environment is favorable for the caterpillar development as no informant reported abundant fruiting of the fungus in degraded areas. Plantations of *Betula utilis, Rhododendron* spp, and *Juniperus* spp. should be established at lower forests to supplement growing stock depleted by the extraction of fuelwood during collection seasons. To maintain a healthy pasture environment, over trampling effects and over grazing should be minimized and checked.

Acknowledgements

I am indebted to late Dr. D. P. Parajuli, Dr. K.C. Paudel, Dr. M. K. Adhikari and Dr. K. R. Bhattarai from the Ministry of Forests and Soil Conservation, Nepal for their ideas and suggestions prior to the field visits. Dr. Suresh K. Ghimire from Central Department of Botany, Tribhuvan University, is to be thanked for offering editorial comments to the early drafts of this manuscript. I am thankful to Mr. Maan B. Rokaya, Mr. Mani R. Shrestha and Mr. Ram K. Deo for their constructive assistance. WWF Nepal Program and SAFE Concern, Kathmandu provided financial and logistic supports for this study.

References

Adhikari, M.K. 2000. **Mushrooms of Nepal.** P.U. Printers, Kathmandu, Nepal.

Adhikari, M.K. 2008a. *Cordyceps* in Nepal. In: *Proceeding of Second National Seminar and Fair on Herbs*. Organized by Herbs Products and Spices Trade Association, Nepalgunj. Pp.39-50

Adhikari, M.K. 2008b. The diversity of Cordycepioid fungi (Ascomycotina: Clavicipatales) reported from Nepal. *Bulletin of Department of Plant Resources.* **30:** 1-7.

Boesi, A. 2003. The dbyar rtswa dgun bu (*Cordyceps sinensis* (Berk).Sacc): An important trade item for the Tibetan population of the Lithang Country, Sichuan Province, China. *The Tibetan Journal* **28.3:**29-42.

Chen, S.J., Yin, D.H., Li, L., Zha, Xi., Shuen, J. H. and Zhama, C. 2000. Resources and distribution of *Cordyceps sinensis* in Naqu Tibet. *Zhong Yao Cai* **23**.11:673-5.

Chhetri, R. and Lodhiyal, L.S. 2008. Collection of *Cordyceps sinensis* (Berk). Sacc. (yarsagomba) and its implications to rural livelihood and biodiversity conservation: A case of Darchula, Nepal. In: *Medicinal Plants in Nepal: An Anthology of Contemporary Research*. (eds. P.K Jha, S.B. Karmacharya, M.K. Chetri, C.B. Thapa and B.B. Shrestha). Ecological Society (ECOS), Kathmandu, Nepal. Pp. 214-223.

Christensen, M., Bhattarai, S., Devkota, S. and Larsen, H.O. 2008. Collection and use of wild edible Fungi in Nepal. *Eco. Bot.* 62(1) pp. 12-23.

Devkota, S. 2006. Yarsagumba [*Cordyceps sinensis* (Berk) Sacc.]: traditional utilization in Dolpa district, Western Nepal. *Our Nature* **4** (48-52).

Devkota, S. 2008a. Approach towards the Harvesting of *Cordyceps sinensis* (Berk.) Sacc. in Pastures of Dolpa, Nepal. In: *Medicinal Plants in Nepal: An Anthology of Contemporary Research.* (eds. P.K Jha, S.B. Karmacharya, M.K. Chetri, C.B. Thapa and B.B. Shrestha). Ecological Society (ECOS), Kathmandu, Nepal. Pp. 90-96.

Devkota, S. 2008b. Distribution and status of highland mushrooms: A study from Dolpa, Nepal. *Jour. of Nat. Hist. Mus.* 23 (51-59).

Ghimire, S.K. 2005. The endemic flora in Dolpa, North-West Nepal: distribution patterns, Life forms, Habitat Specificity and Conservation Status. *Botanica Orientalis* **5**. 35-39.

IUCN. 2000. **National Register of Medicinal Plants.** IUCN Nepal.

Jha, S. G. 2006. Linkages between biological and cultural diversity for participatory management: Nepal's experiences with Makalu-Barun National Park and its buffer zone. *Banko Janakari.* **16 (2):** 37-44.

Kobayasi, Y. 1982. Keys to the taxa of the genera *Cordyceps* and *Torrubiella*. *Trans Myco. Soc. Jap.*. **23**: 329-364.

Kobayasi, Y. and Shimizu, D. 1960. Monographic studies of *Cordyceps*. 1. group parasitic on *Elaphomyces. Bull. of Nat. Scien. Mus., Tokyo.* 5(2): 70-82.

Kobayasi, Y. and Shimizu, D. 1963. Monographic studies of *Cordyceps*. 2. group parasitic on Cicadidae. *Bull. of Nat. Sci. Mus., Tokyo.* **6 (3) 52:** 286-314.

Lama Y. C., Ghimire, S.K. and Aumeeruddy Y. Thomas. 2001. **Medicinal plants of Dolpo: Amchi's Knowledge and Conservation.** WWF Nepal and People and Plants Initiative, Kathmandu, Nepal.

Lawrence, G. H. M. 1967. **Taxonomy of Vascular Plants.** Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, India.

Martin, G. J. 1995. **Ethnobotany: A People and Plants Conservation Manual.** Chapman and Hall.

Polunin. O, and Stainton, J.D.A.1984. **Flowers of the Himalaya.** Oxford University Press. India.

Sherchan, R., Chapagain, N. R. and Chhetri, M. 2005. Distribution. Conservation practices and trade of Yarsagumba in Manang District of Annapurna Conservation Area, Nepal. *Forestry* (Jour. of Inst. of Fore., Nepal). **13.** pp. 99-107.

Shrestha, T.B. and Joshi, R. M. 1996. **Rare, Endemic and Endangered Plants of Nepal.** WWF Nepal Program, Kathmandu, Nepal.

Singh, B. B. 2001. **Socio-Economic Study of Makalu-Barun Landscape Complex**. Final Report submitted to Nepal Biodiversity Landscape Project, Kathmandu, Nepal.

Stainton, J. D. A.1972. **Forests of Nepal**. John Murray, London.

Sung, J. M. 1996. **Cordyceps of Korea**. Kyo-Hak. Publishing Co. Ltd., Seoul. 299 pp.

Sung, G. H., Hywell-Jones, N. L., Sung, J. M., Luangsa-ard, J. J., Shrestha, B. and Spatafora, J. W. 2007. Phylogenetic classification of *Cordyceps* and the clavicipitaceous Fungi. *Stud. in Myco.* **57:**5–59.

Winkler, D. 2000. Patterns of forest distribution and the impact of fire and pastoralism in the forest region of the Tibetan Plateau. In: *G. Miehe & Zhang Yili (eds.): Environmental change in high Asia, Marburger Geographische Schriften* **135:** 201-227.

Winkler, D. 2008. Yartsa Gunbu (*Cordyceps sinensis*) and the fungal commodification of Tibet's rural economy. *Eco. Bot.*, XX(X), 2008, pp. 1–15.

Wu, N. 1997. Ecological situation of high-frigid rangeland and its sustainability - A case study on the constraints and approaches in pastoral Western Sichuan/China. *Abh. Anthropogeo.* **55:** 1-281.

Zang, M. and Kinjo, N.1998. Notes on the Alpine *Cordyceps* of China and nearby nations. *Mycotaxon* **66**:215-229.

Table 1: Frequency in associations of *Ophiocordyceps sinensis* with flowering plants

S.N	Plot No	Plants																
		Juncus thomsonii	*Potentilla fulgens*	*Euphorbia stracheyi*	*Anaphalis monocephala*	*Bistorta macrophylla*	*Oxygraphis polypetala*	*Primula denticulata*	*Rhododendron anthopogon*	*Unidentified* sp	*Nardostachys grandiflora*	*Neopicrorhiza scrophulariiflora*	*Primula macrophylla*	*Rumex nepalensis*	*Aconitum* sp	*Androsace robusta*	Total plants species	Total frequency of *O. sinensis*
1	RY 01	+	+	+	+	+											5	5
2	RY 02	+	+	+	+	+											5	4
3	RY 03	+	+	+	+	+											5	4
4	RY 04	+	+	+	+	+											5	2
5	RY 05	+	-	-	-	+	+										3	1
6	RY 06	+	+	+	-	+	+										5	2
7	RY 07	+	-	+	-	+	-										3	3
8	RY 08	+	+	-	-	+	+										4	4
9	RY 09	+	+	-	-	+	-										3	7
10	RY 10	+	+	+	-	+	-										4	10
11	RY 11	+	+	-	-	+	-										3	5
12	RY 12	+	-	-	-	+	-	+									3	2
13	RY 13	+	-	+	-	+	-	+	+								5	3
14	RY 14	+	+	+	-	+	-	+	-								5	9
15	RY 15	+	+	-	-	+	-	+	-								4	1
16	RY 16	+	-	-	-	+	-	-	-								2	1
17	RY 17	+	+	+	-	+	-	-	-								4	4
18	RY 18	+	+	-	-	+	-	-	-								3	2
19	RY 19	+	-	+	+	+	-	-	-								4	9
20	RY 20	+	+	-	+	+	-	-	-								4	3
21	RY 21	+	-	-	+	+	-	-	-								3	1
22	RY 22	+	+	-	+	+	-	-	-								4	3
23	RY 23	+	-	-	+	+	+	-	+								5	2
24	RY 24	+	-	-	+	+	-	-	+								4	10
25	RY 25	+	-	-	+	+	-	-	+								4	2
26	RY 26	+	+	-	-	+	+	+	-								5	14
27	RY 27	+	+	-	-	+	+	+	-								5	1
28	RY 28	+	-	-	-	+	-	+	-								3	1
29	RY 29	+	-	-	-	+	-	+	-								3	1
30	RY 30	+	+	-	-	+	-	-	-								3	2
31	RY 31	+	-	-	-	+	+	-	-								3	13
32	RY 32	+	-	-	+	+	+	-	-								4	9
33	RY 33	+	-	-	-	+	-	+	-								3	2
34	RY 34	+	+	-	-	+	-	+	+								5	2
35	RY 35	+	+	-	-	+	+	+	+								6	1
36	RY 36	+	+	-	-	+	+	+	-								5	2
37	RY 37	+	+	-	-	+	+	+	-								5	2
38	RY 38	+	+	-	-	+	+	+	-								5	1
39	RY 39	+	-	-	-	+	-	+	+								4	2
40	RY 40	+	+	-	-	+	-	+	+								5	2
41	MY 01	+	+	+	+	+	-	-	-	+							6	4
42	MY 02	+	+	+	-	+	-	-	+	+							6	14
43	MY 03	+	-	-	-	-	-	-	+	+	+						4	15

44	MY 04	+	-	+	+	-	+	-	+	+	-						6	19
45	MY 05	+	+	-	-	-	+	+	+	-	+	+					7	5
46	MY 06	+	+	-	-	-	+	+	+	-	+	-					6	19
47	MY 07	-	-	-	-	-	+	-	+	+	+	-					4	19
48	MY 08	+	+	-	-	-	-	-	+	+	+	+	+				7	20
49	MY 09	+	-	-	-	-	-	-	+	-	-	-	+				3	20
50	MY 10	+	-	-	-	-	-	-	+	+	+	+	-				5	21
51	MY 11	+	+	-	-	-	-	-	+	-	-	-	-				3	18
52	MY 12	+	+	-	-	-	-	-	+	-	-	-	-	+			4	24
53	MY 13	+	+	-	-	-	-	-	-	+	-	-	-	+			4	18
54	MY 14	+	+	-	-	-	-	-	+	+	-	-	-	+			5	11
55	MY 15	+	-	+	+	+	-	-	+	+	-	-	-	-			6	6
56	MY 16	+	-	-	-	+	-	-	+	+	+	-	-	+	+		7	16
57	MY 17	+	-	+	-	+	+	-	+	+	+	-	-	-	+		8	10
58	MY 18	+	+	+	-	+	-	-	+	+	-	-		-	-		6	18
59	MY 19	+	-	-	+	+	-	-	+	+	-	-	-	-	-		5	21
60	MY 20	+	-	-	+	+	-	-	+	-	-	-	-	-	-		4	10
61	MY 21	+	-	-	+	+	-	-	+	+	-	-	-	-	-		5	11
62	MY 22	+	-	-	-	+	-	-	+	-	-	-	-	-	-		3	11
63	MY 23	+	-	-	+	+	-	-	+	-	-	-	-	-	-		4	21
64	MY 24	+	-	-	+	+	+	-	+	-	-	-	-	-	-		5	11
65	MY 25	+	-	-	+	+	+	-	+	-	-	-	-	-	-		5	13
66	MY 26	+	-	-	-	+	-	-	+	-	-	-	-	-	-		3	25
67	MY 27	+	-	-	-	+	-	-	-	-	-	-	-	-	-	+	3	23
68	MY 28	+	+	+	-	+	-	-	+	-	-	-	-	-	+	-	6	11
69	MY 29	+	-	+	+	+	+	-	+	-	-	-	-	-	-	-	6	15
70	MY 30	+	-	+	+	+	-	-	+	-	-	-	-	-	-	-	5	14
71	MY 31	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	2	6
72	MY 32	+	-	-	-	+	-	-	+	-	-	-	-	-	-	-	3	5
73	MY 33	+	-	-	+	+	+	-	+	-	-	-	-	-	-	-	5	16
74	MY 34	+	-	-	+	+	+	-	+	-	+	+	-	-	-	-	7	15
75	MY 35	+	-	-	+	+	+	-	-	-	+	+	-	-	-	-	6	14
76	MY 36	+	-	-	-	+	+	-	-	-	+	+	+	-	+	-	7	3
77	MY 37	+	-	-	-	+	+	-	+	-	+	+	-	-	-	-	6	5
78	MY 38	+	+	+	-	+	-	-									4	22
79	MY 39	+	-	-	-	+	-	-	+	-	-	+	-	-	-	-	4	4
80	MY 40	+	-	-	-	+	-	-	-	+	+	+	-	-	-	-	5	12
	Total	79	36	21	26	68	25	18	40	16	13	9	3	4	4	1		

Note:

RY = Raha Yarsagumba; MY = Majphal Yarsagumba; + = Present; - = Absent

Sunbuki, Dhochi = *Juncus thomsonii;* Gorukajera = *Potentilla fulgens;* Peitei Jasto = *Euphorbia stracheyi;* Jhullya = *Anaphalis monocephala;* Nimbu, Nyakuri = *Bistorta macrophylla;* Pahelo tarey = *Oxygraphis polypetala;* Doeli phool = *Primula denticulata;* Paluwa = *Rhododendron anthopogon;* Narku = *Unidentified* sp.*;* Bhutley = *Nardostachys grandiflora;* Kutki = *Neopicrorhiza scrophulariiflora;* Katarey = *Primula macrophylla;* Halhaley = *Rumex nepalensis.;* Bikh = *Aconitum* sp.*;* Begarey Jhar = *Androsace robusta.*

Depredation and deteriorating condition of *Shorea robusta* and *Terminalia alata* in Bardia National Park: an imperative to address park biodiversity sustainably

G. R. Acharya[1], B. Bhatta[2], and A. R. Gyawali[3]

The paradigm shift in park management from a fortress mentality to the participatory concept is represented as a major transformation in the conservation discourse in Nepal. The involvement of local people in the management of resources in national parks has been significantly effective in attaining the conservation goals of conserving wildlife without compromising the basic forest resource needs of the local people. Nevertheless, some economically important species have not been afforded due consideration during such management. This study investigates the species composition and regeneration status of *Shorea robusta* (Sal) and *Terminalia alata* (Saj) in 4 Buffer Zone community Forests of Bardia National Park in Thakurdwara VDC in 1999/2000, 2002/2003 and 2005. The results reveal that *Shorea robusta* (Sal) and *Terminalia alata* (Saj) both constituted a large proportion of species diversity but that their regeneration from seedlings to established stages were low, suggesting vulnerability of this forest and their sustainability at risk due to their dwindling conditions. Immediate management concern of these economically important forest tree species is warranted.

Keywords: Biodiversity, national park, s*horea robusta*, sustainability, *terminalia alata*

Bardia National Park (BNP) covering an area of 968 sq.km is the largest protected area of Terai and Bhabar regions. It lies in the mid western development region and represents the subtropical climate of Nepal. BNP is famous for its wild habitats that is home to animal species such as wild elephants, tigers, deers, and translocated rhinos (Bhatta, 1994; Gyawali, 1995).

One of the largest rivers of Nepal, the Karnali flanks the western bank of the national park while many other rivers, including the Babai, flow through it. These rivers provide habitats for aquatic animals and waterfowl as well as for the rearing of endangered amphibians and reptiles.

The old concept of segregating people from the national park has been reconsidered to accommodate the participation of local people (Acharya and Dhungana, 2009). In this process the forest areas buffering the national park were declared as Buffer Zones in 1996 and the neighbouring people were mobilized to manage these forests properly by organizing them into user groups (PPP, 1999; Karki, 1997).

Before the implementation of the buffer zone concept, the people residing in the vicinity were not granted access to the national park resources. The park was sealed from the people. Later it was realized that such isolation of the national park from the people threatened the sustainability of the park and its resources. This notion has been validated in all kinds of community based natural resource managements (Allendorf, 1999; Acharya, 2007; Tamrakar and Sharma, 2002).

With the declaration of buffer zone areas in the BNP, the concern for effective Buffer Zone Community Forest (BZCF) management is rising within the user groups. Activities such as benefit sharing, Non Timber Forest Product (NTFP) promotion, forest species composition and management are gaining attention (Acharya, 2002).

Knowledge about the species composition and their regeneration status is a necessary tool for managing the forests scientifically. This knowledge enables the selecting of species that have the most importance to the users and their sustainable management for the wildlife in the park.

[1] Natural Resources Management Specialist, MEH Consultants (P.) Ltd., Kathmandu Nepal. Email: ganeshraj.acharya@gmail.com
[2] Director-Research, Alliance Nepal
[3] Associate Professor, Institute of Forestry, Pokhara

Materials and methods

Study site

The study area is located in Bardia district of mid western development region of Nepal. The study was carried out in four BZCFs of BNP. Of the four BZCFs, Chidkaiya, Thakurdwara and Betani had areas of 62 hectares each whereas the area of Bhudkaiya was 92 hectares, consisting of a 50 ha natural forest and a 40 ha plantation.

Only the natural forests were considered for this study. Similarly Bhudkaiya was a separate BZCF whereas the other remaining three BZCFs were contiguous with each other. All four BZCFs were part of the Thakurdwara VDC. The BNP headquarter is located at Thakurdwara and is accessible by a 13 km gravel road from Ambasa, on the East-West Highway of Nepal.

Data collection and analysis

Tree species composition and regeneration survey of BZCF were carried using stratified systematic sampling method. Stratification was done based on stand density and canopy cover. For the study of tree species composition, a 1% sampling intensity was conducted with plots of 10mx10m. Within these plots, only tree species compositions were identified by counting the number of trees in each plot. Later, tree numbers were tabulated as percentages. The total number of plots in Chidkaiya, Thakurdwara and Betani BZCFs were 62 and in Bhudkaiya, it was 50.

Similarly for regeneration survey, a 0.1% sampling intensity was used for plots of 2m x 2m within the (10m*10m) plots used for tree species composition. The total number of plots in Chidkaiya, Thakurdwara and Betani BZCFs were 155 and in Bhudkaiya, it was 125. The regeneration survey was carried out by recording the regeneration of the species into various categories as follows (Khanna, 1996):

- Established (e): whose height should be in between 2.5 m to 4 m.
- Woody (w): unestablished seedling, whose height should be between 1.5 m to 2.5 m
- Whippy (u): unestablished seedling, whose height should be between 50 cm to 1.5m
- Sub whippy(s): unestablished seedling whose height is between 20 cm to 50 cm
- Recruit(r): current year's seedling, whose height is up to 20 cm with six leaves maximum

Data was analyzed using descriptive statistics and presented graphically.

Results and discussions

Species composition

Figure 1 reveals that within all BZCFs, *Shorea robusta* and *Terminalia alata* were found to be the major species.

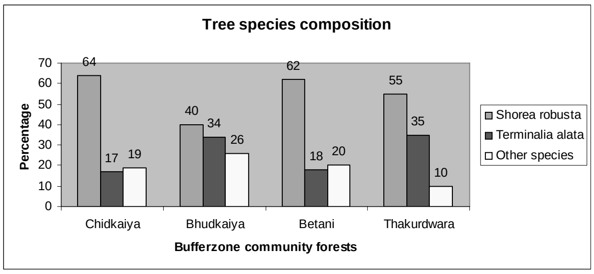


Figure 1: Tree species composition on Buffer Zone community forests

Other species category in the Figure 1 included: *Acacia catechu* (Khayer), *Adina cordifolia* (Haldu), *Bassia indica* (Mahuwa), *Cassia fistula* (Rajbriksha), *Ficus religiosa* (Peepal), *Garuga pinnata* (Dabdabe), *Lagerstroemia parviflora* (Botdhaire), *Mallotus phillippinensis* (Rohini), *Myraine semiserrata* (Kalikath), *Schleichera trijuga* (Kusum), *Semecarpus anacardium* (Bhalayo) and *Syzyzium cumini* (Jamun) among others.

The management system needs to promote economically important species such as *Shorea robusta* and *Terminalia alata,* which are valued as timber for their durability and superior quality while species such as *Mallotus phillippinensis* are economically less important but could still be used as fodder for animals.

Regeneration and species density

Figure 2 shows that in terms of the regeneration status, current year recruits seedling occupied the highest percentage of seedlings in all 4 Buffer Zone Community Forests, followed by other categories.

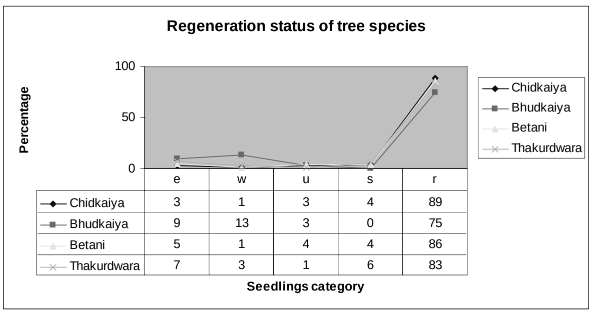


Figure 2: Regeneration status of tree species

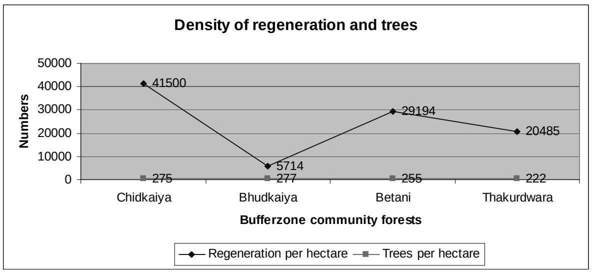


Figure 3: Regeneration and tree status of the species

Figure 3 above shows that in all BZCFs, the numbers of trees per hectare were similar (222-277) but regeneration numbers differed significantly. Chidkaiya CF had the highest number of regeneration (41,500) whereas Bhudkaiya had the least (5714). Fencing along the boundary and strict prohibition on grazing in Chidkaiya forest contributed to its highest regeneration. The worst regeneration in Bhudkaiya was due to unrestricted grazing allowed inside this forest.

Profuse regeneration of *Shorea robusta* occurred under the open canopy. Similarly, protection also contributed to the profuse regeneration. As Chidkaiya and Betani forests were controlled from grazing, the number of seedlings in these forests was comparatively higher. Erecting fencing along the boundary is expensive and may not always be feasible. Instead the prohibition of open grazing system can help in facilitating high regeneration like that in Chidkaiya.

Condition of *Shorea robusta* and *Terminalia alata* in future

Table 1 reveals that there was no established seedlings "e" of *Shorea robusta* in all the forests studied. Table 2 shows the absence of "e" category from all the forests; this is an indication of the deteriorating status of *Shorea robusta* and *Terminalia alata* species. In particular, the absence of "w", "u", and "s" categories of *Terminalia alata* seedlings reveals an even more vulnerable condition for this species.

The absence of established seedlings of *Shorea robusta* and *Terminalia alata* in all the BZCFs underscores the high risk to the future sustainability of these forests. This absence also suggests that species management of BZCF has not been scientific. Between these two species, the condition of *Terminalia alata* is more vulnerable with zero established, woody and whippy categories. If this condition is not redressed in due time, eventually this species will head towards extinction in the BZCFs.

Shorea robusta and *Terminalia alata* represent important species in the Terai region of Nepal. Both species are not only economically but also ecologically very important. While managing these species, other species in the forest should also be given importance because of their ecological and economic significance (Jackson, 1994; Ojha et al., 2008, Acharya et al., 2009).

Conclusions

The findings on tree species composition and regeneration survey will be helpful in understanding the composition of forest. These findings will further help in selecting important species. *Shorea robusta* and *Terminalia alata* were found as dominant tree species in the BZCFs but their regeneration indicated an even lower representation in established form (e). Both these species need immediate attention for their management and this research could serve as a benchmark for further investigations.

Acknowledgements

We would like to thank NTNC team of Bardia (formerly KMTNC/BCP) for partial funding to

Table 1: Condition of established seedling of *Shorea robusta*

Chidkaiya (%)	**Bhudkaiya** (%)	**Betani** (%)	**Thakurdwara** (%)
e=0	e=0	e=0	e=0
w=0.12	w=0	w=0	w=0
u=0.5	u=0.48	u=0	u=0
s=0.95	s=0.93	s=0.89	s=0
r=97.5	r=97	r=93.15	r=50

Table 2: Condition of established seedling of *Terminalia alata*

Chidkaiya (%)	**Bhudkaiya** (%)	**Betani** (%)	**Thakurdwara** (%)
e=0	e=0	e=0	e=0
w=0	w=0	w=0	w=0
u=0	u=0	u=0	u=0
s=o	s=o	s=o	s=o
r=1.6	r=1	r=2.3	r=8.4

undertake this research. We would also like to thank Dr. Shanta Raj Gyawali, Mr. Baban Prasad Kayastha and Dr. Rajendra Prasad Adhikari for their input, help and suggestions. Inputs from anonymous reviewers are duly acknowledged.

References

Acharya, G.R. 2007. Conflict Management in Community Forestry: A Study of Community Forests in Nepal. MSc thesis, Wageningen University, The Netherlands. 105 p.

Acharya, G.R. 2002. A study of some factors related to sustainable management of buffer zone community forest in Royal Bardia National Park. M.Sc. Thesis, Pokhara University, Nepal, 61 p.

Acharya, G.R., Koirala, P.N., Neupane, L. and Devkota, S.C. 2009. Livelihood option from minor forest produce: context of non timber forest product and poverty reduction in mid hills of Nepal. *Journal of Wetlands Ecology* **2:** 56-65

Acharya G.R. and Dhungana, H.P. 2009. Participatory planning formulation in conservation area. In *Biodiversity and Livelihoods* (ed) Dhungana, H.P., Ghimire, S. and Adhikari, J. Martin Chautari, Nepal, 317-332.

Allendorf, Terling D. 1999. Local Residents Perception of Protected Areas of Nepal: Beyond Conflicts and Economics. Ph. D thesis, University of Minnesota, USA.

Bhatta, S.R. 1994. Beginning with Buffer Zone Management: A Case Study from Royal Bardia National Park Nepal. M.Sc. thesis, Agricultural University of Norway, Norway.

Gyawali, S.R. 1995. Population Ecology of Greater One-Horned Rhinoceros (*Rhinoceros unicornis*) with Particular Emphasis on Habitat Preference, Food Ecology and Ranging Behaviour of the Reintroduced Population in Royal Bardia National Park in low land Nepal. Ph.D thesis, Agricultural University of Norway, Norway.

Jackson, J.K. 1994. **Manual of Afforestation in Nepal**: Volume 2. 2nd edition. Forest Research and Survey Centre, Kathmandu.

Karki, J.B. 1997. Effects of Grazing, Utilization and Management of the Grassland of the Royal Bardia National Park, Nepal. M.Sc. thesis, Wildlife Institute of India, Dehradun, India.

Khanna, L.S. 1996. **Principle and Practice of Silviculture**, 6th edition. Khanna Bandhu Publication, Dehradun, India.

Ojha, S.K., Acharya, K.P., Acharya, B. and Regmi, R. 2008. Simple coppice management options for the sal (*Shorea robusta* Gaertn.f.) forests in the Terai of Nepal. *Banko Jankari* **18 (1)**: 32-41

Park People Programme (PPP) 1999. **Biodiversity Conservation Initiatives in and around Protected Areas**. Park People Programme, DNPWC Nepal, 28p.

Tamrakar A. and Sharma, B.K. 2002. Conservation and development of local forest resources and wildlife through community forestry: a case study from Baghmara community forest, Chitwan. *Banko Jankari* **12 (1)**: 49-53.

Short note

Agrobiodiversity Conservation to deal with Climate Change

S. Nepal

Climate change is real and the effects of climate change vary with different spatial scales. At a broader global scale, climate change may have negligible impact whereas at the local and regional scales, the impact may be severe and substantial. For instance, at the local/regional levels of an agricultural ecosystem, climate change may impact agricultural sustainability in two interrelated ways. First, it may reduce the long-term ability of the agroecosystem to provide enough food and fiber for the world's population and second, it may induce alteration in agro-climatic conditions and spatially shift agroecosystems, thus endangering natural habitats and their floral and faunal diversities. Climate change is, therefore, a serious concern for agricultural ecosystems and there is a need for an agrobiodiversity conservation approach to combat with these problems.

Agrobiodiversity comprises of all the components of biological diversity pertinent to food and agriculture present in agro-ecosystems, including microbes, insect pollinators, and the hedgerows that support soil stability and provide a home for wildlife. It also provides opportunities to develop and implement adaptation strategies to the biotic and abiotic stresses resulting from climate change, while mitigating the emissions of green house gases. So, agrobiodiversity can be the basis for reducing emissions of green house gases, sequestering carbon, suppressing pests and diseases, using water and nutrients efficiently and maintaining the productivity of agriculture as a whole. Thus in the long run, agrobiodiversity can be the basis for enhancing food security, livelihood, and the conservation of resource base to mitigate climate change.

Agrobiodiversity based conservation approaches to address the climate change include: i) genetic enhancement of crops for a more changing and heterogeneous environment, ii) use of integrated pest management (IPM) with the best combination of cultural, biological and technological measures of pest control, iii) change in cropping patterns by promoting agroforestry, agroenergy and new crop species, and iv)organic and traditional farming systems with less dependence on energy-intensive fertilizers, chemicals, and concentrated feeds.

Recently, a new concept of Agrobiodiversity Conservation Credit (ACC) has been proposed to address climate change. Climate change might consider exploring credits for carbon sequestration in soils through conservation tillage as well as agroforestry and other climate friendly practices (no use of fertilizers/pesticides) in agricultural landscapes. Compared to orthodox methods of agriculture, these approaches offer higher productivity per unit area, easy management for agricultural systems and less harm to human health and environment.

All these approaches have the potentials to address climate change. However, the most challenging job to implement these approaches is to convince people to accept these approaches. People's participation at various levels of planning and policy making may be effective for addressing these people. A key to address climate change may be increasing participation of the general public, private sectors, policy makers and research institutions to integrate agrobiodiversity research in various national and international agenda and plans to revitalize conservation efforts in agrobiodiversity.

In conclusion, climate change is real and inevitable; its effects cannot be completely controlled but large reductions of adverse impacts are possible when adaptation and mitigation measures are fully implemented. Agrobiodiversity conservation supported by integrated systems of environmental, social and political sciences is one of the best approaches to climate change and to influence multiple ecosystem services such as agricultural productivity, water quality, energy conservation and human health.

Graduate Research Assistant, University of North Dakota, E-mail: sandhya.nepal@nodak.und.edu

Central Forest Library Acquisition List No. 52, May 2009

Books

Hasettu, B. B. 2002. **Glimpses of Biodiversity,** New Delhi : Daya publication 296p.

Hayes, H. K. 2009. **Methods of Plant Breeding,** India : Biotech Books [2nd ed.] 551p.

Sawahel, W. A. 1997. **Plant Biotechnology Education Programmers: from Schoot to University,** NewDelhi : Daya Publishing. 72p.

Khan, M. A. 2008. **Plant Breeding,** New Delhi : Biotech Books. 318p.

Sawahel, W. A. 1997. **Plant Genetic Engineering from A to Z,** New Delhi : Daya Publishing. 143p.

Sawahel, W. A. 1997. **Plant Genetic Transformation Technology,** India : Daya Publishing. 137p.

Sharma, B. 2008. **Plant Tissue Culture & Transformation for Production Technique,** New Delhi : Daya Publishing. 155P.

Goel, A.I K. 2007. **Post Harvest Management & Value Addition,** India : Daya Publishing .317P.

Bansal, P. B. 2006. **Potential of Plant Biotechnology,** India : Genetech Books. 268p.

Das, G. 2001. **Research Priorities in North North East India – Manipur,** India : Regency Publishing. 54p.

Zeol, L. 2001. **Research Priorities in North North East India – Manipur,** India : Regency Publishing, 53p.

Gopalakrishnan, R. 2001. **Research Priorities in North North East India – Assam,** India : Regency Publishing. 104p.

Gassah, L. S. 2001. **Research Priorities in North North East India,** India : Regency Publishing, 77p.

Singh, V. 1988. **Sea Buckthorn : A Multipurpose Wonder plant,** Vol.2.- India : Daya Publishing. 600p.

Singh, V. 2008. **Sea Buckthorn: Modern Cultivation Technology,** New Delhi : Daya Publishing. 155p.

Singh, G. 2008. **Seed Testing,** India : Gene Tech Books 262p.

Gerram, M. R. K. 2006. **a Text Books on Forest Management,** New Delhi : Asiatic Publishing. 156p.

Bajpai, G. 1989. **Agrarian Urban Economy & Social Change,** New Delhi : Daya Publishing, 198p.

Ramanathan, T. 2004. **Applied Genetics of Oilseed Crops,** New Delhi : Daya Publishing. 424p.

Dhiman, A. K. 2006. **Ayurvedic Drug plants,** India New Delhi Daya Publishing 598p.

Drury, C. 2005. **Ayuverdic Useful Plants of India 2ed,** India Asiatic Publishing.512p.

Vidhyasekaran, P. 1990. **Basic Research for Crop Diseases Management,** New Delhi,Daya Publishing. 410p.

Bandyopadhyay, P. C. 2007. **Breeding and Crop Production,** New Delhi. 286p.

Gangawane, L. V. 2008. **Crop Disease : Identification & Management,** New Delhi Daya Publishing 244p.

Economic Branch of Fri 2002. **The Development of India's Forest Resources,** New Delhi, Daya Publishing. 39p.

Janardhanan, K. K. 2002. **Diseases of Major Medicinal Plants,** New Delhi. Biotech Books,189p.

Pushpangadan, P. 2008. **Ethno Pharmacology Recent Advances,** New Delhi Daya Publishing. 260p.

Thangadurai, D. *et al.* 2006. **Genes, Genomes and Genomics,** vol 1st, New Delhi . Regency Publication. 216p..

Thangadurai, D. *et al.* 2007. **Genes, Genomes and Genomics,** vol 2nd, New Delhi . Regency Publication. 244p..

Thangadurai, D. *et al.* 2005. **Genetic Resources and Biotechnology,** vol 1st, New Delhi . Regency Publication. 316p..

Thangadurai, D. *et al.* 2005. **Genetic Resources and Biotechnology,** vol 2nd, New Delhi . Regency Publication. 355p..

Thangadurai, D. *et al.* 2005. **Genetic Resources and Biotechnology,** vol 3rd, New Delhi : Regency Publication. 350p..

Crane, M. B. 2045. **Genetics of Garden Plants,** 4th ed. New Delhi : Biotech Books, 301p.

Ciesla, W. M. 1998. **Climate Change, Forests and Forest Management,** New Delhi : Daya Publishing, 128p.

FAO/FTP. 2005. **Community Forestry Rapid Appraisal of Tree and Land Tenure,** New Delhi : Daya Publishing. 90p.

Hossetti, B. 2008. **Conservation in Wildlife Management,** New Delhi : Daya Publishing. 428p.

Singh, M. P. 2004. **Conservation of Biodiversity and Natural Resources,** New Delhi : Daya Publishing. 368p.

Singh, M. P. 2007. **Forest Environment and Biodiversity,** New Delhi : Daya Publishing. 556p.

FAO. 2001. **Guidelines for Management of Tropical Forests,** New Delhi : Daya Publishing. 293p.

Brown, N. C. 2002. **Principles and Methods of Harvesting Timber,** New Delhi : Biotech Books. 418p.

Chaudhuri, A. B. 2004. **Project Tiger Reserves : Resources, Diversity, Sustainability, Ecodevelopment,** New Delhi : Daya Publishing. 341p.

FAO. 2002. **Rattan Current Research Issues & Perspects for Conservation and Sustainable Development,** New Delhi : Daya Publishing. 272p.

Kumar, V. 1998. **Scientific Management of Forest Libraries,** New Delhi : Daya Publishing. 157p.

Central Forest Library

Department of Forest Research and Survey,
E-mail: dapsmishra@yahoo.com
Tel. No. +977-1-4269491
P.O. Box: 3339, Kathmandu, Nepal

Notice

The Central Forest Library hereby requests all researchers, academicians and students to send one copy of their thesis and research papers related to forestry, wildlife, botany, soil conservation, socio-economic studies, Medicinal Plants, environment and biodiversity to this library.

Central Forest Library

Department of Forest Research and Survey,
E-mail:foresc@wlink.com.np
Tel. No. 220482/4269491
P.O. Box: 3339, Kathamdu, Nepal

Key word index to Vol. 19, No. 1, May 2009

Guidelines for contributors

Banko Janakari is a refereed journal. Articles, short notes, book reviews, news items, or letters to the editors may be submitted to *Banko Janakari.* Articles, etc. are subjected to change and necessary corrections. They are accepted on the understanding that the editor may shorten or alter them in an appropriate way. In the case of scientific articles authors will be consulted as far as possible depending on the difficulties of communication. Please state whether an article, in any way related to the one submitted to *Banko Janakari,* has already been submitted to another publisher and has been accepted or is awaiting a decision, or if article submitted relates to work that has been commissioned by any government or other organisation, or done in any connection with a course of study at a university or other institution.

Articles should be of interest to the broad categories of forestry professionals in general and be understandable to non-specialist also. Articles should be written in plain and concise language and jargons should be avoided. Technical terms that may be unfamiliar to readers should be defined when they appear for the first time. Footnotes should be avoided as far as possible. Manuscript should be in English, typed in double space and submitted in duplicate. However, manuscripts in electronic format, either on diskette or as e-mail attachment is preferred to hard copies. The length of the manuscript should be between 3000 and 4000 words for longer articles and 1000 and 2000 for short notes. However, shorter or longer articles may be considered in certain cases. Articles should follow the journal's format: a) Abstract b) Introduction/Background c) Materials and Methods d) Results and Discussion e) Conclusion and f) References.

The first page of the article should provide the full name, title and complete address of the author(s) including e-mail address. Subsequent pages should be numbered sequentially. The article should commence with a concise and informative abstract in one paragraph without reference to text or figures. It should be within 250 words. The abstract should follow four to five keywords.

Authors are requested to provide supporting illustrative materials (Tables, graphs, maps and drawings) with manuscripts. Such materials must be numbered and supplied on separate sheet. Photographs should be black and white (preferably glossy prints from black and white negative; alternatively the negative may be sent-they will be returned). All measurements should be given in the metric system. Exchange rate of Nepalese Rupees with US dollars is a must where monetary figures are supplied. All the tables more than half of A4 size paper and those other than results should be kept as annexes.

References should be given at the end of the article on separate sheet of paper. Reference cited in the text must be listed alphabetically. References used in the text should indicate the name of the author(s) and date of publication at appropriate points (e.g. Sarkeala, 1995; Dennis *et al.,* 2001), with the full reference given in a separate list at the end of the article. The term *et al.* should be used in the text when there are three or more authors. However, complete list of the authors should be named in references. For the convenience of authors, some examples of citation from different publications are given below:

Journal articles

Sarkeala, J. 1995. Use of satellite imagery in preparing a national forest inventory for Nepal. *Banko Janakari* **5(2)**: 64-68.

Dennis, R., Hoffman, A., Applegate, G., Von Gemmingen, G. and Kartawinata, K. 2001. Large-scale fire: creator and destroyer of secondary forests in Western Indonesia. *Journal of Tropical Forest Science* **13 (4)**: 786-799.

Books

Draper, N. R. and Smith, H. 1981. **Applied Regression Analysis.** 2nd edition. Wiley and Sons, New York.

Edited books (Proceedings)

Tsuchida, K. 1983. Grassland vegetation and succession in eastern Nepal. In *Structure and Dynamics of Vegetation in Eastern Nepal* (ed) Numata, M. Chiba University, Japan, 47-87.

Reports

EPC. 1993. **Nepal Environment Policy and Action Plan: Integrating Environment and Development.** Environment Protection Council, GON Nepal, 87p.

Paper (Seminar/Workshop)

Alder, P. and Kwon, S. 1999. "Social capital : The Good, The Bad and The Ugly" paper presented at the academy of management meeting, Chicago, USA.

Thesis

Shrestha, S. M. 1993. Comparison of Different Sampling Techniques in Forest Inventory in Southern Nepal. M.Sc. Thesis, University of Joensuu, Finland, 9 p.

Contents