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Payment for Environmental Services: an emerging issue to be addressed

Globally, economic approach to environmental management has been receiving recognition in all sectors of the economy. Forests provide ecosystem services such as pleasant landscapes, carbon sequestration, biodiversity conservation, watershed protection and so on. Forest ecosystems provide a wide variety of environmental services such as water regulation, biodiversity conservation, carbon storage for climate change mitigation & so on. Therefore, paramount importance is being given to forest management issues these days. Environmental goods and services not only benefit the local communities, it will also provide benefits to the global communities. However, not all environmental uses generate financial, returns commensurate with their real economic value. Environmental services are not traded in the market and have no observable price, which may be the reason. Implementing Payment for Environmental Service (PES) mechanisms can be a way for natural resource conservation, and achieve development goals and, especially in low-income regions.

The use of Gross Domestic Product (GDP) or Gross National Product (GNP) as indicators Of economic performance, however, has been critically debated, not only because they do not account for many environmental values but more importantly because they do not provide correct measures of change in well- being. As a result, the Natural resource and Environmental Accounting (NRA) approach emerged to provide the operational framework for measuring and evaluating progress towards sustainable development by including all environmental values missing from the current Systems of National Accounts (SNA). It is relatively easy to assess the value of tangible commercially exploited natural assets such as, timber and fuel wood compared to the non-traded and indirect services of ecosystems such as regulating climate, water purification, supporting for nutrient cycling, soil formation and biological diversity.

PES, therefore, develops mechanisms to capture environmental externalities and bring them into marketplace. The basic principles of PES are: beneficiaries of environmental services pay for their provision; and providers of environmental services get paid to provide them. It is important to identify the demand and supply side of the environmental services. The demand aspects include the questions such as What are the specific services? Who benefits from these services? How much benefit do they receive? Similarly, some questions related to supply side are how are these services generated? How much more or less of these services would we receive if land use changed? Who generates these services?

Before understanding and implementing PES, some crucial and pertinent questions need to be answered such as:

- What is the willingness-to-pay of the beneficiaries of environmental services to help finance conservation (Contingent Valuation)?
- How can their willingness-to-pay be translated into real resource flows?
- How should the collected funds be used to structure payments to those who are doing conservation activities?
- How do these questions differ when global and local PES are taken into consideration?

People in Nepal are not much aware of the intangible benefits of the forestry sector. There are enormous environmental benefits that forests can provide in a sustainable way. Realizing such environmental values of forests locally and globally, concerned institutions need to start working on “Payment for Environmental Services” with a concerted effort.

An Estimation of Tree Species Diversity in Rural Farmland of Nepal

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Biodiversity is an important consideration in maintaining natural environmental balance in a particular habitat. This becomes particularly important in areas, where due to the encroachment of natural forests, biodiversity is depleting causing a potential loss in the natural habitat. In such a situation, biodiversity in the farmland becomes an important consideration. Biodiversity is measured and analyzed using various indices. In this study, we present the result of our study through a field work in a rural village in Nepal. The study was conducted through direct field observation and survey of sampled households. The status of tree biodiversity using species biodiversity index and species richness index for the case study are presented. The study has also identified the relationship between the tree species diversity and major socioeconomic factors. Our analysis shows that tree species biodiversity in the rural farmland of study area are lower in comparison to the similar areas of countries like India, Bangladesh and Sri Lanka. The lower biodiversity status is mainly due to the wide distribution of two dominating tree species of *Dalbergia sissoo* and *Melia azederach*. Similarly, Tree species biodiversity in the farm land has been found affected by the socioeconomic situation of the area. Further study is suggested by involving more socioeconomic factors and covering a large sample size and time of study.

Key words: Farmland, Forest, Homegarden, Nepal, Species Diversity, Species Richness, Trees.

Deforestation, one of the biggest environmental problems, need to be contained to conserve the diversity of trees as well as other plant and animal species in natural ecosystem (Mishra, 1998). However, in Nepal, in a period of about 15 years (1979 to 1994), nearly one and half million hectares of forest land were lost for fuel, agriculture activities and settlements giving a cumulative loss of about 1.7% of forest areas in an annual basis (DFRS, 1999). This process is still continuing in the remaining forest patches. This is quite an alarming situation for a mountainous country like Nepal, whose economic output largely depends on agricultural and forest based activities.

When the natural forests are in the verge of extinction, farmland plays significant role in the species conservation. As deforestation continues, along with the increase of population, it will be extremely difficult to conserve biodiversity in the isolated island of forest (Wickramasinghe, 1995). Due to natural habitat loss, several species have been threatened or reached to the point of extinction in

the absence of immediate conservation action (Brooks et al, 2001, Mishra, 1998). As it has been difficult to contain deforestation except for those places where forests are protected, researchers are diverting their attention to farm lands as potential reservoir to maintain the biodiversity level in an area. Traditional agro-ecosystems are particularly rich in sources of both biodiversity and indigenous knowledge about its management. Farmers have different needs on resources. For example, they tend to fulfill their needs for fruits, fodder, fuelwood, timber, medicine, gardening, religious activities, and other environmental protection from bio-resources around them. Therefore, such needs cannot be fulfilled by a few species only. Also, as the farm size are small but supports the family's economic and culinary activities, farmers tend to increase biodiversity to protect themselves against the risk of failing some species. Halladay and Gilmour (1995) found that such a traditional system could facilitate the conservation of genetic diversity outside the forested lands. Biodiversity also helps in maintaining

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stability and resilience. Therefore, the policy planners would have to understand not only the biodiversity of the natural forests, but help to increase their index in the farmlands as well so that not only the natural habitat of species is extended, but also support the livelihood of the households in the rural areas. However, to implement such a policy, it is necessary to understand the existing biodiversity levels in terms of species diversity index and species richness index of trees on rural farmlands. Such an index could also be linked to socioeconomic factors to better understand the impact of biodiversity on the rural population.

Materials and methods

Study area

This study was conducted in a rural village of Chitwan district in Nepal. This village has been selected mainly due to diverse community structure and land use type so that comparison among the different categories of each socio-economic variable can be analyzed easily. The community is diverse particularly in terms of ethnic group, time of settlement, economic level and occupation. The village has natural forest mainly dominated by *Shorea robusta* forest some part of which are managed by community forest user groups and remaining are controlled by government agency itself. East-west national highway of the country touches in southern part of the village with semi urban characteristics whereas typical rural settlements and natural forest are found in northern part.

Sampling methods

The study was carried out in 98 households of the Birendranagar Village Development Committee (VDC) of the Chitwan district, Nepal. The VDC is the lowest unit of local government structure. The field work took about six months and completed in 2000. The preliminary field work was aimed to observe the community structure, land use type, vegetation and other socio-economic condition of the area. A semi-structure questionnaire was used for formal household survey under the stratified random sampling techniques. The study considered each Ward number of the VDC as a single stratum resulting total nine strata in the whole study area. Sampled household in each stratum was identified through random walk by which first household was selected randomly and subsequent households were selected in a regular interval of 20 to maintain 5% sampling intensity for the study. An interval of 20 households

along the walk was maintained to avoid bias in responses and to obtain as much diversity in the responses as possible. Field observation was done simultaneously to assess the distribution of tree species inside the farmland. All the individuals of each tree species (above 1.3 meters height) were counted regardless of their age in the farmland belonging to the sampled household. A group of early residents of the area in each strata of the study area was consulted to understand the dynamics of tree species in their farmland. Problems and constraints, in terms of biodiversity of tree species in the area, were taken during the consultation.

Estimation of Species Diversity Index (SDI)

The species diversity index for the average farmland and total study area were calculated by using a specific method ($H' = -\sum P_i \times \ln P_i$) as suggested by Shannon and Weaver (1949). H' refers to the index value of biodiversity whereas P_i refers to the proportion of all individuals of i th species against the all individuals of all tree species. The Shannon diversity index for the natural communities is often found to fall between 1.0 to 6.0. The maximum diversity of a sample is obtained when all species are equally abundant and is represented as H_{\max} (Stilling, 1996).

Estimation of Species Richness Index (SRI)

Species richness are generally measured in terms of a ratio of total number of species and total number of individuals of all species of a specified area. It gives more priority to the number of species rather than number of individuals. By this method, increasing a few numbers of individuals within a species gives higher value of index than the increasing large number individuals within the species. It means higher the number of individuals in a species lowers the species richness index of a given community. This study used Margelef (1969) method ($R = S-1/\ln N-1$) while assessing the SRI of the trees both at individual farmland and the total study area level. Here R stands for Richness Index of tree species, S stands for total number of tree species and N stands for total number of individuals of all tree species of the area.

Categorization of the variables

We observed many socio economic variables to understand their relationship with the SDI and SRI. Annex 1 gives the list of variables and their categorization including the ranges and numbers of sampled households. Variables were categorized into

different groups according to their distribution pattern found in the study area. Most of the variables were categorized into three groups so that difference among them can be shown clearly. The critical values for categorizing the variable and their number of categories were identified after field survey during the analysis.

Data Analysis

The data were analyzed using MS-Excel, Minitab and MS-Access for data compilation, regrouping and developing regression and correlation between various factors being examined. Analysis of variance (ANOVA) was applied to find the impact of variables on species diversity, species richness, tree density, tree per capita, average species holding and average tree holding. The results of the analysis are presented below.

Results

Status of Tree Species Biodiversity

Species diversity index and species richness index of the tree resources of the study area were 1.80 and 5.01 respectively. Table 1 below shows the descriptive information on species diversity, species richness, number of species and number of trees in the study area. A total of 60 tree species were found in all sampled farmlands in the study area. The analysis shows that average species per household is about 8 with a maximum value of 30. Average number of

individual tree within a species is about 2148 for all areas, whereas this figure comes to 9 in case of the average household level. The result shows that some households have higher value of diversity and richness indices compared to the value of all study area. The formula is designed in such a way so that the value of species diversity index comes higher once the number of tree individuals of all available species is nearly equal.

Diversity and richness indices by categories of tree species are provided in table 2. The principle uses of tree species were considered for their categorization. However, some tree species were accounted into two categories based on their prime use. Both the SDI and SRI of the fodder species were higher than other types of the tree species in the area. It is to be noted that species richness is directly proportional to the species number and inversely proportional to the tree number.

Socio Economic Impacts on Biodiversity

Several factors determine the status of biodiversity at various levels. Household and/or farmland are the smallest unit of biodiversity management. Other level of the management could be a watershed/catchment area, natural landscape/seascape, topographical, physiographic and ecological region etc. Some factors are crucial for species diversity management and others may affect less. Socioeconomic factors are the most important to be considered in farm and/or

Table 1: Species diversity and species richness of the area

Description	Descriptive information on tree biodiversity				
	Total	Average/HH	Min.	Max.	Std
Species Diversity Index (H')	1.80	1.35	0.00	3.07	0.75
Species Richness Index (R)	5.01	2.00	0.00	6.32	1.24
Number of species (S)	60.0	7.70	0.00	30.00	5.69
Number of trees (N)	128864	66.70	0.00	1514	183.20

Source: Field survey; 2000

HH= Household, Max. = Maximum, Min. = Minimum, Std = Standard Deviation,

Table 2: Diversity and species richness of tree species type

Description	Species type				
	Fruit	Fodder	Timber/ Furniture	Fuel wood	Other
Species Diversity Index (H')	0.20	0.37	0.31	0.20	0.05
Species Richness Index (R)	2.87	4.40	0.12	0.47	1.43
Number of species (S)	19.0 (2.6)	29.0 (4.9)	7.0 (0.5)	9.0 (1.4)	7.00 (0.3)
Trees per HH	5.40	23.3	38.90	51.70	0.60

Source : Field survey, 2000

Note : Figure in bracket gives the average number per household

: Some species were counted in more than one category based on their prime use.

Table 3: Impact of socioeconomic factors on biodiversity

Variables	Categories of Variables	Average value of SDI of each category of variable	Average value of SRI of each category of variable
Farm size	Small - Medium - Large	1.12 - 1.54 - 1.63 (P = 0.016)	1.55 - 2.27 - 2.97 (P = 0.001)
Homegarden size	Small - Medium - Large	1.12 - 1.70 - 1.89 (P = 0.00)	1.52 - 2.55 - 3.71 (P = 0.00)
Livestock size	Small - Medium - Large	0.8 - 1.5 - 1.4 (P = 0.001)	1.2 - 2.1 - 2.3 (P = 0.001)
Fuelwood consumption	Low - Fair – High	1.21 - 1.31 - 1.67 (P = 0.082)	1.74 - 1.96 - 2.52 (P = 0.073)
Income Class	Low - Medium - High	1.26 - 1.53 - 1.26 (P = 0.25)	1.74 - 2.37 - 2.18 (P = 0.059)
Major Income sources	Agriculture – Labor - Business - Service - Pension	1.56 - 0.96 - 1.68 - 1.11 - 1.32 (P = 0.02)	2.38 - 1.36 - 2.44 - 1.55 - 1.85 (P = 0.01)
Forest distance	Near - Medium - Far	1.40 - 1.38 - 1.15 (P = 0.48)	2.00 - 2.05 - 1.82 (P = 0.80)
Caste	Bramin - Chhetri - Other - Lower	1.99 - 2.46 - 1.81 - 2.64 (P = 0.383)	7.8 - 10.5 - 6.8 - 7.0 (P = 0.341)
Settlement period	Early - Middle - New	0.89 - 1.21 - 1.42 (P = 0.14)	1.19 - 1.83 - 2.10 (P = 0.12)

Source : Field survey, 2000

Note : Sample numbers and ranges of each category is presented in annex 1

household biodiversity management. Species diversity, size, shape and plant density also vary from place to place depending on cultural, ecological and socio-economic factors (Soemarwoto, 1987). Tree planting and use were found to be correlated with socio-economic factors such as ethnic group, economic level and farm size (Karki and Karki, 1994).

Single factor hardly determines the level of biodiversity completely. However, it is also true that some factors could influence more than others. As shown in Table 3, both species diversity index and species richness index are significant among the categories of the farm size, homegarden size, livestock holding size and types of income sources. Whereas, both index are not significantly different among the different categories of income class, fuelwood consumption, settlement period, forest distance and caste.

Both SDI and SRI are significantly different among the small, medium and large categories of farm size. However, no strong linear relationship exists between the species diversity and farm size ($r^2 = 0.028$, $n = 98$). It implies that farm size alone is not the powerful determinant of the species diversity. Home garden size significantly affects tree species diversity and species richness, even though no strong linear relationship exist between homegarden size and species diversity ($r^2 = 0.19$, $n = 98$). Livestock has great influence on species diversity, species richness, tree number and tree species number in rural

households of Nepal. Although large number of trees are required to support the large number livestock, our study shows that livestock is also not a powerful determinant for tree biodiversity ($r^2 = 0.06$, $n = 98$). Large herds of livestock are found in higher income household and large farm holders. Fuelwood consumption alone does not influence much in species diversity of the farmland, though little difference is found among the categories. Even the linear relationship between fuelwood consumption and species diversity is not strong ($r^2 = 0.051$, $n = 98$). Although the difference is not significant, large number of trees and species are generally found in households with high fuelwood consumptions. As a result, high fuelwood consumption may be problem in other areas, but it encourages farmers to maintain large number of trees in the farmland.

Difference in the species diversity, species richness and tree density are not significant among the categories of the income group. Income level of the households alone does not determine the species diversity ($r^2 = 0.004$, $n = 98$). However, significant differences are observed in average holding of trees and tree species. Lowest number exists in low-income households. Larger farm size might have supported higher number of trees and tree species in medium and high-income household.

In households where people work outside providing their labor (laborers), the species diversity and species richness is the lowest. This is due to the fact such

households have small farmland size and are not able to earn subsistence from their farmland alone. Consequently, they have small home garden as well. Therefore, the three factors, farm size, income and home garden size mostly determine the species diversity in the rural farm. As mentioned before, small farm size does not support large number of trees and tree species though highest tree density exists in such type particularly in labor based households.

The linear relationship is also weak between species diversity and forest distance ($r^2 = 0.01$, $n = 98$). Number of tree holding and tree density is higher in households which are further away from the forested areas. Therefore, in rural farmlands, where agriculture supports the subsistence, households closer to the forest are not worried much about having large number of tree in the farm as they can easily collect their requirements from the nearby forests. However, in some households at a distance from the forests, people have to spend whole day in collecting the household requirements such as fuel, fodder and timber from the forest areas. Therefore, larger the distance from the forests, there is more incentive to plant more trees and with diversity in species.

The data shows that the species diversity and species richness increase as the years of settlement of households increase, but the difference is not significant among the categories. Even the linear relationship between settled time and species diversity is very weak. Late settlers might not have sufficient time to grow and maintain large number of trees. They are still new for the area. But old settlers know quite more about their surrounding and environment. They have crossed the experimental stage to select the best and suited species in the farm while new settlers must start from the beginning. When a household decides to sell the farmland partially or wholly, they exploit the resources from the farm as much as possible before leaving it, which might be the possible reason to have less number of trees and species in late settlers' farms. New settlers generally start the farm from nothing.

In rural Nepal, caste system is still prevalent and that is not an exception in the study area as well. The analysis of survey response to link caste with biodiversity did not show any correlation. The survey found that all households regarded the importance of tree species equally. However, in consistent with earlier findings, if the household with lower caste people have small farm size, small home garden size

and low income then they generally have lower diversity and richness of trees in their farm.

Discussion

The tree species biodiversity at the study site is very low as compared to the similar areas of other south Asian countries particularly the Bangladesh, India and Sri Lanka. Bashar (1999) has found Shanon diversity index of 3.24 for fruit species in Bangladeshi homegardens. Sellathurai (1997) found that for Sri Lanka the index was 3.93. Wide individual distribution of few tree species was the main reason for lower biodiversity. Some households contain higher level of biodiversity compare to all study area. It is therefore very important to consider the household level management for biodiversity conservation.

Das (1999) has found similar result in the farmland of eastern Nepal who has recorded more than 60 species as grown by farmers on their farmland. Carter (1992) recorded 101 tree species in a study conducted in middle hills of Nepal. Rusten (1989) found 127 tree species in the same elevation. It simply reveals that farmland in the hilly region conserve more tree species than the Terai. The Hill farming system is more fragile and sensitive than that of Terai. Hill settlers may need more resources and diversity for security in terms of fodder, fuelwood and land protection. Forest and tree products can be replaced by alternative sources in case of Terai but it is difficult in most part of the hill because of poor transportation and low income. Average tree number per hectare and per household are consistent with the figure mentioned by Karki (1988) in a study conducted in the same physiographic region. He estimated that smallholders planted and maintained an average of 60 trees on land holdings averaging 1.1 ha.

Tree types and their biodiversity

Species diversity is less important in fuelwood and timber/furniture species. Household concerns are amount, not the diversity in terms of fuelwood and timber requirement while diversity is prime consideration in fodder and fruit species. May be the single tree species can meet the fuelwood requirement of a household. Fuelwood and timber/furniture can be stored after harvest and used later on. Fuelwood can be collected whenever needed.

Unlike fuelwood and timber/furniture trees, species richness is important for fodder and fruit trees.

Productivity and taste are the prime consideration in case of fruit trees while harvesting season is of concern in fodder trees. Varieties of fruit species satisfy man with different taste in different seasons. Furthermore, not all fruit trees produce good number of fruits and seeds every year and their diversity may compensate such variation. Higher diversity might reduce the risk of production failure of single species. Fruits are also the sources of income in critical situation. It can be sold in the market though it is uncommon in the rural context. Sometime, it can be a matter of pride for household if they please the relatives, visitors, or higher status person serving fruits. Fruit trees are also highly used for shading purposes in the summer as the temperature often soars to 40 degree Celsius in the study area. Fruit trees are mostly planted in nearby home either in the home garden or in the home yard. Some fruit trees such as *Artocarpus heterophyllus* and *Morus alba* serve varieties of products at a time. All these factors may explain why rural farmland holds higher fruit species richness.

Different fodder trees are harvested in different seasons. Large number of fodder tree species supports the livestock feeding longer. Green tree fodder is the nutritious feed for stall-fed livestock. Higher diversity of these tree species might supply the fodder resources round the year. In rural areas, where the purchase of livestock feed is out of question due first to non-availability in the nearby places and second due to the cost of feedstock in the main markets, the supply of green fodder becomes the most important nutrient source. As livestock rearing is an integral part of rural communities, sustainability of the rural farming system depends on proper combination of agricultural crop, livestock and tree/forest resources in Nepal.

Socio economic impacts on tree biodiversity

Since the farmers' priority is agricultural crops, small farm size may not be sufficient to grow large number of trees and species in the same unit of land, even though tree density is higher in such farm. Panday (1987) reports that the farm size holdings are small for afforestation plots and on the other hand, there is no income incentive for tree planting as there is no timber market. The trend shows that the increased homegarden size increases the species diversity and richness continuously. Therefore, complete loss of the system and reduction in size will lead to the loss

of tree species diversity unless other socioeconomic factors are changed.

Conclusions

The present study gives important information about biodiversity related to the tree species in rural households in Nepal. Although the result may not be generalized due to diverse eco-climatic zones in Nepal, the result obtained from this study gives an important conclusion: the level of biodiversity in rural households in Nepal does not depend on one socioeconomic factor. Factors such as landholding size, homegarden size and livestock size have more influence on tree biodiversity than others at household level. Settlements, which depend solely on fodder and fuelwood and are far from the forest areas generally plant large number of trees with varied species. Also, households with large number of livestock generally have large number tree species. The frequent changes of land ownership and their divisions in smaller sizes are the discouraging factor for conservation of tree biodiversity in rural farm level.

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Annex 1: Socio economic variables, their categorization and sample distribution of the study area

SN	Variables and unit	Category	Range	Sample #
1	Farm size (Katha)	Small	≤ 15	47
		Medium	$>15 - \leq 45$	40
		Large	>45	09
2	Home garden size (Katha)	Small	≤ 1	62
		Medium	$>1 - \leq 2$	28
		Large	>2	08
3	Livestock size (LU)	Small	≤ 2	23
		Medium	$>2 - \leq 5$	38
		Large	>5	37
4	Fuelwood consumption (Kg)	Low	≤ 1500	37
		Medium	$>1500 - \leq 2250$	41
		High	> 2250	20
5	Income Class (NRs./year)	Low	$\leq 50,000$	57
		Medium	$>50,000 - \leq 100,000$	33
		High	$>1,00,000$	08
6	Forest distance (Minutes)	Near	≤ 15	41
		Medium	$>15 - \leq 45$	40
		Far	>45	17
7	Settlement period (Years)	New	≤ 5	08
		Middle	$>5 - \leq 10$	13
		Early	>10	77

Unit conversion

- 1 Hectare = nearly equal to 30 kattha
- 1 Cow = 1 LU, 1 Buffalo = 1.5 LU and 1 Goat = 0.6 LU
- 1 US \$ = NRs. 68

Altitudinally coordinated pattern of plant community structure in the Shivapuri National Park, Nepal

Shalik Ram Sigdel¹

Study on plant community structure was undertaken in different altitudinal ranges of Shivapuri National Park. The general objective of this study is to analyse different plant community structure in Shivapuri National Park with regards to altitudinal variation. The forest was divided into three distinct altitudinal ranges on the basis of dominancy. In each altitudinal range standard quadrats method was applied for vegetation analysis. The highest number of species was found in site II. All the ecological parameters of the plant species were higher in site II except Basal Area of tree that was highest in site III. The pattern of distribution of plant species was not uniform according to altitude. At higher elevation, the forest was mature with almost closed canopy and trees were large; so the tree density was low. Species richness was highest in site II. Species diversity among tree and shrub species was higher in site I. But for herb species diversity was higher in site II for both seasons. Such type of variations may be due to nature of soil i.e. acidity, nutrient availability and other micro-climatic factors. The most noteworthy thing was that variation in flower colour of *Rhododendron arboreum* i.e. deep scarlet at low altitude, but it gradually changed into pinkish white as altitude increased.

Key words: Altitude, Density, Plant community, Species diversity

Nepal, a Himalayan Country, rises from the Indo-Gangatic plain, about 60 m asl in the south to world's highest peak, the Mount Everest (8,848 m asl) in the north. With increasing altitude, vegetation changes from tropical, through sub-tropical and temperate, to alpine (Stainton, 1972; Numata, 1983; Jackson, 1994). The boundaries of these vegetation zones are subject to much variation, being sometimes abrupt and sometimes gradual, in relation to various local factors such as topography, climate and aspect. There is a great variation in the vegetation along the rainfall gradient across the country - from the high rainfall area in the east to the low rainfall in the west. Thus, Nepal's geographical, altitudinal and climatological conditions taken together with various local factors account for the high species richness within the country's geographical area of 147,181 km², extending along the Himalayan range.

Nepal covers only 0.1% of the world's total land area, which is well known for different types of flora within a short distance. The angiospermic flora of Nepal is unique. It has one of the richest floras in the world as far as the diversity of angiospermic taxa is concerned. Nepal has a share of 2.6% of the world's flowering plants (Chaudhary, 1998). It has been believed that around 7,000 species of flowering plants

are present in Nepal, however only 5,636 species has been reported in the publication of DPR, 2001. But 6666 species of flowering plants has been reported in the recent publication (Bhujju *et al*, 2007).

Vegetation of Nepal has been divided into following six bio-climatic zones (Dobremez, 1980): Topical (< 1000m), sub-tropical (1000 - 2000m), temperate (2000m – 3000m), sub-alpine (3000 – 4000m), alpine (4000 - 5000m) and nival (> 5000m). Forest is mainly found from tropical to temperate region. TISC (2002) revised the forest classification and mentioned 33 types.

Sub-tropical to temperate region has 41.14% of total forest in Nepal (DFRS, 1999). The subtropical region has *Schima-Castanopsis* forest with other deciduous species in the east and central Nepal and *Pinus roburghii* forest in the west. The major associates in the former are *Engelhardia spicata*, *Acer oblongum*, *Pyrus pashia*, *Eurya acuminata*, *Myrica esculenta* etc. but in the later the associates are *Myrica esculenta*, *Lyonia ovalifolia*, *Quercus lanata*, *Q. incana*, *Rhododendron arboreum* etc.

It is essential to understand the local and regional pattern of vegetation distribution, stratification in resource availability and for the management of forest. In addition to climate, other factors such as

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biotic interactions also determine the vegetation type and their vigour. Since Shivapuri National Park is watershed of Bagmati River and one of the main sources of drinking water for Kathmandu valley, forest type and ecological balance of the region directly determine the quantity, quality and sustainability of water supply to this capital city. It is anticipated that the present study provides baseline information for developing sustainable management strategy, which is of utmost importance for uplifting the conservation of natural resources.

Materials and methods

Study area

Shivapuri National Park (27°45' to 27°52' N and 85°15' to 85° 30' E; altitude range from 1366m to 2732m asl and area 144 sq m) lies at about 12 km north of Kathmandu valley. The Park is the source of high quality drinking water. The Shivapuri area provides about 1 million cubic litre of water per day (DNPWC, 2003). It is the watershed of Bagmati, Bishnumati, Nagmati, Syalmati, Sani Khola, Thuli Khola and Alle Khola. The most important objective of establishing the Shivapuri National Park is to increase the supply of high quality drinking water through the conservation and rehabilitation of the watershed. The park covers 23 village development committees of Kathmandu, Nuwakot and Sindhupalchowk districts.

The Land Resource Mapping Project (1984) classified forest of this Park into two types: deciduous mixed broad-leaved forest and coniferous chir-pine forest. Here subtropical and temperate type of vegetation is prominent. The subtropical zone is dominated by *Schima wallichii*, *Castanopsis indica*, *C. tribuloides* and *Pinus roxburghii*. The common associates are *Alnus nepalensis*, *Prunus cerasoides*, *Engelhardia spicata* and *Quercus glauca*. The shrubs include *Mussaenda frondosa*, *Osbekia stellata*, *Hypericum cordifolium* and *Phyllanthus parvifolius*. At higher elevations, mixed temperate forest of oak (*Quercus lanata*, *Q. semecarpifolia*) and *Rhododendron* (*Rhododendron arboreum*) are predominant. The common associates are *Lyonia ovalifolia*, *Myrica esculenta*, *Q. lamellosa*, *Symplocos* sp., *Rhus* sp, *Gaultheria fragrantissima*, *Potentilla fulgens*, *Hedyotis scandens*, *Rubia manjith* (Chaudhary, 1998).

Data collection and analysis

A field reconnaissance survey was executed in the Shivapuri National Park area from last week of July to first week of August 2003. The purpose of the

initial exploration was to assess the feasibility of this work. From this exploration, southern part of the park was selected for this study.

The study area (1600m to 2732m) has three distinct types of forests along the altitudinal gradients; *Pinus roxburghii* forest (1600m-1800m), *Quercus*–*Castanopsis*-*Rhododendron* forest (1900m-2300m) and *Q. semecarpifolia* - *Rhododendron arboreum* forest (2400m-2732m) (Dahlen, 1993). They are designated as site I, II and III respectively. The vegetation sampling was done by quadrat method (Kershaw, 1973). The quadrats of 10m x 10m for trees, 5m x 5m for shrubs and 1m x 1m were laid down for the estimation of quantitative data. For tree, two quadrats were laid at every 100m increment of elevation, starting from 1600m. Individuals of tree species were classified into tree, sapling and seedlings (IFRI, 1994). Altogether 24 quadrats for trees, 48 for shrubs and 96 for herbs were studied. For that two sub quadrats (5m x 5m) were laid down in two corners of the 10m x 10m quadrat for shrub and four sub quadrats (1m x 1m) were laid down in four corners of the 10m x 10m quadrats.

Specimens of all species were collected and the herbarium prepared as used for identification. Some of the plants were identified using standard references (Hara *et al.* 1978; 1979 and 1982, Stainton, 1988; Shrestha, 1998) and others with the help of specimens deposited at Tribhuvan University Central Herbarium (TUCH) and National Herbarium and Plant Laboratory, Kathmandu (KATH). For nomenclature Press *et al.* (2000) was followed.

Field data were used to calculate density, frequency, basal area, their relative values and importance value index following Zobel *et al.* (1987).

Density and relative density

Density represents the numerical strength of the species in a community.

Density (p/ha) =

$$\frac{\text{Total number of individual of a species}}{\text{Total no. of quadrat studied} \times \text{Area of a quadrant (m}^2\text{)}} \times 10,000$$

Relative density is a proportion of density of a species with respect to total density of all species.

Relative density (%) =

$$\frac{\text{Density of species 'A'}}{\text{Total density of all species}} \times 100$$

Frequency and relative frequency

The frequency and relative frequency was calculated using following formulas.

Frequency (%) =

$$\frac{\text{Total no. of plots in which a species 'A' occurred}}{\text{Total no. of plots sampled}} \times 10,000$$

Relative frequency =

$$\frac{\text{Frequency of species 'A'}}{\text{Total frequency of all species}} \times 100$$

Basal area and relative dominance

It is measured from diameter at breast height (dbh) and its basal area was calculated. It is one of the chief characteristics to determine dominance. So, relative dominance was determined as the relative value of basal area.

$$\text{Basal Area} = \pi (\text{dbh})^2 / 4$$

The relative dominance was calculated as follows:

Relative dominance (%) =

$$\frac{\text{Basal Area of a species}}{\text{Total Basal Area of all species}} \times 100$$

Importance value Index (IVI)

IVI is the sum of relative density, relative frequency and relative dominance of a species in a community. The IVI value of any species in community ranges between 0-300 and the sum of IVI of all species is 300.

Similarity Index (IS)

IS was calculated as Sorrenson's index modified by Greig-smith (1964).

$$\text{IS} = \frac{2C}{A + B} \times 100$$

Where, A = Total no. of species in one sample

B = Total no. of species in another sample

C = Total no. of common species in both the sample

Species diversity and index of dominance

Among the several indices, most commonly used two indices are Simpson's index (Simpson, 1949) and Shannon-Wiener's index (Shannon and Weaver, 1949). Simpson's index (C) reflects dominance and Shannon-Wiener index (H') reflects species diversity. It was calculated as follows:

$$C = \sum_{i=1}^S (P_i)^2$$

$$H' = -\sum_{i=1}^S (P_i)^2 (1/n P_i)$$

Where, C = Simpson's index of dominance

S = total number of species

P_i = Proportion of all individuals in the sample that belongs to Species i

H' = Shannon-Wiener Index

Results and discussion

The study area had natural forest which has been protected for more than three decades. Grazing and collection of fallen branches for wood fuel were frequent while felling for timber was not observed. Altogether 147 species (36 trees, 37 shrubs and 74 herbs) belong to 125 genera and 58 families were reported from the study site. Numerically important families were: Asteraceae (16 spp), Rosaceae (9 spp) and Poaceae (8 spp). Nearly half of the species were herbs. The number of herb species was higher in rainy season than in dry season. Site II was rich in number of species for all plant habits. The variation of total species richness along the elevation gradient is shown in the following table.

The highest number of species (109) was found in site II. This may be due to the transition zone of sub-tropical and temperate zone. This site acts as eco-zone. But in site III comparatively lower no. of species were reported. This may be due to the mature forest with almost closed canopy and trees were large; so the number of species was low. In case of site I,

Table 1: Number of species at different altitude

	Site I (1600m-1800m)	Site II (1900m-2300m)	Site III (2400m-2732m)
Tree	22	25	10
Shrubs	29	37	17
Herb (rainy)	28	36	27
Herb (dry)	17	26	23

the lower number of species in comparison with site II may be due to more acidic soil as this is pine dominated forest. The pattern of distribution of plant species was not uniform according to altitude due to variation in micro-climate.

At lower altitude *Pinus roxburghii* is dominant among tree species. The major associate tree species are *Alnus nepalensis*, *Schima wallichii*, *Lyonia ovalifolia* etc. Generally pine forest has less number of biodiversity compared to broadleaved but here higher diversity was reported in pine forest rather than broadleaf forest. That may be due to mature forest with almost closed canopy and trees were large; so the tree density was low in the broadleaf forest. *Phyllanthus parvifolius* is most dominant species among shrub species. *Melastoma malabaricum*, *Berberis aristata*, *Sarcococa coriacea*, *Crotalaria cytisoides*, *Osyris nighiana*, *Antidesma acuminatum* were associated common species. *Eupatorium adenophorum* is the most dominant species among herbaceous species.

At middle altitudinal range, *Rhododendron abroreum* and *Quercus lanata* were frequently dominant among the tree species and major associated species are *Castanopsis tribuloides*, *Quercus glauca*, *Symplocos ramosissima*, *Myrsine capitellata*, *Gaultheria fragrantissima* among shrub and *Melastoma malabaricum*, *Berberis aristata*, *Sarcococa coriacea*, *Crotalaria cytisoides*, *Osyris nighiana* were associated common shrub species and *Chlorophytum nepalensis* among herbs. Here the number of *Castanopsis tribuloides* was higher with lower basal area as well as IVI value.

At higher altitude, *Quercus semecarpifolia* was dominant among tree specie with IVI value 108.37 followed by *Rhododendron arboretum* (81.07) with *Quercus lamellosa*, *Persea duthiei* and *Eurya acuminata* as major associated species, *Daphne bholua* among shrub species. The common associated species were *Berberis asiatica*, *Rubus acuminatus*, *Rubus paniculatum*, *Lindera pulcherrima*, *Indigofera atropurpuria*, *Arundinaria falcata* and *Aconitum ferox* among herbaceous species, which were ecologically most important species in the study area. The most noteworthy thing was that variation in flower colour of *Rhododendron arboreum* i.e. deep scarlet at low altitude, but it gradually changed into pinkish white as altitude increased (above 2450m).

Important Value Index (IVI)

The important value index provides a quantitative basis for the classification of community. The IVI

value of any species in community ranges between 0-300 and the sum of IVI of all species is 300. In site I, the highest IVI (68.19) was recorded for *Pinus roxburghii* followed by *Lyonia ovalifolia* (24.41), *Alnus nepalensis* (21.16). Similarly, the lowest IVI (3.26) was recorded for *Eriobotrya elliptica*. In site II, the highest IVI (45.71) was recorded for *Rhododendron arboreum* followed by *Quercus lanata* (45.43) and *Quercus semecarpifolia* (37.85). Similarly, the lowest IVI (2.03) was recorded for Theaceae sp. In site III, the highest IVI (108.37) was recorded for *Quercus semecarpifolia* followed by *Rhododendron arboreum* (81.07). Similarly, the lowest IVI (5.33) was recorded for *Lindera nacusua*. It means these species are ecologically important to maintain the existing ecosystem.

Index of Similarity (IS)

The similarity index value ranged between 18.75% and 62.82% for trees, 17.39% and 45.45% for shrubs/saplings, 14.54% and 37.5% for herbs/seedlings in rainy season and 10% and 27.9% for herbs in dry season. The most frequent and common species have greater role on similarity between two stands (Podani, 1978). So, variation in altitudinal range is the most important factor for determining the IS. It may also be due to the different topography and edaphic factors. Floristic similarity is the response of species to the micro and macro environment (Krebs, 1972). The highest value of IS (62.82) was recorded between site I and site II for tree species and 45.45 for shrub/sapling between same sites. This may be due to more common tree and shrub species between site I and II. While this value was highest between site I and Site III for both rainy and dry season i.e. 47.6 and 53.06 respectively. For all type of plants the value was lowest between site I and Site III 18.75, 17.39, 14.54 and 10.0 respectively. This may be due to less common species and variation in altitude.

The index of similarity value for tree species was found to be highest (62.82%) between site II and I and lowest (18.75) between site I and III. In case of shrub, the highest IS (45.45%) was found between sites I and II. while lowest (17.39%) between site II and I. In case of herbs, the highest IS was found between site II and site III in both seasons i.e. rainy (47.6%) and dry (53.06%). Similarly IS was the lowest between site II and I in both seasons.

Table 2 : Index of similarity (%) of trees, shrub/saplings and herbs/seedlings between different sites

Habit	Site I and II	Site II and III	Site I and III
Tree	62.82	34.28	18.75
Shrub/Sapling	45.45	40.74	17.39
Herbs/seedling (rainy)	37.50	47.60	14.54
Herbs/seedlings (Dry)	27.90	53.06	10.00

Species richness and species diversity

Species diversity is the combination of species richness and species evenness. Species evenness is the distribution of individuals among the species. The total number of tree species (species richness) was the highest in site II but species diversity (2.64) was higher in site I. Despite of higher species richness in site II, contribution of single dominant species was high in site III had higher Simpson's index (0.1898) because the index was more sensitive to dominant species.

Shrub species richness was higher (37) in site II. Species richness (17) and species diversity were low in site III but index of dominance was high. The evenness was low and dominance concentrated to a single species. For shrubs, the index of dominance ranged from 0.036 to 0.116 and species diversity from 2.45 to 3.39. For herbs index of dominance was high in site III (0.046) as there were lowest number of species richness with lowest value (0.032) was recorded in site II as there were highest number of species richness in rainy season. It was because, higher the number of individuals, lower their contribution to make dominance. Reverse type of result was recorded; in case of species diversity i.e. species diversity was directly proportional to total number of species while index of dominance was inversely proportional to species richness. Similar result was recorded for herbs in the dry season.

Conclusion

Altogether 147 (36 trees, 37 shrubs and 74 herbs) species belonging to 125 genera and 58 families were reported from the study site. Species richness in terms of species number was greatly contributed (about 50%) by herbaceous species. The numbers of herbaceous species were higher in the rainy season than in dry season.

Pinus roxburghii was the ecologically most important tree species in lower altitude. At mid elevation *Rhododendron arboreum* and *Quercus lanata* were the most frequent and dominant species. At the higher altitude *Quercus semecarpifolia* was the most dominant species. This result shows the three distinct forest types in the study area. The major associated tree species were *Alnus nepalensis*, *Schima wallichii*, *Lyonia ovalifolia* etc. at lower altitude, *Castanopsis tribuloides*, *Quercus glauca*, *Symplocos ramosissima*, *Myrsine capitellata* at middle altitude and *Quercus lamellosa*, *Persea duthiei* and *Eurya acuminata* at higher altitude.

Among shrubs and saplings, *Phyllanthus parvifolius* was the most frequent and dominant species at lower altitude and *Melastoma malabaricum*, *Berberis aristata*, *Sarcococa coriacea*, *Crotalaria cytisoides*, *Osyris nighiana*, *Antidesma acuminatum* etc. were associated common species. In middle range *Gaultheria fragrantissima* was most frequent and dominant species with association of *Phyllanthus parvifolius*, *Mussaenda frondosa*, *Hypericum*

Table 3 : Species richness (S), Diversity Index (H) and Index of dominance (C) of tree, shrub/sapling and herb/seedling layers in different altitudes

Altitude (site)	Habit	S	C	H
Site I (1600m-1800m)	Tree	22	0.078	2.76
	Shrub/sapling	29	0.093	2.80
	Herb/seedling (Rainy)	28	0.042	3.08
	Herb/seedling (Dry)	17	0.079	2.68
Site II (1900m-2300m)	Tree	25	0.082	2.73
	Shrub/sapling	37	0.367	3.39
	Herb/seedling (rainy)	36	0.328	3.45
	Herb/seedling (Dry)	26	0.592	2.99
Site III (240m-2732m)	Tree	10	0.189	1.91
	Shrub/sapling	17	0.116	2.45
	Herb/seedling (Rainy)	27	0.467	3.04
	Herb/seedling (Dry)	23	0.059	2.95

cordifolium, *Daphne bholua*, *Arundinaria falcata*. In higher altitude *Daphne bholua* was most frequent and densely distributed species. The common associated species were *Berberis asiatica*, *Rubus acuminatus*, *Rubus paniculatum*, *Lindera pulcherrima*, *Indigofera atropurpurea*, *Arundinaria falcata* etc.

Regarding herbs and climbers *Eupatorium adenophorum* and *Cymbopogon citratus* were most frequent and dominant species at lower altitude in both seasons. In middle altitudinal range *Chlorophytum nepalensis* makes its dominance in both seasons. But in higher altitudinal range *Aconitum ferox* was the most important species during rainy season and *Chlorophytum nepalensis* during dry season. The other common herbaceous species were *Cyperus rotundus*, *Bidens pilosa*, *Saccharum spontaneum*, *Desmodium concinnum*, *Scutellaria discolor*, *Achyranthus aspera*, *Potentilla fulgens*, *Chirita urticifolia*, *Smilax aspera*, *S. lanceolata*, *Cyanodon dactylon*, *Rubia manjith*, *Plectertus mollis*, *Fragaria nubicola*, *Digitaria ciliaris*.

Species richness was highest in the middle range of altitude. Species diversity among tree and shrub species was higher in site I. But for herb species diversity was higher in site II for both seasons. Index of dominance for tree and shrub species was highest in site III but for herbs index of dominance was highest in site I in dry season and in site III for rainy season.

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Commercial utilization of Allo (*Girardinia diversifolia*) by the Rais of Sankhuwasabha for income generation

Tanka P Barakoti¹ and Keshav P Shrestha²

Studies carried out during 1999 and 2000 on utilization of Allo (*Girardinia diversifolia* L.) in the eastern hills revealed that traditional knowledge was highly used in developing commercial enterprise of this species. Surveys conducted on various aspects of this species through semi-structured interview identified that *Allo* has become an established income generating commodity in Bala, Sisuwa, Tamku and Mangtewa VDCs of Sankhuwasabha district.

Time line showed that Allo activities were started by Kulung Rais from 1950, but increased after 1993. The community started to make fancy items, such as varieties of bags, jewellery purse to travel bags, coat cloth, and ladies items-shawl, brassier, when the outsiders took interest in Allo products. Dyeing was also practiced according to customers' demand using local plants: *Majitho*, *Banmara*, *Chutro*, *Dar*. For spinning, bamboo made hand spindle called *Katuwa* was used (94.8 % respondents). It is handy and easy to spin thread while walking. Weaving was done in locally made wooden handloom. Traditional processing method adopted was: green *lokta*- drying (2-3 days), boiling with wood ash, washing, drying, dry fibre- mixing with micaceous clay (*Kamero*). Wood ash was used to boil easily (39 %) and also make the fibre soft (20.8 %). No idea about the use of caustic soda instead of ash. The quantity of ash for one *Dharni* (2.5 kg) of *lokta* varied 4-24 *Manas* (1 Mana equals about 300g). White clay was used @ 2 kg for 2.5 kg dry *lokta* to make the fibre soft and easy for spinning (62.3 %).

Keywords: Allo, Enterprise development, Indigenous knowledge, Rai, Sankhuwasabha.

The Himalayan Giant Nettle, *Girardinia diversifolia* (Friis, 1981), which belongs to the family Urticaceae, is locally known as *Allo* in Nepali in the eastern and central regions, and *Puma* in the western part of Nepal. There are several vernaculars to name it: Bhangre Sisnu, Lekhko Sisnu, Thulo Sisnu, Potale, Nagai etc (Gurung, 1988). Endemic to Himalayan region, it is one of the historically important non-timber forest products (NTFPs) for Nepal. It grows in the hill districts from east to west between the altitudes of 1200 to 3000 meter and can be found in the tropical areas of Asia and Africa (Friis, 1981, Shrestha and Hoshion, 1998). Its fibre was previously used for weaving coarse cloths to make *Dhokero* (long sack) for putting grains and flour, fishing net, bag, *Namlo* (porter's head band for carrying *Doko*, *Dhokero*), *Damlo* (rope for tying cattle, buffalo, goat), *Bhangre Topi* (cap, hat), etc since generations. Use of Allo fibre had been declining before coming jute, synthetic and other products in the hills. There is a popular proverb in Nepali "Bhangra ko Topi lai Guyenli ko Phool" means good flower on rough cap, i.e. odd or not matching.

Allo is an under-shrub about 1.5m to 4m tall, armed with stinging hairs. It naturally occurs in forests. The species prefers sparsely shade areas. As a result of increasing pressure of population, its availability is declining, especially at lower altitudes due to destruction of habitat. In Sankhuwasabha, natural stands are found beyond the normal area of the villages, in remote jungles. According to Sinha (1989) declining trend of Allo in the nearby areas for collection suggests need of planting to meet the increasing demand. As the species is shade loving, cultivation could be combined as an under-storey crop (Singh and Shrestha, 1989).

In the eastern hills, Sankhuwasabha district is well known for Allo product. Rais are famous for weaving Allo cloths (Joshi et al, 1989). Shrestha (1994) reported that 95 percent out of 1029 families in four VDCs were using yarn spun from Allo. They have been extracting bast and spinning fibre to weave fashionable bags, sacks, mats, jackets, porter's headbands, cloths and castanets. Most items are made

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for home use and are sold in *Melas*, *Bazaars* at Dingla and Bhojpur (Dunsmore and Dunsmore, 2000). The fashionable items have attracted the tourists and gained popularity.

Changing circumstances led higher demand of fashionable products of Allo. Hence the residents of Sangkhuwasabha started to harvest it extensively for weaving different materials to fulfil outsiders/ tourists' demand. As a result, natural stands have been declining despite the rules and regulation of the forest user groups, as they open for harvesting only from September to December (Shrestha, 2000). The users have been applying local knowledge and implements for processing bast, for spinning and weaving. There is little information on ethno-botany, processing, weaving, marketing, and domestication practices. Therefore identification of the existing situation needed for better planning research and development works, for management and sustainable utilization to meet the increasing demand. In order to make better of the Allo business in a sustainable way, to identify the practices, constraints and opportunities through a study, surveys were planned with the following objectives in the proposed area.

- To understand the existing situation of *Allo* works and its utilization
- To verify farmers' knowledge on the *Allo* growing environment
- To assess local processing techniques and materials for further improvement

Materials of methods

The study on *Allo* was conducted through the review of literature and field survey. The literatures available in the concerned libraries of different organizations in Pakhribas, Sankhuwasabha and Kirtipur were consulted. For field study, an exploratory visit of a multidisciplinary team of socio-economist, agronomist, farming system specialist, soil scientist, cottage development specialist, entomologist, and plant pathologist was organized to Allo areas in northern hills of Sankhuwasabha district in 1999. As recommended by the team, a semi-structured questionnaire was developed and pre-tested. Then surveys were conducted in 1999 and 2000 with 77 informants of Bala, Sisuwa, Tamku, and Mangtewa VDCs. These sites were selected based on the literature and information acquired. Studies were undertaken on various aspects of Allo: habitat, types, availability, agro-eco-requirements, socio-economy, cultural value, ratio of green and dry *lokta*, processing

procedure, spinning, weaving, production of different products, use and marketing. The data were analyzed in the SPSS (Statistical Package for Social Science) computer soft ware package.

Result

Socio-economic value

It was revealed that *Girardinia diversifolia* has economic and cultural values for Rai, Gurung, Sherpa, Magar in the hills of Nepal. Kulung Rais use it in their religious ceremonies. They offer Allo cloth to God in their *Nagi Puja*. They have to wear *Bhangra* cloth at the entry of new house, and upon demise of a family member. They also present cloth when the daughter gets married. Allo has other values: it is a source of livestock feed, bedding material, fuel-wood (Gibbon et al, 1988) and live fence. Manandhar (1989) reported that decoction from leaf is used to treat headache, joints, and fever. It can be used for making blue dye and paper. The seed containing 10-12% oil could be used for soap and other oil based industries (Dunsmore and Dunsmore, 2000).

Time line of allo works in the study area

Utilization of Allo was since generation in Nepal from the early stage of Nepalese civilization. However, the history of Allo works was as early as 2007 BS in the study area i.e. from the advent of democracy. Different informants had started the work at different years (Table 1). Few of them (4 persons) started earlier (2007-2023 BS), some of them (21 persons) during 2024-2040, and most of them (51 persons) started during 2041-2057, the maximum reached in 2050 B.S. The frequency/percent showed no definite trend of Allo works in the years (Fig. 1).

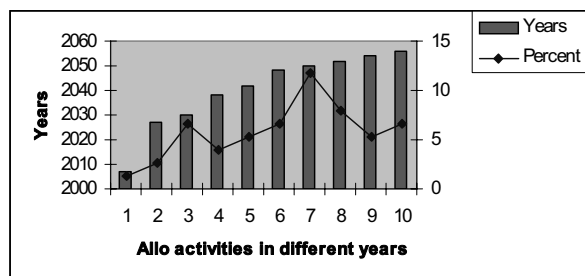


Figure 1: Allo work started by the respondents

Availability and growing

Allo is known to grow naturally in the middle and high hills partly from east to the west of Nepal. It can be grown up to 3000 m above sea level however,

it occurs beneath the forest canopy, mostly between 1500-2500m. Its availability has been declining with the increasing pressure of population especially at lower altitudes due to the need for tree cover. In Sankhuwasabha, natural stands found in forests are beyond the normal area around villages. In the remoter villages at higher altitudes it is available within day's walking distance.

Habitat: altitude, aspect and soil

Allo is found from mid hills (1400m) and high hills (up to 2500m) areas. The study site lying between this ranges housed different pockets of *Allo* from thin to dense populations. The natural stands are found commonly grown in relatively moist and shady land, which seems suitable habitat. The pockets located in the community forests of the study area represent it. *Allo* is therefore available in many parts however, this forest species as a major NTFP is not utilized in other areas like in the study area.

Most of the respondents (80.6%) reported that the best altitude for *Allo* is mid belt of mid to high hills (Table 1). About 15 % mentioned mid altitude and its top region (2500m) to be suitable, but they were not confident about the exact altitude. Similarly, the suitable aspect for *Allo* mentioned by 48.7 per cent informants (Table 2) was west followed by the east (17%). Some informal respondents told north facing also to be suitable. As the aspects for *Allo* vary in other parts of the country, the respondents might have depended just on their locality. Therefore it is difficult to rely on this information only. Study of the aspect in other parts will give clearer picture in this regard. In case of soil type, black and fertile soil is the prerequisite. Above 93 % interviewees (Table 2) expressed the need of black fertile soil, which must be deep and well drained. Brown soil is also okay. Similarly, bank of streamlets is good for better growth.

Collection of bark (Bast)

Bast is collected from the community forests of each VDC in the study area. Bast collection has become a regular business and this activity is carried in organized manner. Members of the FUGs and VDCs are confined to the concerned community forest for harvesting of *Allo*. For example, farmers of Bala VDC use Turni, Chhinka villages, and Mudhe and Benchhong villages use Chitre forest. Best time for harvesting is November to December. Collection rule of FUG has been recently adopted. One user should pay NCRs. 15 for a coupon to bring a *Bhari* (about 30-40 kg) load on back from that community forest. The users have to pay double (NRs. 30) per coupon to use other's community forest. Extraction of bark or *Lokta* from the stem is very tedious and time consuming job. It is hard due to nettle stings in the bark, so thick and hard glove required for warping. The extractors have to spend 3-5 nights in the *Allo* forest and one can extract 1.5 (= 3 kg) to 3 *Dharni* per day. Females are also involved in this work. 44.2% informants expressed that they not only collect but also buy dry *Lokta* and threads among each other (Figure 2). Of the respondents, 42.6% collect green *Lokta* or bast from the forest. Only 9.1% purchase yarn for making clothes.

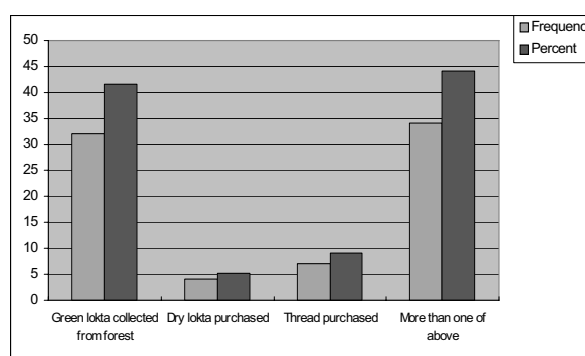


Figure 2: Source of materials used to produce yarn.

Table-1: Altitude, Aspect, and Soil for *Allo*.

Description	Altitude		Name	Aspect		Type	Soil	
	Frequency	%		Frequency	%		Frequency	%
Around 2000 m	32	41.6	West	37	48.7	Blackish	59	76.6
1700-2500 m	30	39.0	East	13	17.1	Fertile black	13	16.9
1100-1700 m	8	10.4	Not known	9	11.8	Not known	5	6.5
Not known	4	5.2	North	6	7.9	-	-	-
Around 1700 m	3	3.9	North-East	6	7.9	-	-	-
-	-	-	North-West	5	6.6	-	-	-
Total	77	100	Total	76	100	Total	77	100

Respondents were asked for the time taken to reach *Allo* growing areas for collection. 39.5% needed more than 4 hrs., whereas 24% requires 1-2 hrs to reach in the *Allo* pockets (Figure 3).

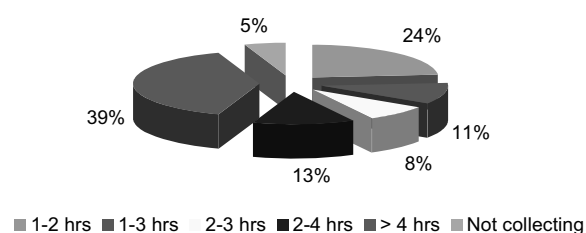


Figure 3: Time to Reach *Allo* Pockets from the houses of the Respondents

Shade Requirements

Allo is a shade loving plant. It can tolerate frost, but may die if frost remains more than 3-4 days. Out of 77 interviewees, 50.6% mentioned that *Allo* requires maximum shade, and 31.2% mentioned optimum requirement (Figure 4).

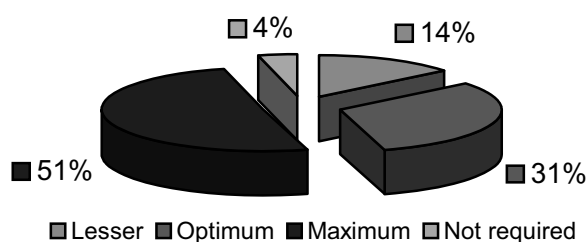


Figure 4: Shade Requirement for *Allo*

Ratio of lokta, fibre and thread

The ratio or proportion of dry bark (*Lokta*) from green was different as reported by the respondents. The ratio between *Jakhilma* (Fibre) and bast as well as between thread and *Jakhilma* is presented (Table 2). The farmers use their traditional measuring system, i.e. *Dharni* and *pol*, where one *Dharni* equals

about 16 *pols* = 2.54 kg. The variation might be mainly due to maturity of *Allo* stem, and time of collection.

Processing

The villagers/ weavers have been using traditional methods for processing *Allo* fibre. It follows a number of steps such as drying green *Lokta*, boiling, washing, drying, mixing with *Kamero mato* etc. They also mix wood ashes with raw bast while boiling in water. Caustic soda is rarely used. Out of 77 respondents only one used caustic soda. While querying the reason, 84.4% replied that its use is unknown (Table 3), 13% mentioned that caustic soda is not available. The green *Lokta* is dried for 2-3 days during sunny day before boiling.

Use of wood ash

Ash is the major processing material for cooking *Lokta*. It is produced from fuel-wood, while cooking food and other product. As the population pressure has been resulting in degradation of the community forest, the quantity of wood ashes required for boiling raw fibre was assessed to examine future sustainability on this product. All the informants anonymously expressed that there was no problem of fuel wood for ash making at present.

The result presented in Table 3 shows various reasons of using ashes, of which most (39%) replied that it helps to make easy for boiling, whereas 20.8% said easily to boil as well as make *Jakhilma* soft for spinning. It also eases to wash the yarn. It requires more ashes taking longer time for boiling. The quantity of ash required for boiling one *Dharni* of dry *Lokta* was 2 to 24 *Mana* (Table 3), where 38.4% respondents noted 16 *Mana*, and 24.7% respondents noted 8 *Mana* (One *Mana* is about 250g). The extreme differences need to practically verify.

Table 2: Ratio of *Lokta*, *Jakhilma*, and thread from one *Dharni* (2.5 kg)

Dry <i>Lokta</i> from 2.5 kg green <i>Lokta</i>			<i>Jakhilma</i> from 2.5 kg dry <i>Lokta</i>			Thread from 2.5 kg <i>Jakhilma</i>		
Ratio	Freq.	%	Ratio	Freq.	%	Ratio	Freq.	%
11	24	31.6	16	39	51.3	8	27	36.5
16	21	27.6	8	26	34.2	16	26	35.1
8	17	22.4	11	3	3.9	24	10	13.5
5	8	10.5	4	2	2.6	4	6	8.1
6	4	5.3	14	2	2.6	11	4	5.4
4	1	1.3	24	2	2.6	26	1	1.4
10	1	1.3	9	1	1.3	Total	74	100
Total	76	100	26	1	1.3	Mean	14.8	

Table 3: Using ash for boiling dry *Lokta* and quantity of ash required for 2.5 kg *Lokta*.

Reason of ash use	Frequency	%	Ash (<i>Mana</i>)	Frequency	%
To cook easily	30	39.0	10	21	28.8
To cook easily and make <i>Jakbilma soft</i>	16	20.8	7	4	5.4
To make <i>Jakbilma soft</i>	9	11.7	4	9	12.3
It is traditional system	7	9.1	12	5	6.8
It is readily available	5	6.5	24	6	8.2
Readily available and traditional	4	5.2	16	28	38.4
Cook easily, make <i>Jakbilma soft</i> & white	4	5.2	-	-	-
It makes thread white	2	2.6	-	-	-
Total	77	100	Total	73	100

Use of *kamero mato* (Micaceous Clay)

The farmers use *Kamero* to make the fibre soft and easier for spinning. It also gives the thread white in colour. The 62.3% respondents told both purpose of using *Kamero*. Quantity of *Kamero* used for one *Dharni* of dry *Lokta* also varied from 2 to 16 *Mana*, however the mean is about 9 *Mana*. The result is presented in Table 4.

Table 4: Proportion of *kamero* for one *dharni* of dry *lokta* in *Mana*

Proportion	Frequency	Percent
1	1	1.4
2	8	10.8
3	2	2.7
4	15	20.3
5	9	12.2
6	2	2.7
7	1	1.4
8	19	25.7
10	4	5.4
12	1	1.4
16	8	10.8

The quality and color of fiber depends upon growing environment in the natural habitat. Dyeing for whitening of fibre is not necessary if *Allo* is grown under shady and moist places. Washing and cleaning is also easier. From sunny areas, *Lokta* fibre looks blackish in color and is difficult for washing. But the cloth from its yarn is strong. *Lokta* can be extracted up to the tip of the stem, but the fiber from upper part is weak.

Table 5: Reasons for preferring hand spindle by farmers

Reasons	Frequency	%
It can be used while walking and shepherding	56	74.7
It is traditional and no idea about other	13	17.3
It makes better quality of thread	3	4.0
It can be used while walking, shepherding and makes quality thread	2	2.7
It can be used while walking, shepherding and no idea about other	1	1.3
Total	75	100

Spinning

Women are traditionally involved in spinning using lightweight hand spindles (called *Katuma* in Nepali and *Wasnam* in Rai language) by their men folk. These are about 30-40 cm long, the shaft is usually made of bamboo and the whorl carved from bone or wood. 94.8% of respondents used hand spindle. Only about 5% know about other spinning devices. Such hand spindle is slower than spinning on a wheel device. Reason for preferring local spindle *Katuma* was also assessed. It was understood that majority people prefer *Katuma* because it is easy for spinning whilst carrying out other work (Table 5).

Dyeing

The *Allo* product makers of the study area have been gradually skilled and commercialized. They produce items according to the client demand. So some of them started to dye the thread and weave fashionable materials. In response to the query, 26.7% farmers found practicing to dye thread and cloths, while others still had not practiced at all. Dyeing of yarn is done with different plant products for making different colours. The locally available plants are *Banmara* to make light green or grey colour, *Majitho* for red, *Dar* for brown and *Dudhilo* to make light yellow colour. Dyes are prepared using bark and/or leaf of these plants with different proportion of copper sulphate, ferrous sulphate and potassium dichromate, which were made available by an NGO, Eco-Himal during training.

Weaving and knitting

Weaving is done in locally made wooden handloom. One can weave 2-2.5 m of cloth per day if everything is ready. Knitting is being popular due to its high demand. Hand knitting of Shawls, vests and other items by women found while walking for their farm work and by school girls while they go to and come from the school.

Marketing

Marketing of *Allo* products is generally done as per demand locally in the country and from abroad. Some products are exported to foreign country like UK, Germany and USA etc. For the knitted products like shawls, vests and others have markets in other countries.

Marketing of products from the study area done through *Allo* club and co-operatives formed in the villages. Eco-Himal and other NGOs had supported the farmers of Benchhong buying *Allo* products and timely giving the payment. Price of *Allo* cloth in the club and co-operative was NRs. 160-200 per meter. The thread is marketed locally at Rs. 600-800 per *Dharni* based on quality and location. Fine thread costs higher. A lorry of thread costs Rs. 5 to 10 based on the size. One shawl costs NRs. 400-600 as per quality and size.

Conclusion and recommendations

Allo works traditionally started to fulfill the household needs around 1950 has gradually transferred into commercial enterprise after 1984. The exploitation rate of *Allo* in the study area has been affecting availability and sustainability of raw material in the natural habitat. The situation indicates need of sustainable management through domestication and proper harvesting technique. Need of introducing cost effective processing techniques and improved spinning and weaving methods have been realized. *Allo* has become a major raw material for cottage industry in the remote areas like Bala, Sisuwa, Tamku, Mangtewa, Yaphu VDCs of Sankhuwasabha district. It grows naturally and can grow in upper mid to lower belt of high hills (1200 to 3000 m) having partial shade, black fertile soil, west and east aspects. There is gradual decline of *Allo* production in areas, where over-harvested without considering regeneration. The situation is alarming/ demanding for sustainable harvesting and cultivation in the study area.

Extraction of bast and its processing method for quality yarn and thread is difficult, tedious, labor intensive and has low profit margin for the farmers. Despite this, different products are sold in local bazaar, Mela and to the buyers of Kathmandu in reasonable prices.

The users applied local skill and materials for processing, spinning and weaving. There is need of improved processing technique for cost effective and environmental points of views. Traditional knowledge applied for income generation by the Rais seems to disseminate in other parts of the country. Exploring marketing channels of overseas markets for fashionable products is necessary to sustain the enterprise and enhance income generation.

Research and development works should focus on domestication, cultivation, regeneration and sustainable harvesting along with appropriate processing and spinning techniques for better utilization of *Allo*. Research in this line is being continued by ARS Pakhribas. Supporting partners and stakeholders are welcomed.

Indications of declining availability in the natural forests and increasing distances and time needed for collection in the study area suggest that *Allo* planting will be necessary to meet the rising demand. As *Allo* cultivation may be combined with community forestry programs as an under-storey crop, we recommend the following research:

- identify different types/ varieties of *Allo* plant and fibre yields.
- Need to know the effects of various growing conditions and harvesting practices on fibre quality and quantity, so that optimum conditions can be employed
- Need to investigate ways in which *Allo* might usefully find a places within existing farming and forestry system.

Harvesting/ fibre extraction, processing and spinning techniques are still traditional. It is tedious, labour intensive, health hazardous, requires more fuel and affect on forest and soil degradation. Therefore appropriate technology for these purpose needs to be investigated so as to overcome the problems and increase the income generation of the rural communities residing in the remote villages of northern hills of Nepal.

There is not assured market of produces. Sometime farmers get pay back of their produces even after nine months. According to exporter based at Kathmandu, there is big demand of *Allo* product that was never fulfilled. It seems that there is problem of appropriate marketing channels, and intermediates need to be identified for strengthening marketing system.

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Potential role of sacred grove of Lumbini in biodiversity conservation in Nepal

Khem Raj Bhattarai¹ and Sushim R. Baral²

This study was conducted in the sacred grove of Lumbini to elucidate its potential role in biodiversity conservation in Nepal. Lumbini Development Trust enumerated tree species of the grove. We have assessed taxonomic validity by identifying the species. A total of 65 tree species, 39 are indigenous to Nepal, were found in the grove. Most of the species were tropical/subtropical elements that are found to be distributed in Nepal from 100 to 2400m asl. Among total indigenous trees, 64 % trees have their distribution in the whole Nepal, whereas 19 %, 14 % and 3 % are limited to central, eastern, and both central and western part of Nepal respectively. The indigenous species found in the grove accounts for 11 % of total tree diversity of Nepal. Of these tree species, five are of threatened, vulnerable and endangered categories. The forest formation of the grove conforms to *Dalbergia sisoo-Acacia catechu* type's forest of Nepal. However, majority of the trees in the grove were produced by plantation so it has contributed to ex-situ conservation of trees, and hence this reflects the importance of sacred grove.

Key words: conservation, distribution, indigenous trees, Lumbini, Sacred grove, sacred plants, tree species.

The sacred groves are small patch of forests conserved through man's religious beliefs since human civilization that comprise valuable genetic resources (Basu, 2000; Jamir and Pandey, 2003). They have become refuges for plants, birds, mammals, and other forest dwelling animals (Dash, 2005), and local community depends upon them for various products used in everyday life (Wadley and Colfer, 2004). The sacred groves are found throughout the world in different temporal and spatial scales, and have contributed significantly for conservation of rare and endangered species (Mgumia and Oba, 2003). In the earlier centuries, conservation programs were based on religion and spiritual belief as reflected from the practices like i) people used to plant trees as an offering to god, ii) forests were used to preserve as religious sites, iii) new species used to introduce from pilgrimage tour and preserved them in sacred grove. Some of the ruminants of forests were also preserved as sacred groves due to its historical significance and spiritual value (Dash, 2005).

Although the sacred groves are economically and religiously important, these are getting pressure from local community through over harvesting for fuel wood, timber, fodder and grazing their cattle. These

human pressures may possibly lead to decline in the species diversity and changing in floristic composition. Inventories of species preserved in the particular sacred grove may provide information about dynamics of plant communities, rationale of preservation in the past, history and socio-cultural values linked with particular species and societies (Bhagwat and Rutte, 2006).

Some of the sacred groves have emerged by planting species with medicinal, religious and aesthetic value (Dash, 2005). These sorts of activities are still in practices and have existed in Nepal since the historic periods of *Budha*, *Licchibi*, *Mallas* and *Rana*. Therefore, several sacred groves are expected to be found in Nepal ranging from tropical to alpine climatic zone, but their inventories and potential role in the conservation of biodiversity have not been documented so far.

Nepal is richer in its ethnic diversity so there are diverse human societies with different social customs; myths and beliefs that are interconnected for the protection and conservation of fauna and flora. Some of the sacred groves have been used as shrines and for spiritual worships (Wadley and Colfer, 2004). Thus,

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conservation of plant species by establishing sacred groves was one of the most widespread practices in the past, which helped to conserve cultural landscapes as well (e.g. Odera, 1997; Posey, 1999). The groves occur in different forms such as remnants of old forests, burial grounds, and sites of ancestral worship (Githitho, 1998; Mgumia and Oba, 2003). However, the sacred groves and their role for conservation of rare and endangered species have been overlooked.

Lumbini has been considered one of the most sacred places on earth amongst Hindus and Budhists. Because of birth place of Lord Budha and valuable historical importance, it has been enlisted by UNESCO as a world heritage site. The birth of Budha has connection with gardens, flowers and trees (see Kausalyayana, 1985). During 7th and 6th centuries BC, Lumbini was a beautiful garden maintained by the Sakya dynasty of Kapilavastu and the Koliyas dynasty of Ramagrama (Bidari 2004). In the Buddhist literature, Lumbini is described as sacred grove with blooming *sal* trees and varieties of beautiful flowers (see Kausalyayana, 1985). Thus, introduction of sacred species in the grove of Lumbini might be a regular practice after birth of Budha.

With the establishment of Lumbini Development Trust in 1985, the area of the grove was extended and planted with hundreds of seedlings of trees belonging to various indigenous and exotic species. Among them, some were rare and endangered (see Shrestha and Joshi, 1996). Inventory of species, evaluation of distribution patterns, floristic composition and adaptation of species in the sacred grove may provide key information useful to promote conservation of rare and endangered species. This study, therefore, intends to: (1) make an inventory of tree species growing in sacred grove of Lumbini, evaluate their regional distribution patterns and floristic composition, (2) classify the trees species of grove according to their use (timber, ornament, medicine and religious purpose), (3) assess the particular forest types formation from existing tree population, and (4) discuss the implication of sacred grove for conservation in general.

Materials and methods

Study site

This study was conducted in the sacred grove of Lumbini in Kapilavastu district, close to the Indian boarder (Fig. 1). It is situated at 180 m above sea level between 27° 28' N

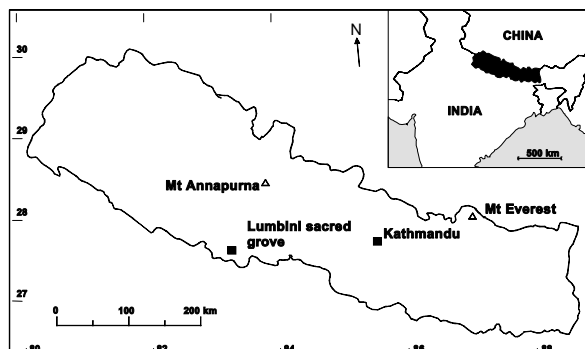


Fig. 1 Location of study area

latitude and 83° 43' E longitude. It has a monsoon climate similar to that of Indian plateau. The most of the rainfall occurs during summer (from June to September) whereas the winter is relatively dry. The Lumbini belongs to tropical vegetation zone of Nepal. Major dominant forest forming species are: *Shorea robusta*, *Terminalia* spp., *Lagestroemia parviflora*, and *Dalbergia sisoo*.

Survey, data collection and analysis

Fieldwork was carried out in June 2007. In order to get information about master plan for conservation and development of Lumbini, a preliminary discussion was done with project manager of Lumbini Development Trust. Vegetation data: botanical species, number of trees, and number of planted seedlings were collected from Lumbini Development Trust which conducted tree census in 2000. To verify this census data, each and every parts of the grove was observed. Some of the species could not be confirmed for the taxonomic identity in the field, so that sample was collected and identified by comparing with voucher specimens (herbaria) preserved in the National Herbarium and Plant Laboratories at Godawari, Lalitpur. In order to obtain information of plant species, their use, religious value, mythological linkage to Buddha, and purpose of introduction of species in the grove; an informal interview and focus group discussion was also conducted with local residents, staff of Lumbini Development Trust and monks of monasteries.

The distribution range and conservation status of the species were based on published literature (e.g. Shrestha and Joshi, 1996; Press *et al.*, 2000; DPR, 2001). In order to find the elevational range of tree species in the natural habitats, the range was interpolated (see Bhattarai and Vetaas, 2006).

Since Nepal Himalayas is divided into three phytogeographical regions: the east, central and west

(Banerji, 1963), tree species found in the sacred grove of Lumbini were also checked for their longitudinal distribution along these phytogeographical regions. The species found in the grove were categorized according to the red data book prepared by International Union for Conservation of Nature and Natural Resources (IUCN) as endangered, vulnerable, rare, commercially threatened and uncertain species (Shrestha and Joshi, 1996). Scatter plot and descriptive statistics were used to summarize the data.

Results

Species composition and distribution

A total of 65 species of tree (angiosperms and gymnosperms) including nine unidentified were found in the sacred grove of Lumbini. These species totaled to 191,448 tree stands. Most of the species were found to be tropical/subtropical element. Among the indigenous trees, majority of them were produced by plantation in different periods of time. The regional distribution pattern of these species along the Himalayan elevation gradient is presented in Fig. 2.

Of the 65 species, 39 are indigenous and 17 are exotic (Table 1 and 2) to Nepal. Regional distribution of these indigenous species was found ranging from 100-2400 m along the elevation gradient of the Himalayas. Some of the exotic trees could not be identified. *Dalbergia sisoo* was found to be most dominant tree species that accounted for 85 % of total tree stands, which was followed by *Callistemon citrinus* and *Albizia lebbek* that accounted for 2.8 % and 1.98 % of total number of tree stands respectively. Among the indigenous trees, five species fall under the categories of vulnerable, endangered and threatened (Shrestha and Joshi 1996; Kurmi and Bhatta 2003, see Table 1).

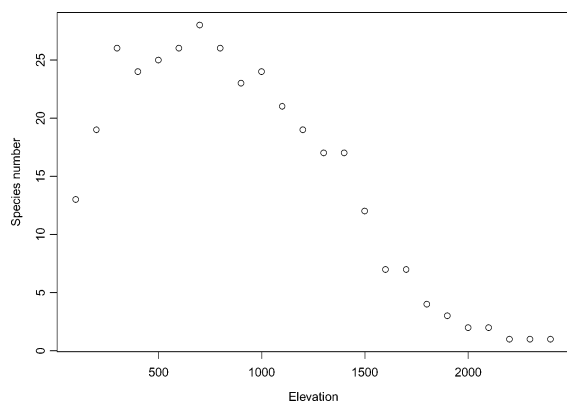


Fig. 2 Regional distribution pattern of indigenous tree species of Lumbini sacred grove along elevation gradient in the Himalayas

Among the indigenous tree species of the grove, 22 were found to be distributed in Nepal Himalayas (WCE), five were found limited only in the centre Nepal (C), and seven species were found both in the centre and east (CE) Nepal (Fig. 3). However, *Pterocarpus marsupium* was only species reported its natural distribution in the west (W) Nepal (Kurmi and Bhatta 2003), and it was found in the sacred grove as well. The tree species of the grove were found to have medicinal, timber, fodder, religious, and ornamental values. Significant number of tree species found in the grove did not found in the natural habitats. These species were found introduced in the grove. However, purpose of introduction of six tree species could not be ascertained (Table 2).

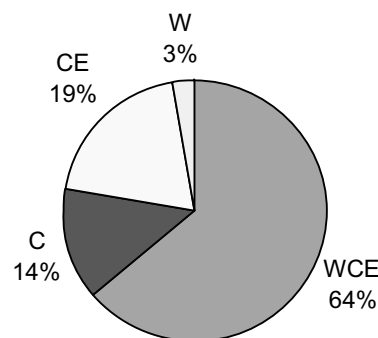


Fig. 3 Proportional phytogeographical distribution of tree species in Nepal

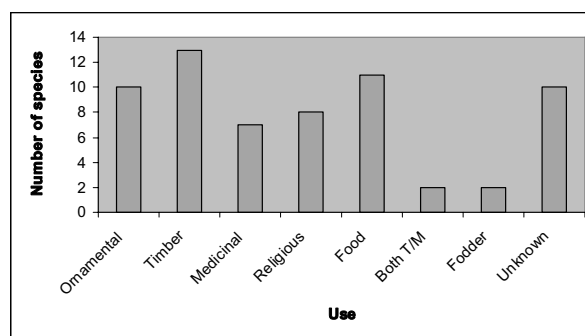


Fig. 4 Proportion of different tree species and their use, T = Timber, M = Medicinal

Table 1: Indigenous trees of Lumbini sacred grove and their distribution pattern in Nepal Himalayas

Tree species	Altitudinal distribution m asl	Biogeographical distribution	Conservation status
<i>Acacia catechu</i>	200-1400	WCE	CT
<i>Accacia nilotica</i>	1500	C	N
<i>Adina cordifolia</i>	150-800	WCE	N
<i>Aegle marmelos</i>	300-1100	WCE	N
<i>Albizia lebbek</i>	250-800	WCE	N
<i>Antbocephalus chinensis</i>	290-800	CE	N
<i>Artocarpus heterophyllus</i>	100-800	C	N
<i>Artocarpus lakocha</i>	700-1400	C	N
<i>Azadirachta indica</i>	300-1700	CE	N
<i>Bambusa sp</i>	400-1200	WCE	N
<i>Bauhania variegata</i>	150-1900	WCE	N
<i>Bombax ceiba</i>	200-900	CE	E
<i>Butea monosperma</i>	150-1200	WCE	E
<i>Cassia fistula</i>	150-1400	WCE	N
<i>Cinnamomum camphora</i>	1300-1500	C	N
<i>Dalbergia latifolia</i>	300-1000	WCE	E
<i>Dalbergia sisoo</i>	200-1400	WCE	N
<i>Delonix regia</i>	200-1100	E	N
<i>Elaeocarpus sphaericus</i>	700-1700	CE	V
<i>Eugenia formosa</i>	300	E	N
<i>Ficus benghalensis</i>	500-1200	WCE	N
<i>Ficus racemosa</i>	300	WC	N
<i>Ficus religiosa</i>	150-1500	WCE	N
<i>Lagostromia indica</i>	1000-1500	WCE	N
<i>Madhuca latifolia</i>	300-1200	C	N
<i>Magnifera indica</i>	100-1200	WCE	N
<i>Mitragyna parviflora</i>	150-200	WCE	N
<i>Moringa oleifera</i>	150-1100	CE	Un
<i>Morus macroura</i>	1200-1700	E	N
<i>Phyllanthus emblica</i>	150-1400	WCE	N
<i>Pinus roxburghii</i>	1100-2100	WCE	N
<i>Psidium guajava</i>	200-1200	WCE	N
<i>Pterocarpus marsupium</i>	100	W	En
<i>Saurauia napaulensis</i>	750-2100	WCE	N
<i>Sesbania orientale</i>	600-2400	WCE	N
<i>Shorea robusta</i>	150-1500	WCE	N
<i>Syzygium jambos</i>	600-1400	CE	N
<i>Tamarindus indica</i>	200-400	CE	N
<i>Trenea nudiflora</i>	150-1800	WCE	N

WCE, W = West, C = Centre, E = East, N = Normal, En = Endangered, CT = Commercially threatened, V = Vulnerable, Un = Status unknown

Discussion

Tree species richness and forest formation

Tree species found at sacred grove of Lumbini accounted for ca. 11 % of total tree species of Nepal. These species were distributed along the elevation gradient of the Himalayas from 100 m to over 2000 m. There are total 614 tree species found in Nepal,

which are distributed from 100-4400 m (Bhattarai and Vetaas, 2006). Although, grove was located at 180 m above sea level the tree species were distributed below and above this range (Fig. 2.). This indicated that the species have wider distribution range. Relatively, species having wider range of distribution are considered as more adapted in the natural habitats (Subedi et al., 2007).

The dominant tree species in the grove were *Dalbergia sisoo*, *Albizia lebbek*, *Callistemon citrinus*, and *Acacia catechu*. Except *Callistemon citrinus* others were indigenous to tropical parts of Nepal. Majority of the trees of the grove were produced by plantation, so that the newly emerged forest patch could be assumed as tropical type with different species composition than the natural forest. According to forest classification based on species composition, the forest formation of the grove falls under the category of *Dalbergia sisoo-Acacia catechu* types of Nepal (Stainton, 1972), which is common in new alluvial deposit along the streams and rivers of *terai* and *dun* valleys.

Of all the tree species in the grove, *Dalbergia sisoo* accounted for 85 % whereas rest of species accounted for only 15 %. The 15 % of various other species might be insignificant in number in order to maintain the integrity of ecosystem. The majority of species accounted for less than 1 % among the total stands, showed that this was almost monoculture plantation of *Dalbergia sisoo*. There is a long-standing debate over whether to use mono- or polyculture when establishing plantations. Hartley (2002) reviewed the literature and found that polyculture was found to be beneficial against monoculture in many parts of the world. These benefits include: (1) more efficient nutrient use (2) site quality and yields are conserved over time (3) reduced risk of catastrophic damage from storms, insects, or disease outbreak (4) some species provide nurse effect to neighboring species and protect against shade, frost, etc. (5) enhance higher ecological integrity due to higher species diversity. Research has shown that polyculture species are more resistant and can use nutrients more efficiently than monoculture do because of differences among species in rooting patterns, mycorrhizal associations (Perry et al., 1992), phenology (Keenan et al., 1995), nutrient demands

(Kelty, 1992), and soil mineralization rates (Matthews, 1989). Adhikari et al. (2006) have found that the major die back disease in monoculture plantation of *Dalbergia sisoo* in Lumbini was mainly caused by fungi (*Ganoderma lucidum* and *Fusarium solani*).

Table 2. Exotic tree species and their purpose of their introduction in the sacred grove

Species	Purpose of introduction
<i>Callistemon citrinus</i>	Ornamental
<i>Tectona grandis</i>	Timber
<i>Eucalyptus camaldulensis</i>	Medicinal
<i>Terminalia arjuna</i>	Medicinal/religious
<i>Leucaena leucocephala</i>	Fodder
<i>Polyalthea longifolia</i>	Religious/ornamental
<i>Acacia mollissima</i>	?
<i>Thuja compacta</i>	Ornamental
<i>Ficus sp.</i>	Fodder
<i>Oreodoxa regia</i>	Ornamental
<i>Mimusops elengi</i>	?
<i>Ficus idostics</i>	?
<i>Polyalthea barmige</i>	Religious/ornamental
<i>Pithecolobium sp</i>	?
<i>Populus sp</i>	Ornamental
<i>Annona squamosa</i>	Food
<i>Jacaranda mimosifolia</i>	Ornamental

According to phytogeographical division of Nepal, the sacred grove of Lumbini is located at the boarder between central and western Nepal. Three species *Delonix regia*, *Eugenia formosa* and *Morus macoura* which are found only in east Nepal were also found in the grove. Similarly, there were five species limited to central Nepal and only one species of west were found in the sacred grove. These species were not found in the natural forests around the sacred grove (see Stainton, 1972). Such evidence may indicate that beside natural regeneration, tree species might have introduced from other parts of Nepal. Thus, sacred grove of Lumbini has played an important role for ex-situ conservation of tree diversity in Nepal.

Table 3: Sacred species of the grove and their symbolization as deities

Botanical species	Local name	Associated god/goddess
<i>Anthocephalus chinensis</i>	Kadam	God Krishna
<i>Azadiarachta indica</i>	Neem	Goddes Sita
<i>Bauhinia variegata</i>	Koiralo	God Bishnu
<i>Butea monosperma</i>	Palsh	God Shiva
<i>Eragrostis cynosuroides*</i>	Kush	God Vishnu
<i>Ficus bengalensis</i>	Bar	God Burhma
<i>Ficus religiosa</i>	Peepal	God Bishnu
<i>Hibiscus rosasinensis**</i>	Japapuspi	Goddes Durga
<i>Saraca indica</i>	Ashok	God Kamadev

** Shrub and * grass

Sacred grove and conservation in Nepal

Lord Budha was born under the tree of *saal* (*Shorea robusta*) which is considered sacred as a mother goddess (Bidari, 2004). However, some people are in the opinion that the tree was Ashoka (*Saraca indica*) not a *Shorea robusta*. According to Buddhist literature, Maya Devi (mother of Budha) wished to be at the base of a tree and gazing upon the garden-grove in Lumbini at the time of delivery. After birth of Budha, people started to worship the tree and the worshipping become very popular and common among the people of that period. Lumbini Development Trust has planted various religious trees in the grove and continued the religious tradition. At present there were ca. 9 % of trees species in the grove were considered as religious (Fig. 4). Various Hindu deities and their forms have been symbolically associated with these species (Table 3). Majpuria (1999) have reported 56 sacred plant species from Nepal. The most worshipped trees are flower bearing with medicinal values.

Beside tree, there is a sacred grass (*Eragrostis cynosuroides*) and a sacred shrub (*Hibiscus rosasinensis*) species in the grove. These species have been preserved because of their associated religious and spiritual beliefs. Hence, these plant species are worshipped. Felling and destruction upon religious species is considered against the spirit of religion. Such religious beliefs have played important role for conservation of these trees in the grove from centuries. Now time has come to check what species have been preserved in the grove of Lumbini.

Although *Dalbergia sisoo* having no religious and ornamental value was still dominant tree in the grove. The plantation, which was done by Lumbini Development Trust in the earlier days, might have focused to increase the greenery rather than beautifying the grove. Some species, *Bombax ceiba*, *Butea monosperma*, *Dalbergia latifolia* are endangered tree species are conserved in the grove. Beside indigenous trees, 17 exotic tree species were introduced in the grove (Table 2). Some of the introduced species were highly valuable due to their medicinal properties (e.g. *Terminalia arjuna*).

Recently, Lumbini Development Trust is constructing a sacred pond around the periphery of birthplace of Budha, which is going to be a potential habitat for several species of birds and aquatic life forms. Aquatic plant like *Nelumbium speciosum* has been introduced in

the aquatic habitats of the grove. This shows that grove may provide the habitat for endangered, rare and sacred species of plants. Thus, potential role of sacred grove in biodiversity conservation of Nepal would be realized and conservation programs would be formulated for the better management and conservation of grove.

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Simple coppice management options for the sal (*Shorea robusta* Gaertn. f.) forests in the Terai of Nepal

S. K. Ojha¹, K.P. Acharya¹, B. Acharya², R. Regmi²

The paper examines simple coppice management options for sal (*Shorea robusta* Gaertn. f.) forest that maximizes total biomass production. The study is based on the data obtained from two non-replicated research blocks located at Butwal and Dharan, which were established in 1988 and 1989 respectively by the Department of Forest Research and Survey. Out of four blocks in each site, one block was of simple coppice management option. Simple coppice management option had four treatments, i.e. 1) 3 s/s, 2) 1 s/s, 3) 3-2-1 s/s, and 4) Control, which were designed for fodder and fuelwood production in a short rotation of four years. The analysis was done to estimate the productivity of the treatments for the four successive rotations. In on average, it was found that treatment 3-2-1 s/s was the best to produce maximum biomass in short rotations. Both treatments 1 s/s and 3-2-1 s/s were found best for foliage production. Local community user groups benefit from the result to choose appropriate simple coppice management option in their sal forests, if fodder and fuelwood production in short rotations is the main objectives of the forest management.

Key words: biomass, coppice, Nepal, regeneration, Sal forests.

Sal (*Shorea robusta* Gaertn. f.) forests are widely distributed and cover largest area of forests in Bhabar, Terai and Siwalik hills from east to western Nepal. Sal is the most valuable and high-price wood in Nepal. The country mainly depends on this forest to meet the timber requirement (Acharya *et.al.* 2002).

In the past, sal forests was heavily exploited both for resettlement programs and for generating state revenue. Moreover, this forest was heavily cut down to meet the forest product demand of continually increasing population. Due to this, many of such forests have either become degraded in quality and quantity or converted into agricultural land.

The forest policy of Nepal has emphasized the protection of forests in Terai during the past decades. This has led to passive management, producing overmature degraded forests and that eventually disappear (Pesonen and Rautiainen 1995). The rate of decline of the forest area is 1.3 percent per annum in the Terai in the past 12 years (FRIS 1993). Thus the total loss of forest area in the plains during that period has been found 99,000 ha. In spite of degradation, the forest resources of the Terai are substantial and offer an excellent basis for sustainable management. An estimate has shown that a total of 3654 million ha of forest area is available for

improved management. Out of which sal occupies 13,20,000 ha of forest area in Nepal (Sowerine 1994, cited in Acharya *et. al.* 2002). In the absence of active management of forests, uncontrolled felling, encroachment and land clearing exist. Pesonen and Rautiainen (1995) found that, about 70 percent of production forests would be suitable for the even-aged silvicultural system in Terai.

According to the Pesonen and Rautiainen (1995), most of the sal forests are over mature, since the best option for forest management is, initiating active management of natural forests based on natural regeneration of indigenous species. The production capacity of the sal forests can be improved considerably with a change in the forest management strategy and silvicultural systems. Wood production can be enhanced threefold. Young stands produce more foliage than old ones. The management system should be selected that would boost production such that local people benefit more from the new system than from the existing one.

Nowadays, people are interested to manage sal forests for multiple products as to meet local livelihood demands of forest products. This in fact needs to identify appropriate management system or

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silviculture regime. To design silviculture regimes for multiple-product management, it is important to have knowledge of stand growth and productivity (Gautam and Devoe 2006).

Natural forest management research program mainly focus on regeneration establishment in Nepal and it studies the effect of different harvesting regimes on growth performance and biomass productivity of the stand. These long-term researches were started in the 1980s at the time when the national focus in forestry sector was on renovation of degraded sites (Acharya *et. al.* 2002). These research plots were established in Tropical Sal Forest Type in the Terai region of Nepal and the objectives were:

- to investigate best management practice to establish the natural regeneration through coppice management.
- to identify best management option that can maximize fodder and firewood production from degraded Terai forests of Nepal.

Materials and methods

Study Area

The data used in this study was taken from two research sites established by the Forest Research Division (FRD) of the Department of Forest Research and Survey (DFRS).

The experiment block was established at Jogikuti, Butwal of Rupandehi district in Western Terai as a large unreplicated block which is representative of the area. The study site is about 5 km south of Butwal town and accessible by vehicles. It is accessible from the Butwal-Bhairahawa road, which passes through Jogikuti village. The plot is situated at latitude of 27°42' and longitude of 83°28' and at altitude of 263 masl. The forest was selectively logged by the authority and the remnant mature trees were removed gradually by illegal felling until 1987. The site was highly degraded and only two trees were present at the time of plot establishment in 1988 (FRP 1989). In 1988, Forest Research Project (FRP) cleared all the existing patchy bushes by coppicing so that the resulting crop would be all the same age. There was substantial re-growth after the area was protected (previously it was a grass/grazing ground). This research site is located in a place which is near the city and surrounded by the highly crowded population. By the time very few patches of forest like this were left in the area because of deforestation and population pressure.

The research block with the same management system and treatments was established at Chaukibari, Dharan of Sunsari district in Eastern Terai and intended to be a replication of the experimental site mentioned above. The study site is located at about 1.5 km east of Chaukibari of Sunsari district (Near Dharan) and about 3 km South of Dharan on the road to Ghopa Camp. The plot is situated at latitude of 26°49' and longitude of 87°17' and at altitude of 400 masl. It is located within the scrubland national forest of Sunsari district. The site is situated in a Dun valley of the Terai Bhabar zone of Nepal and is accessible by the vehicles. The site is gently undulating. The forest was under selective logging and the remnant mature trees gradually removed by illegal felling until 1989. At the time of plot establishment, there were very few trees present within the plot. Forest Research Project (FRP) cleared the area in June 1990 to establish the permanent silviculture research plots (FRP 1990). During plot establishment all the trees including felled trees were coppiced and after few month area got covered with profuse and vigorous regeneration.

Butwal and Dharan research blocks are situated apart at a distance of about 350 km in the Bhabar Terai area of Nepal as shown in figure 1.

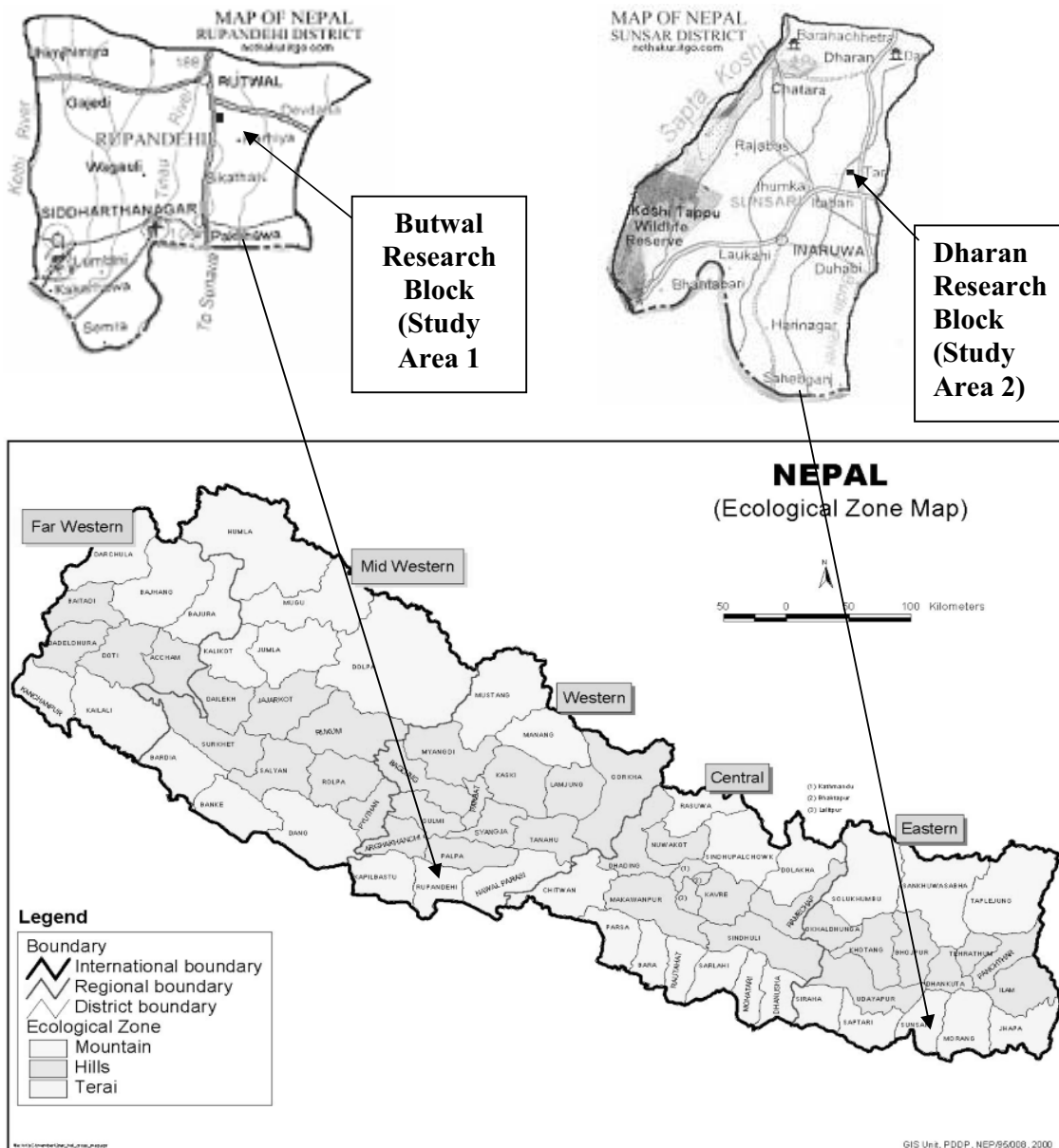
Site Conditions

Butwal Site

Soil: Butwal site is flat and fertile. The soil is loamy, deep, well drained and has adequate nutrient capability. According to the map of the Land Resource Mapping Project (LRMP), this area belongs to the class I, most suitable land for agriculture and forestry. Actual landuse for this area is shown as degraded tropical mixed hardwood forest. Soil physical and chemical properties are exceptionally good for forestry use (FRP 1989).

Climate: The climate is sub-tropical and sub-humid with regular monsoon between June-August. Frost occurs seldom and the annual average number of days with minus temperature is 0 (Jackson, 1994). Mean total annual precipitation is 2452 mm of which more than 80% falls from June to September. Monthly mean maximum and minimum temperature are 31.4°C and 17.7°C respectively with an absolute minimum of 4.3°C (Jackson 1994).

Vegetation: Sal forest diversity consists of more than 80 percent sal (*Shorea robusta*). Other associated tree species in this forest are asna (*Terminalia alata*), amala



http://ncthakur.itgo.com/districtmaps/rupandehi_district.htm
http://ncthakur.itgo.com/districtmaps/sunsari_district.htm

Figure 1: Location of the study area in the map of Nepal.

(*Phyllanthus emblica*), barro (*Terminalia belerica*), bhalayo (*Semecarpus anacardium*) botdhairo (*Lagestroemia parviflora*), harro (*Terminalia chebula*), jamun (*Syzygium cumini*), kalikath (*Myrsine semiserrata*), karma (*Adina cordifolia*), raj briksha (*Cassia fistula*) and sindure (*Mallotus philipinensis*).

Dharan Site

Soil: Dharan site is also flat and fertile. The soil is loamy, deep, well drained, and gravelly and has adequate nutrients. Capability map of the Land Resource Mapping Project (LRMP) classifies the area

as class I as most suitable land for agriculture and forestry. Land use is defined as degraded tropical mixed hardwood forest. As previous site, physical and chemical properties of the soil are exceptionally good for forestry use (FRP 1990).

Climate: The climate is sub-tropical and sub-humid with regular monsoon between June-August. Frost occurs seldom and the annual average number of days with minus temperature is 0 (Jackson, 1994). Mean total annual precipitation is 2401 mm of which more than 80% falls from June to September. Monthly mean maximum and minimum temperature

are 28.2°C and 17.1°C respectively with an absolute minimum of 5°C (Jackson 1994).

Vegetation: The vegetation structure and composition of this site is similar to Butwal site.

Research design and layout of the plots

The block has been divided into four different management options: i) simple coppice, ii) high forest, iii) coppice with standards 25% and iv) coppice with

Figure 2. Layout design of the research Block at Dharan

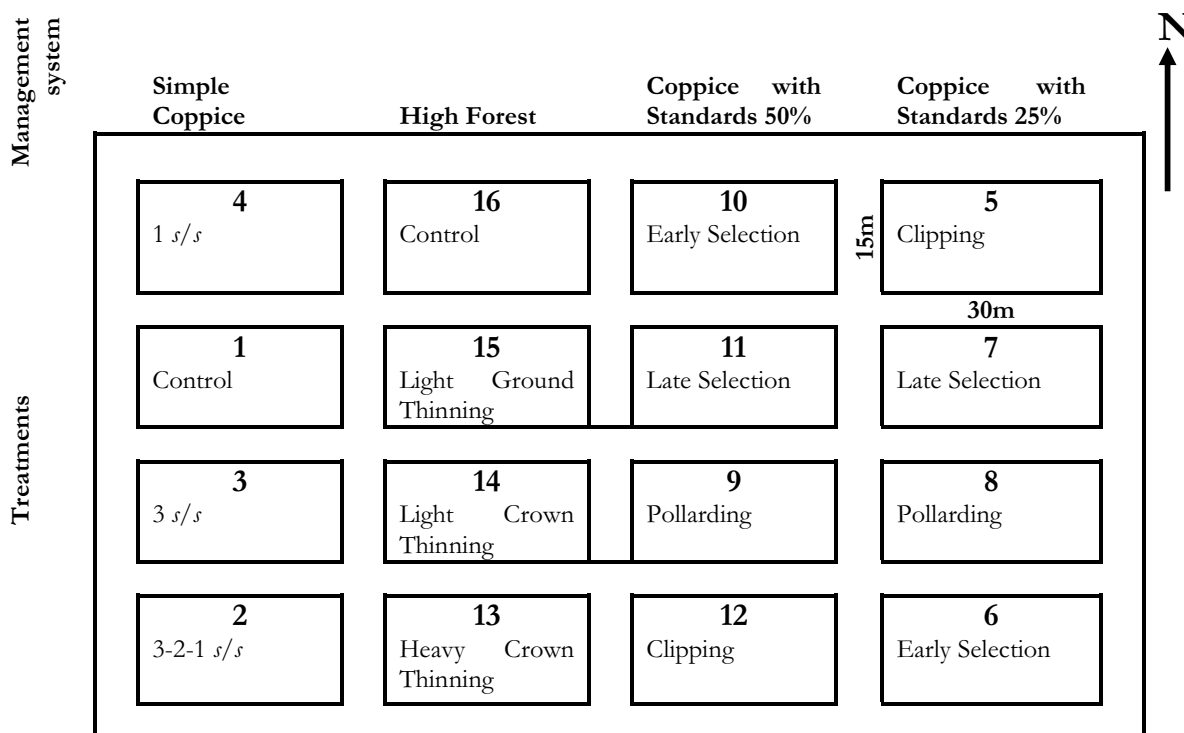
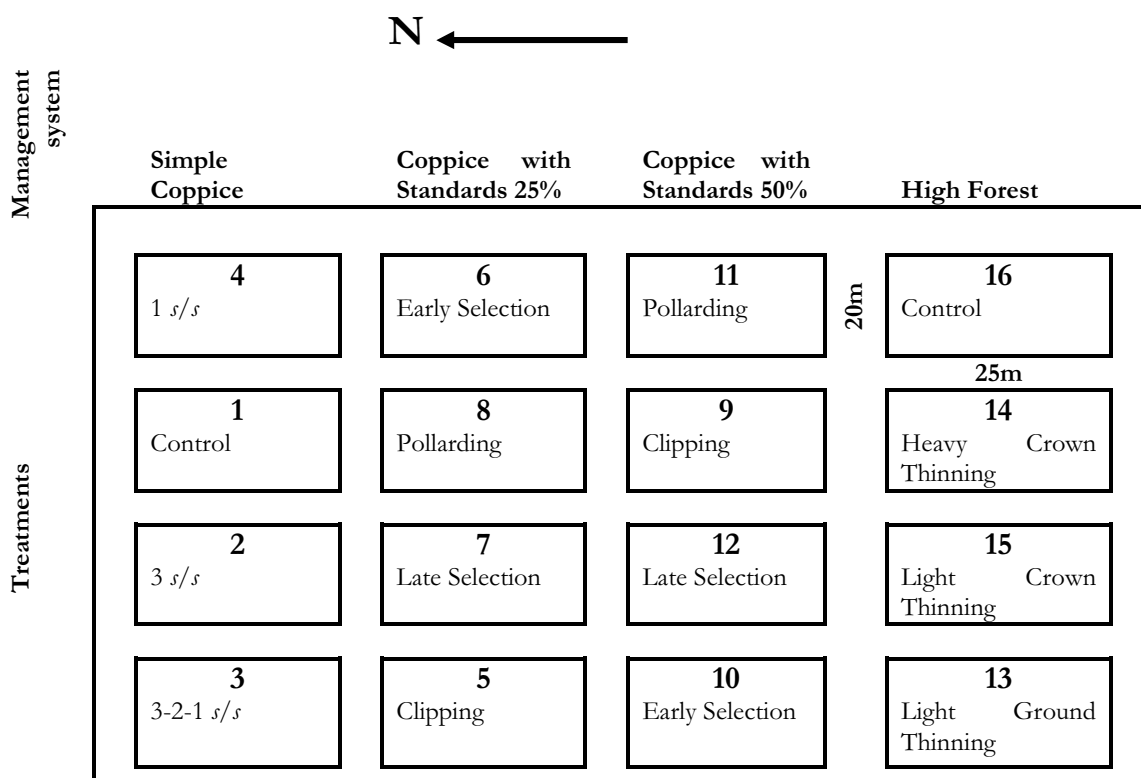


Figure 3. Layout design of the research Block at Butwal



standards 50% (Figure 2 and 3). Each of these management options has four treatments. Each treatment-plot was randomly located and demarcated apart with a buffer between them. All plots have equal size and dimension. Each plot in Dharan has an area of 450 m² (30 m * 15 m) and in Butwal has an area of 500 m² (25 m * 20 m). Fire-line around the block and buffers in-between the plots have width of 5 m. This paper analyses the simple coppice management option only.

Measurements

Total enumeration was carried out over plots during biomass measurement. Field measurements were carried out mostly between November to March every year. The harvested biomass (foliage and wood) each year from the plots under the various treatments was weighed and recorded. A weighting apparatus was used to weight the green biomass.

Simple coppice management option

Regeneration of the crop in coppice systems is based on coppicing. This management system produces maximum productivity from the harvested stumps. The simple coppice option had the shortest rotation of four years. In the fourth year, re-growth of coppice was so vigorous that the plot was covered in a dense stand of sal trees reaching a height of four meters or more. Coppices were either annually harvested or protected. The entire crop was harvested (clear felled) at the rotation age. The cycle was repeated for 4 rotations.

The treatments are as follows (Tamrakar, 1994)

- 3-shoots per stool treatment (3 *s/s*)
In the first year after clearfelling, the multiple shoots regenerated from the stump were singled to three best shoots per stump and the rest were harvested. These three shoots were maintained in the following years and new shoots were removed if there were any. Clearfelling was carried out at the rotation in the fourth year.
- 1-shoot per stool treatment (1 *s/s*)
In the first year after clearfelling, this treatment involved singling to one shoot per stump and the rest were harvested. This one shoot was maintained in the following years. Harvesting any new shoots was carried out every following year until the canopy closes and clearfelling was carried out in the fourth year.

- 3-2-1 shoots per stool treatment (3-2-1 *s/s*)
This treatment maintained three best shoots per stump for the first years. These were reduced to two shoots per stump in the second year and further reduced to one shoot per stump in the third year. The canopy closed at four years then the stand was clearfelled.
- Control plot, no treatment
In this treatment only weeding is done to facilitate coppice growth for initial three years. The plot was harvested on the fourth year.

Silviculture history of the of the treatment plots from year 1988 to 2005 is presented in Annex 1.

Results and discussion

Total biomass production

The total biomass production from the treatment plots during four rotations in Butwal and Dharan is shown in figure 4 and 5 respectively (also in Annex 2 and 3). The findings show that the management intervention increases biomass production. In both Butwal and Dharan, the biomass production in all treatment plots is increased in second, third and fourth rotations compared to the first rotation.

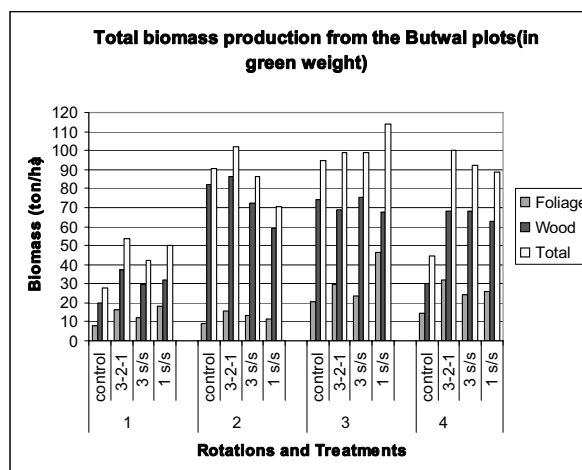


Figure 4: Total biomass production from the Butwal plots.

In Butwal, the biomass production from all treatment plots is significantly higher in the second rotation than in the first rotation. Biomass production for all treatments except treatment 3-2-1 *s/s* is found higher in third rotation compared to second rotation. Biomass production from all treatment plots except 3-2-1 *s/s* plot is lower in fourth rotation in comparison to the third rotation. However, decreased

biomass production in fourth rotation compared to third rotation could have happened due to unfavorable weather and livestock disturbances in the period. The treatment 3-2-1 *s/s* has produced higher biomass compared to other treatments in the first, second and fourth rotations. However, due to highest foliage production, the treatment 1 *s/s* has produced higher biomass compared to other treatments in the third rotation.

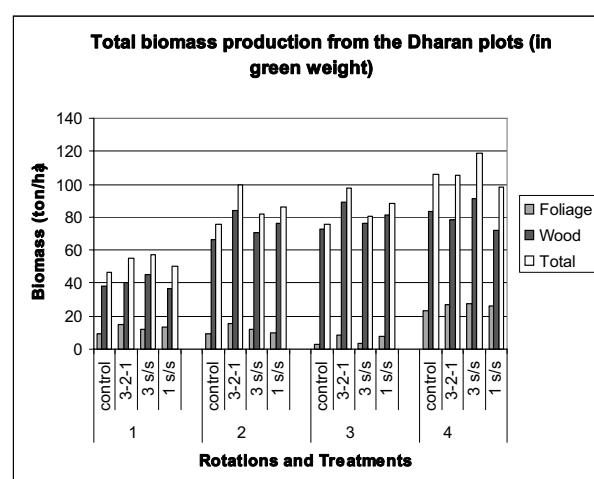


Figure 5: Total biomass production from the Dharan plots.

In Dharan, the biomass production from the treatment plots except 1 *s/s* plot is found lower in third rotation compared to second rotation. This is due to the lower foliage biomass production in all treatment plots in the third rotation compared to second rotation. This could have happened due to late measurement of the plots where already leaf shedding has been started. Biomass production for all treatments is higher in fourth rotation in comparison to the third rotation. The treatment 3-2-1 *s/s* has produced higher biomass compared to other treatments in the second and third rotations. However, the treatment 3 *s/s* has produced higher biomass compared to other treatments in the first and fourth rotations.

The lowest biomass production in first rotation compared to succeeding rotations could be due to unfavorable growing condition at the beginning of the first rotation. These degraded forests were under severe stress due to grazing, forest fire and human disturbances in the past. The protection of the site and development of root system with time could have increased biomass production. The study shows that wood biomass production was significantly higher compared to foliage in all treatments for each rotation. About 80 percent of the foliage produced was in the form of fodder.

Mean biomass production

Mean biomass production from the treatment plots for four rotations in Butwal and Dharan is presented in table 1. It is found that the mean foliage biomass production from the treatment 1 *s/s* is higher compared to other treatments in Butwal. But, the treatment 3-2-1 *s/s* produced the higher mean foliage biomass compared to other treatments in Dharan. The treatment 3-2-1 *s/s* produced the highest mean fuelwood biomass and mean overall biomass in both Butwal and Dharan. The value of standard error shows the extent of variation of biomass production in the rotations.

The study reveals that, for maximum biomass or for maximum fuelwood production in short rotations under simple coppice management, 3-2-1 *s/s* treatment is the best among the tested ones.

Conclusion

Simple coppice management is one of the most suitable forest management options to produce fuelwood and fodder from sal forest in short rotations. In overall, the treatment 3-2-1 *s/s* is found better than other treatments for maximum biomass production. Simple coppice management option is not suitable for timber production. However, it can

Table 1: Mean biomass production from the treatment plots in four rotations (Butwal and Dharan)

Site	Treatments	Rotations	Foliage		Wood (green weight, ton/ha)		Total	
			Mean	S.E.	Mean	S.E.	Mean	S.E.
Butwal	control	4	12.89	2.90	51.69	15.50	64.57	16.66
	3-2-1 <i>s/s</i>	4	23.38	4.30	65.26	10.11	88.64	11.71
	3 <i>s/s</i>	4	18.33	3.15	61.53	10.71	79.85	12.88
	1 <i>s/s</i>	4	25.56	7.59	55.14	7.97	80.69	13.57
Dharan	control	4	11.04	4.32	65.20	9.74	76.24	12.14
	3-2-1 <i>s/s</i>	4	16.44	3.87	73.13	11.13	89.57	11.50
	3 <i>s/s</i>	4	13.77	5.00	71.04	9.55	84.81	12.71
	1 <i>s/s</i>	4	14.29	4.12	66.47	10.17	80.76	10.60

produce some wooden weaving materials (*Bhata*) which can be used for house construction. The information produced in this study gives information to the forest user groups about the productivity of sal forest managed under different simple coppice management options in short rotations.

The main limitation in this research design was the lack of replication of the treatments. Due to this, advance statistical analysis such as testing the significance of difference between the treatments or analysis of variance was not possible. Therefore, principles of experimental research design should be followed during further scientific research designing and planning.

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Annex 1: Silviculture history of the plots from year 1988 to 2005

Dharan				Butwal				Age (yr)	Treatments			Remarks	
Rot 1	Rot 2	Rot 3	Rot 4	Rot 1	Rot 2	Rot 3	Rot 4		Control	1 s/s	3 s/s		3-2-1 s/s
1989				1988				0	complete clearfell	complete clearfell	complete clearfell	complete clearfell	Green biomass weighed every year after harvesting.
1990	1994	1998	2002	1989	1993	1997	2001	1	weeding	singling to leave 1 shoot per stool	singling to leave 3 shoots per stool	singling to leave 3 shoots per stool	
1991	1995	1999	2003	1990	1994	1998	2002	2	weeding	1 shoot per stool	3 shoot per stool	2 shoots per stool	
1992	1996	2000	2004	1991	1995	1999	2003	3	weeding	1 shoot per stool	3 shoot per stool	1 shoot per stool	
1993	1997	2001	2005	1992	1996	2000	2004	4	complete clearfell	complete clearfell	complete clearfell	complete clearfell	

Rot: Rotation

Annex 2: Biomass production, Butwal

Treatments	First rotation		Second rotation		Third rotation		Fourth rotation		Total Biomass production up to 4th rotation		
	Year	foliage wood total	Year	foliage wood total	Year	foliage wood total	Year	foliage wood total			
	Green weight, ton/ha		Green weight, ton/ha		Green weight, ton/ha		Green weight, ton/ha				
control	1989	0	0	0	0	0	0	0	0		
	1990	0	0	0	0	0	0	0	0		
	1991	0	0	0	0	0	0	0	0		
	1992	7.94	20.01	27.95	81.89	90.67	20.46	74.4	94.86	44.8	
	Total	7.94	20.01	27.95	81.89	90.67	20.46	74.4	94.86	44.8	
3-2-1 s/s	1989	2.1	1.1	3.2	3	1.2	4.2	4.2	8.7	6.66	
	1990	1.4	1.3	2.7	1.22	1.09	2.31	3.58	6.8	10.38	6.18
	1991	2.9	5.6	8.5	2.54	3.85	6.39	4.26	10.64	14.9	11.12
	1992	9.64	29.52	39.16	9.1	79.9	89	17.5	47.4	64.9	76.24
	Total	16.04	37.52	53.56	15.86	86.04	101.9	29.84	69.04	98.88	100.2
3 s/s	1989	2.3	1.1	3.4	3.8	1.04	4.84	3.5	3.8	7.3	5.74
	1990	0.7	0.3	1	0.48	0.19	0.67	2.5	1.06	3.56	0.92
	1991	0.4	0.1	0.5	0.108	0.004	0.112	0.08	0.02	0.1	0.3
	1992	8.92	28.23	37.15	9.08	71.32	80.4	17.24	70.78	88.02	85.4
	Total	12.32	29.73	42.05	13.468	72.554	86.022	23.32	75.66	98.98	92.36
1 s/s	1989	6.7	3.6	10.3	4.71	1.75	6.46	12.8	10.3	23.1	8.34
	1990	1.2	2	3.2	1.53	0.97	2.5	4.56	3	7.56	3.1
	1991	1.2	0.6	1.8	0.49	0.29	0.78	0.34	0.04	0.38	1.52
	1992	9.2	25.6	34.8	4.69	55.89	60.58	28.82	54.09	82.91	75.44
	Total	18.3	31.8	50.1	11.42	58.9	70.32	46.52	67.43	113.95	88.4

Annex 3: Biomass production, Dharan

Treatments	First rotation			Second rotation			Third rotation			Fourth rotation			
	Year	foliage total	wood total	Year	foliage total	wood total	Year	foliage total	wood total	Year	foliage total	wood total	Total
	Green weight in ton per ha			Green weight in ton per ha			Green weight in ton per ha			Green weight in ton per ha			
control	1990	0.00	0.00	1994	0.00	0.00	1998	0.00	0.00	2002	0.00	0.00	0.00
	1991	0.00	0.00	1995	0.00	0.00	1999	0.00	0.00	2003	0.00	0.00	0.00
	1992	0.00	0.00	1996	0.00	0.00	2000	0.00	0.00	2004	0.00	0.00	0.00
	1993	9.03	37.87	1997	9.38	66.50	2001	2.63	73.18	2005	23.13	83.24	106.38
	Total	9.03	37.87	46.90	9.38	66.50	75.88	2.63	73.18	75.81	23.13	83.24	106.38
3-2-1 s/s	1990	0.71	0.31	1994	0.79	1.11	1998	0.76	0.97	2002	3.00	1.11	4.11
	1991	1.57	2.23	1995	1.10	1.06	1999	0.91	0.27	2003	0.29	0.36	0.64
	1992	3.01	4.05	1996	1.68	11.84	2000	1.68	8.26	2004	0.18	1.31	1.49
	1993	9.77	33.80	1997	12.02	70.20	2001	4.87	79.80	2005	23.44	75.87	99.30
	Total	15.05	40.38	55.43	15.58	84.22	99.80	8.21	89.29	97.51	26.90	78.64	105.55
3 s/s	1990	0.97	0.33	1994	0.80	0.82	1998	0.69	0.70	2002	2.70	1.17	3.87
	1991	0.80	0.66	1995	0.40	0.23	1999	0.05	0.04	2003	1.07	1.87	2.93
	1992	0.29	0.26	1996	0.02	0.03	2000	0.08	0.09	2004	2.29	8.69	10.98
	1993	9.95	44.31	1997	10.47	69.52	2001	2.90	75.79	2005	21.58	79.67	101.24
	Total	12.01	45.56	57.57	11.70	70.60	82.29	3.72	76.62	80.35	27.63	91.39	119.02
1 s/s	1990	1.64	0.31	1994	2.45	3.09	1998	2.30	3.03	2002	5.66	3.74	9.40
	1991	1.99	2.57	1995	1.40	0.86	1999	1.60	7.00	2003	1.27	1.20	2.47
	1992	1.10	0.70	1996	0.14	1.69	2000	0.12	1.56	2004	0.56	2.33	2.89
	1993	8.68	32.89	1997	6.11	70.67	2001	3.50	69.55	2005	18.63	64.70	83.33
	Total	13.42	36.48	49.89	10.10	76.31	86.41	7.52	81.13	88.65	26.11	71.98	98.09

Who is benefiting more from common property forest resources: poor or less poor?

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This paper intends to assess the distribution of community forestry benefits among economic groups of the users comparing protected area buffer zone with the Department of Forests regime in Nepal. Following the case study approach two forest user groups of Nawalparasi district, each from buffer zone of Chitwan National Park and Department of Forests regime were selected for the study. The study results suggest that the users in the buffer zone receive less benefit from community forestry than the users in the Department of Forests regime. Analysis of inputs and outputs reveals that poor households receive less benefit than the better off households in both of the regimes. Insofar the results counteract the principles of equity as expected from national forest policy goals and approaches.

Key words: benefits, buffer zone, community forestry, equity, heterogeneity, Nepal.

Despite the arguments of the Tragedy of the Commons (Hardin, 1968) in favor of privatization or government control over common goods for their protection, community based natural resource management strategies are growingly implemented in developing countries. Community Forestry (CF) is such an effort, in Nepal, evolved as one of the main components of country's forest development strategy during past two decades. Nepal was one of the first countries to embrace fully community forestry as the main strategy of its national forest policy (Bartlett, 1992). Local communities have usufruct right over the forest resources through a forest user group (FUG), group involving all members of the community that regularly use a forest to meet their household needs. The Forest Act 1993 and Forest Regulation 1995 have legitimized the roles, responsibilities and rights of FUGs as an independent, autonomous and self-governing institution responsible to protect, manage and sustainable use the community forest. So far more than 14,000 FUGs, which constitute about 35% of the population of the country, are managing about 1.20 million ha of forest, about 25% of the country's total forest land (DoF, 2007). Master Plan for Forestry Sector (MPFS), implemented in 1989, recognize about 60% of the country's forest as potential community forests.

Nepal is actively involved in environment protection and biodiversity conservation through establishing

network of protected areas in the country. Till date 19.70% of the country's total area has been declared as protected areas (ICIMOD/MOEST, 2007). Community participation in protected area management has been initiated through buffer zone program in the country since 1996. Buffer Zone (BZ) is a designated area surrounding a national park or reserve within which the use of forest products by local people is regulated to ensure sustainability of the resources, environmental conservation and community development (NBS, 2002). So far 11 buffer zones have been declared in Nepal constituting 17.52% of the protected areas and 3.45% of the total area of the country (DNPWC/PCP, 2006). In buffer zone, community forestry program has been implemented as one of the most important programs.

The Tenth Plan (2002-2007) and Poverty Reduction Strategy Paper (PRSP, 2002) provide the strategic vision, enabling policy framework for decentralization and legitimate the local efforts by devolving and sharing power of the state with the dependent communities. CF program in Nepal is based on the principle of devolution, and it is an attempt to improve the socio-economic conditions of rural communities and halt environmental degradation. Despite the successful development of CF in Nepal there are instances when not all people receive the same benefits that could be conducive to discussion of equity issues within FUGs (Richards *et al.*, 2003). Equity in benefit distribution of community forest

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management is considered to be one of the major determinants of long-term sustainability. This study aims to assess the distributional implications of CF benefits among different economic groups of the users comparing protected area buffer zone with the department of forest regime in Nepal.

Materials and methods

This study was carried out in the buffer zone of Chitwan National Park and its vicinity in Nawalparasi district of western Nepal. Kalika FUG from buffer zone and Choutari FUG from Department of Forest regime were selected for the study considering similar forest types and socio-economic conditions of the users.

Structured questionnaire survey, most widely used and popular technique in social research (Neuman, 1994), was conducted to collect the primary data. Pre-tested questionnaire was filled up through visiting the households during the field visits between October 2006 and February 2007. A total of 131 households, 60 from Kalika FUG and 71 from Choutari FUG, about 10% of total, were selected through stratified random sampling based on wealth ranking for the survey. Participants in the participatory rural appraisal exercise were asked to categorize all households into three different wealth groups, poor, middle class and better off based on the criteria that they considered important for such classification. Six semi-structured interviews and four focus group discussions were conducted with the key informants to triangulate the data. Numerous

literatures and documents were reviewed to collect the secondary data.

The data were analyzed through benefit-cost ratio, Mann-Whitney test, Kruskal-Wallis test and χ^2 -Approximation. Benefits and costs were assessed at household level among different economic groups. Benefit is defined as all direct and tangible products received by users' household *viz.* timber, fuelwood, fodder, grass, leaf litter, and other non-timber forest products (NTFP). The valuation of the products was done based on the local market rates. Cost is defined as all forest protection and management costs incurred by the users. Forest protection and management costs involve product/operating costs and transaction costs. Product/operating costs include fees or charges paid by the users to FUG, time spent by the households in collecting forest products, and the labor input to protect and manage forests. Transaction costs include time spent by the households in meetings and assemblies of the FUG. Labor costs and transaction costs were determined by the opportunity costs of labor at local level. The benefits and costs of individual households of different economic groups were quantified and averaged to determine the benefits and costs of the households of each group.

Results and discussion

The main results of the study on costs and benefits referring to the two different regimes of management have been listed. Table 1 provides an overview on the respective figures, which is explained and discussed in the following paragraphs.

Table 1. Community forestry benefits and costs of households

Average Annual Costs and Benefits of Household in US\$*						
		Group of Households	Better Off	Middle Class	Poor	Total Average
Kalika FUG (Buffer Zone)	Benefit	Total	131.2	18.5	5.5	35.5
		Net	79.3	11.6	0.2	20.8
	Cost	Product/Operating	41.4	4.1	2.7	10.5
		Transaction	10.4	2.8	2.6	4.2
		Total	51.9	6.9	5.3	14.7
	Benefit-Cost Ratio			2.53	2.69	1.04
Choutari FUG (DoF Regime)	Benefit	Total	486.4	175.8	24.3	183.3
		Net	343.4	126.7	11.6	129.7
	Cost	Product/Operating	133.2	43.7	9.2	48.0
		Transaction	9.8	5.4	3.6	5.6
		Total	143.1	49.1	12.7	53.6
	Benefit-Cost Ratio			3.40	3.58	1.91

*1US\$=RS 73 in 2006

Community forestry costs

Average total costs of a household of Kalika FUG and Choutari FUG with regard to community forestry is US\$ 14.7 and US\$ 53.6 per year respectively. Higher total costs in the DoF regime is mainly due to the high product/operating costs. Less forest products are extracted from the CF in the buffer zone and results in low product/operating costs. Product/operating costs of a household reflects the situation of products consumption by the household. Average annual product/operating costs of better off household is fairly high in both of the FUGs. It indicates that wealthier households consume more forest products than poor households.

Transaction costs is considered as an indicator of participation in CF process, particularly in decision-making. Annual transaction costs of Kalika FUG and Choutari FUG is US\$ 4.2 and US\$ 5.6 respectively. The differences in transaction costs between the two regimes is a result of forest management activities. The lesser the management activities the lesser the transaction costs. Transaction costs also varies between the economic groups of the users. Better off household incur three times higher transaction costs than that of poor household in both FUGs. It indicates that poor households have less influence in decision-making process in community forestry.

Management regimes and community forestry benefits

Household benefit from community forestry in the buffer zone is fairly less than the DoF regime. Average annual CF benefit of a household of Kalika FUG and Choutari FUG is US\$ 35.5 and US\$ 183.3 respectively. Annual household net benefit from CF of Kalika FUG and Choutari FUG is US\$ 20.8 and US\$ 129.7 respectively. Mann-Whitney test suggests that annual total and net CF benefit significantly differs between the buffer zone and the DoF regime ($p < 0.000$). Average benefit-cost ratio of a household of Kalika FUG and Choutari FUG is 2.19 and 3.16 respectively. Mann-Whitney test suggests that benefit-cost ratio significantly differs between the two FUGs ($p < 0.005$). Lower benefit-cost ratio of the users in the buffer zone implies their high contribution in the CF but less outputs as compared to the outside. This analysis reveals that CF benefits varied between the buffer zone and the DoF regime; and FUG members in the buffer zone obtain fewer benefits from CF than the members in the DoF regime.

Buffer zone complements the national park in the conservation of biological resources and extension of wildlife habitat. It was observed that community forestry program in the buffer zone is focused, more prominently, on conserving forest resources. Harvesting and extraction of forest products are regulated through a more restrictive rules and practices in the buffer zone. It is clearly seen in the studied CF that the duration of harvesting and extraction of forest products is lesser in the buffer zone than in the DoF regime even though socio-economic condition of the households and per unit stocking is comparable. Extraction of fuelwood is practiced once a year (7-15 days) in Kalika CF whereas it is practiced twice a year (15-30 days) in Choutari CF. Similarly, fodder and grass from CF is extracted during 3-6 months per year in Kalika CF and up to 9 months per year in Choutari CF. It is obvious that longer duration offers, to the users, in collecting more products from community forest.

Economic and livelihood opportunities through forest products are higher in DoF regime since they can sell forest products elsewhere and generate fund for forest management and community development. But, in the buffer zone, Rule 24 (7) of Buffer Zone Management Regulation 1996 prohibits to selling timber and fuelwood, the major sources of income for FUG, outside the zone.

Government of Nepal has implemented a pro-public policy in protected area management with the provision of 30-50% national park income allocating to buffer zone. This fund is aimed for resource management and community development in buffer zone through public participation. About US\$ 2,330,000 has been spent in the buffer zone of Chitwan National Park during the last 8 years. This fund has been utilized for various community development activities such as maintenance of irrigation, water supply, rural road/trail, river training and bio-gas installation. Although this fund does not contribute, substantially, to the household income of the users, it has a contribution in rural development and makes people's attitude positive towards resource conservation (Gurung *et al.*, 2004).

FUG generate fund through charging products price to the members and selling surplus forest products (in the buffer zone product selling is not allowed outside the zone). Kalika FUG generates US\$ 2687.03 while Choutari FUG generates US\$ 18123.88 per year,

although it oscillates. This fund has been utilized for forest management and community development activities focusing livelihood opportunities of the users. Buffer zone fund contributes to the users in this aspect, and, shrinks the CF income gap between the buffer zone and the DoF regime. The communities belonging to studied FUG in the buffer zone received US\$ 4470.90 during the fiscal year 2005/06 from the national park income, through buffer zone program, albeit it fluctuates year to year.

In the past, local communities in the buffer zone relied on the national park for their forest products needs. After establishment of the national park, the extraction of resources is prohibited. However, national park authority opens up the park for 3 days in a year to the buffer zone people who can collect thatch grass/reeds. Thatch grass is very useful, particularly for poor and indigenous households, to construct and repair houses and cattle shades. In the studied FUG, it contributes roughly US\$ 12 to a household in a year and complements to CF benefits in the buffer zone.

Total annual CF benefits of a household in Kalika FUG, after including per capita FUG fund, per capita buffer zone fund and value of the products extracted from the national park, is US\$ 77.76. Similarly, total annual CF benefits of a household in Choutari FUG after including per capita FUG fund is US\$ 206.95. It reveals that the household level CF benefit of the FUG members in the buffer zone is fairly less than the FUG members in the DoF regime.

Economic heterogeneity and community forestry benefits

Annual CF benefit of better off household is fairly large followed by middle class groups in both FUGs. Poor households receive fairly less amount of benefits per year from CF. Annual total CF benefit of better off, middle class and poor household in Kalika FUG is US\$ 131.20, US\$ 18.50 and US\$ 5.53 respectively while in Choutari FUG it is US\$ 486.44, US\$ 175.83 and US\$ 24.25 respectively. The distribution of annual net benefits among economic groups is similar to the distribution of annual total CF benefits in both FUGs. Kruskal-Wallis test suggests that total and net CF benefit significantly differs among economic groups of both Kalika FUG ($p < 0.000$) and Choutari FUG ($p < 0.000$). χ^2 -Approximation, a method of multiple pair wise comparison of mean rank (Sachs, 1997), has been

applied to identify which economic group significantly differs in terms of CF benefits. It suggests that total and net CF benefit significantly differs between better off and poor, better off and middle class and middle class and poor households in both FUGs.

Benefit-cost ratio of the households of middle class group is higher than the poor and slightly higher than the better off households in both FUGs. It implies that middle class households are more efficient. Kruskal-Wallis test suggests that benefit-cost ratio differs significantly between the three economic groups in Kalika FUG ($p < 0.002$) and Choutari FUG ($p < 0.021$). χ^2 -Approximation suggests that it significantly varies between better off and poor, and middle class and poor while the difference between better off and middle class is not statistically significant in both FUGs.

This analysis indicates that the distribution of CF benefits is unequal and influenced by the economic heterogeneity of the users; consequently, poor receive lesser benefits from CF than the better off households in both of the regimes. In buffer zone poor people are suffering more. In the past, poor and indigenous people in the buffer zone were depending on national park for forest resources. After the restriction of resource extraction from national park, they were drawing their livelihoods from the forest resources in the buffer zone. When community forestry was brought as a major component of buffer zone program, in which they have limited influence, access has been controlled and regulated.

Better off households consume more forest products such as fodder, grass and leaf litter since they have larger number of livestock and bigger landholdings than the poor. However, forest products available in the private land complement, to some extent, to the better off households. The poor households have small landholdings and rely on community forest for such products albeit they consume less. Wealthier households consume timber for constructing new houses or repairing the old ones, and cattle shades, and domestic furniture. On the contrary, poor households have low priority in constructing and improving the houses and furniture, and hence have less demand for timber. In the past, poor people in the locality used to collect fuelwood from the forest and sell to the market for their livelihood. But, after handing over the forests to the communities the extraction of the fuelwood has been regulated. It is

observed that poor households are not able to internalize the benefits from forest products currently available in community forests. And, there is no any compensation mechanism in the CF to increase the benefits of the poor who utilize limited quantity of forest products. This finding supports the conclusion drawn by Richards *et al.* (1999) that poor households are currently benefiting less from community forestry of Nepal.

Another reason why poor people receive lower benefits is their lower participation in CF decision-making process. Transaction cost, which is an indicator of participation in decision-making process, is less of the poor than that of middle class and better off households. The distribution of transaction cost is similar in the buffer zone and the DoF regime. In addition, the poor bear less total costs, which indicate their less involvement in the entire process of community forestry. The less participation of the poor in community forestry process is due to high rate of time preference and high opportunity cost of time and labor which is allocated to secure immediate livelihood needs.

Conclusions

This study reveals that users in the buffer zone obtain fewer benefits from community forestry than that of the Department of Forests regime. FUGs of the DoF regime are more autonomous than that of the buffer zones which are subjected to a higher level of restrictions. Withdrawal and management rights are more restrictive in the buffer zone due to the emphasis on conservation of biological resources and extension of wildlife habitat. On the other hand, FUGs in the DoF regime are intended to maximize the product extraction. Economic and livelihood opportunities through forest products are higher in the DoF regime since they sell surplus products in the market, but, in the buffer zone, the sell of timber and fuelwood is prohibited outside the zone. However, 30-50% national park income that is ploughed back to the buffer zone contributes in resource management and development activities within the zone.

This study suggests that current distribution practice of community forestry benefit is not equitable and counteracts national forest policy goals and approaches. Poor households receive lesser benefits from community forestry than the better off households. Furthermore, poor people in the buffer

zone are suffering more due to the higher level of confines in community forestry.

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