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Research Article

Biodiversity comparison of natural *Shorea robusta* mixed forest with *Eucalyptus camaldulensis* plantation in Nepal

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Abstract: Maintaining biodiversity is of great importance for achieving goal of sustainable development. Nepal has long been doing plantations and manages natural forests to conserve and maintain its biodiversity, but the status of plantation areas in terms of biodiversity has not been assessed yet. This paper attempted to compare biodiversity and the distribution of growing stocks of a plantation area with natural forests. Kushmari plantation area and Banke-Maraha collaborative forest were selected as research sites. Altogether 42 samples were taken to collect the data applying the stratified random sampling. The results showed the biodiversity indices of plantation site were less than that of natural collaborative forests. The values of Shannon-Weaver Biodiversity Index were higher, i.e. 2.52 at Kushmari plantation site than that of 2.34 at Banke-Maraha natural forest. Similarly, values of Simpson Biodiversity Indices were 0.36 at Kushmari plantation site and 0.42 at Banke-Maraha natural forest. Basal area and volume per pole were found to be $0.04m^2$ and $0.651m^3$ in the plantation site and those for Banke-Maraha collaborative forest were $0.027m^2$ and $0.346\ m^3$ respectively. Thus, the values of biodiversity indices did not show much variation even if there were huge variations in growing stocks in the plantation and natural forests.
Keywords: Biodiversity, plantation, natural forest, *Eucalyptus camaldunlensis*, *Shorea robusta*.

INTRODUCTION

Forests play an important role in regulating the Earth's climate and biodiversity. Species, genetic material and ecological diversity allure the people's mind [3]. The rapid growth of population is a big challenge to feed the poor people generally in developing countries and consequently, forest areas have been changed into other land uses. Consequences are specifically loss of forest and ultimately loss in biodiversity as well [14, 4].

Nepal having altitudinal ranges from 60m in the Terai to 8848m at Mount Everest above MSL (mean sea level), is very rich in biodiversity but some of them are at threat. Of the world's total land surface area, Nepal covers only 0.1% but harbors 136 ecosystems [2], about 2% of the flowering plants, 3% of the pteridophytes, and 6% of bryophytes of the world's flora [9, 6] but 8 species are suspected to be extinct, 1 species is endangered, 7 species are vulnerable and 31 species fall under the IUCN rare species category [12]. The main reasons among others include pressure on the forests due to increasing population and impacts of global warming. Due to these reasons, biological diversity is decreasing at varied extent at different locations and in different ecosystems. This paper has focused on assessing whether the biodiversity of plantation forest and natural forests are similar or not. Besides, it has also attempted to explore whether growing stocks of plantation forest and natural forests affect biodiversity.

Government of Nepal has established Sagarnath Forest Development Project in 1996 in two districts, i.e. Mahottary and Sarlahi districts, with the aim of producing the firewood and electric poles to meet the needs of the country. For that purpose, previously existed *Shorea robusta* natural forest which has high economic and biodiversity value, had clear-felled for the plantation of *Eucalypus camaldulensis.* Obviously, newly planted *Eucalypus camaldulensis* must have effects on forest biodiversity of Sagarnath forest. Few plantation sites were left as undisturbed condition because of slow growth. Meanwhile growing stock of this plantation is competing with the natural forests. So, the restoration of biodiversity cab is significantly observed in the plantation site if pressures of illegal logging, grazing, fire, etc are removed [8]. Thus, it is important to compare the differences in the distribution of growing stocks and biodiversity in *Eucalypus camaldulensis* plantation (undisturbed) and *Shorea robusta* mix natural forests, and to compare the biodiversity of plantation with natural forest.

MATERIALS AND METHOD

Research Site

Two sites, i.e. Kushmari plantation and Banke-Maraha natural forest under Collaborative Forest Management (CFM) areas were selected to conduct this research work (Figure 1). *Eucalypus camaldulensis*, an exotic species for Nepal is dominant in the plantation site with an area of 295 hectare (ha) and *Shorea robusta* is dominant in Banke-Maraha collaborative forest with an area of 2006 ha.

The study site is situated at 26° 36' N to 28° 10' N and 85° 41' E to 85° 57' E. Tarai (plains) and Chure (low sloppy area) have tropical and subtropical climate. The temperature ranges from 20^0C to 25^0C and average annual rainfall recorded between 1100-3500 mm.

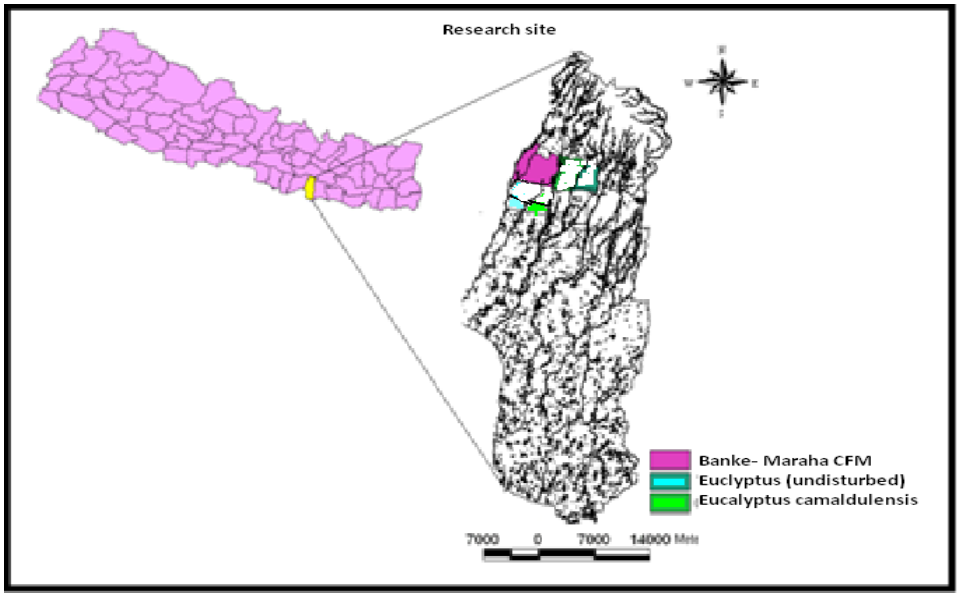

Figure 1: Location of Research sites

Data Collection

The bio-physical data were collected applying stratified random sampling. Out of total 42 samples taken, 11 samples were from *Eucalypus camaldulensis* plantation (undisturbed) and 31 samples were from *Shorea robusta* natural forest using Chako's formula. The size of the sample plot was 10mx10m. The height and diameter were measured and number of species and plants were counted. In the meantime, the number of undergrowth and upper storey plant species were also counted.

Data Analysis

Collected data were analyzed by calculating the average growing stocks per tree and species biodiversity in plantation and natural forests.

Following formulae were used to calculate the tree biodiversity.

1. Shannon and Weaver Biodiversity Index, $H = -\sum_{i=1}^{s}(\text{pi})(\ln \text{pi})$ [11]

2. Simpson Biodiversity Index, $D = \sum_{i=1}^{s} \frac{n(n-1)}{N(N-1)}$ [13]

Basal area and growing stock was calculated using following formulae:

Basal area (BA)= $\pi D^2/4$

Growing stock= $\pi D^2 \times h \times ff/4$, where, value of π is 3.1416, D is diameter at breast height, h is the height of the plant and ff is the form factor (ff= 0.5 as general value).

Statistical data generation

Descriptive statistics was used to show the distribution of growing stock. Mean, standard deviation and standard error were estimated using SPSS 17. Apart from these, t-test was applied to compare the biodiversity of two different sites [7].

Species ranking was calculated based on the highest number of plants in 100 m^2 as rank 1^{st} and second highest as rank 2^{nd} and vice versa.

RESULTS AND DISCUSSION

Variation in diameter and height of plantation and natural forest

The diameter at breast height (dbh) and height (ht) of plants differed in both sites according to the conditions of the forest. It was found that, at sapling stage, average dbh (4.78cm) in plantation was less than dbh (5.67cm) of natural forest but mean ht (5.15m) of plantation was bigger 4.61m than of natural forest. The standard deviation and error were also varied in both sites (Table1).

Table 1: Variation in average DBH and Ht in plantation and natural forest

Statistical Information	Plantation				Natural forest					
	Sapling		Pole		Sapling		Pole		Tree	
	Avg. Dbh cm	Avg. Ht m	Avg. Dbh cm	Avg. Ht m	Avg. Dbh cm	Avg. Ht m	Avg. Dbh cm	Avg. Ht m	Avg. Dbh cm	Avg. Ht m
Average value	4.78	5.15	22.26	16.74	5.67	4.61	18.51	12.88	48.62	20.68
Standard deviation	1.40	1.09	1.09	4.26	2.13	3.35	5.54	3.47	1.32	5.33
Standard Error	0.12	0.09	0.21	7.89	0.32	0.50	0.58	0.36	1.37	0.51

Distribution of growing stocks in plantation and natural forest

The result showed that the basal area per sapling of plantation was less 0.002 m^2 in comparison to 0.003 m^2 of natural forest, but it was more 0.039 m^2 in plantation than 0.027 m^2 of natural forest in case of pole. Moreover, there was no any tree in plantation site, but in case of natural forest, basal area per tree was 0.186 m^2. Number of individual ha^{-1} was high in plantation than natural forest (Table 2).

Table 2: Growing stocks of plantation and natural forest

Category	Kushmari Plantation		Banke-Maraha CFM		
	Sapling	Pole	Sapling	Pole	Tree
BA (m^2/individual)	0.002	0.039	0.003	0.027	0.186
GS (m^3/individual)	0.009	0.651	0.012	0.346	3.840
Individual/ha	1300	431	600	283	70

The study conducted by Dutta et al. [5] indicated that per tree mean basal area and volume were 0.05 m^2 and 0.77 m^3 respectively in Indrakali Community Forest (CF). In the same study of Kalidamar CF, basal area and volume were 0.12m^2 and 3.00 m^3 respectively. The result of first site was similar to the record of plantation while second one was similar to results of tree of natural site. Similarly, the study carried out by Tewari and Karki [15] showed there was about 0.03 m^3 per pole growing stock in Ilam district, this value is similar to the stocks of pole in natural forest of present study. Amatya and Shrestha [1] showed the volume per tree of mature *Shorea robusta* is about 3.78 m^3.

Variation in plant biodiversity

Table 3: Values of bio-diversity indexes

Site	Forest condition Types	Simpson Biodiversity Index	Shannon and Weaver Biodiversity Index
Kushmari Plantation	Tree spp	0.08	2.52
	Understory spp	0.36	1.27
Banke-Maraha Natural Forest	Tree spp	0.09	2.34
	Understory spp	0.42	1.08

In case of plant diversity, the value of Simpson Biodiversity Index at Kushmari plantation site was less i.e. 0.08 than that at Banke-Maraha natural forest area i.e. 0.09. However, the value of the Shannon and Weaver Biodiversity Index was higher i.e. 2.52 at Kushmari plantation site in comparison to 2.34 at Banke-Maraha natural forest area. Similarly, in case of understory, the value 0.36 of Simpson Biodiversity Index was less at Kushmari site than 0.42 in Banke-Maraha CFM area and it was high value of Shannon and Weaver Biodiversity Index 1.27 at plantation site than 1.08 in natural forest. Moreover, seven understory species were found to be common at both the sites, three species were found only at Kushmari site while one species was found only in Banke-Maraha CFM area (Figure 2).

Unexpectedly, the overall plant biodiversity was higher at plantation site than in natural forest because the plantation site was completely intact for 17 years, but the natural forest might be affected due to illegal logging, grazing, forest fire and invasive species.

The study conducted by Sapkota [10] in Hill *Shorea robusta* forest showed the values of Shannon-Weaver Index and Simpson Index were 2.42 and 0.64 respectively. This indicated the values of Shannon-Weaver Index were closer, but the values of Simpson Biodiversity Index differed in hills and Tarai.

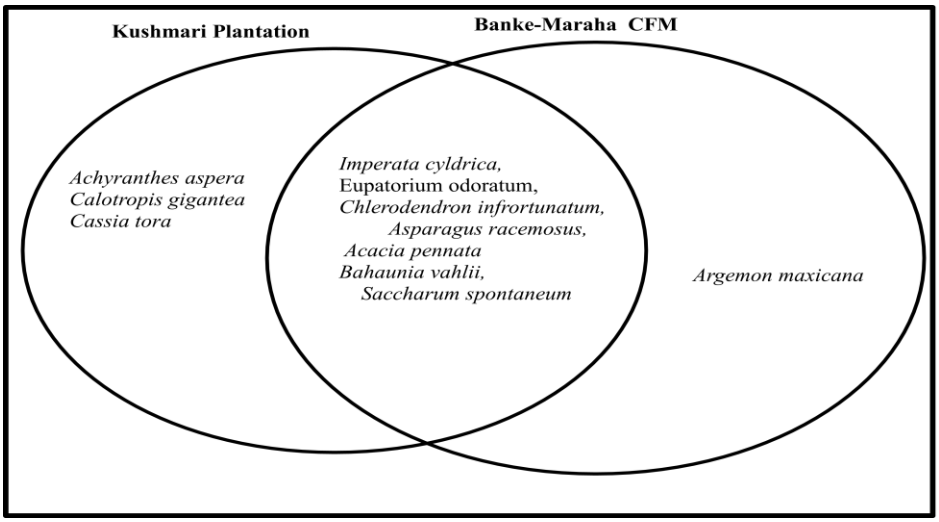

Figure 2: Venn-Diagram showing under storey species in study sites

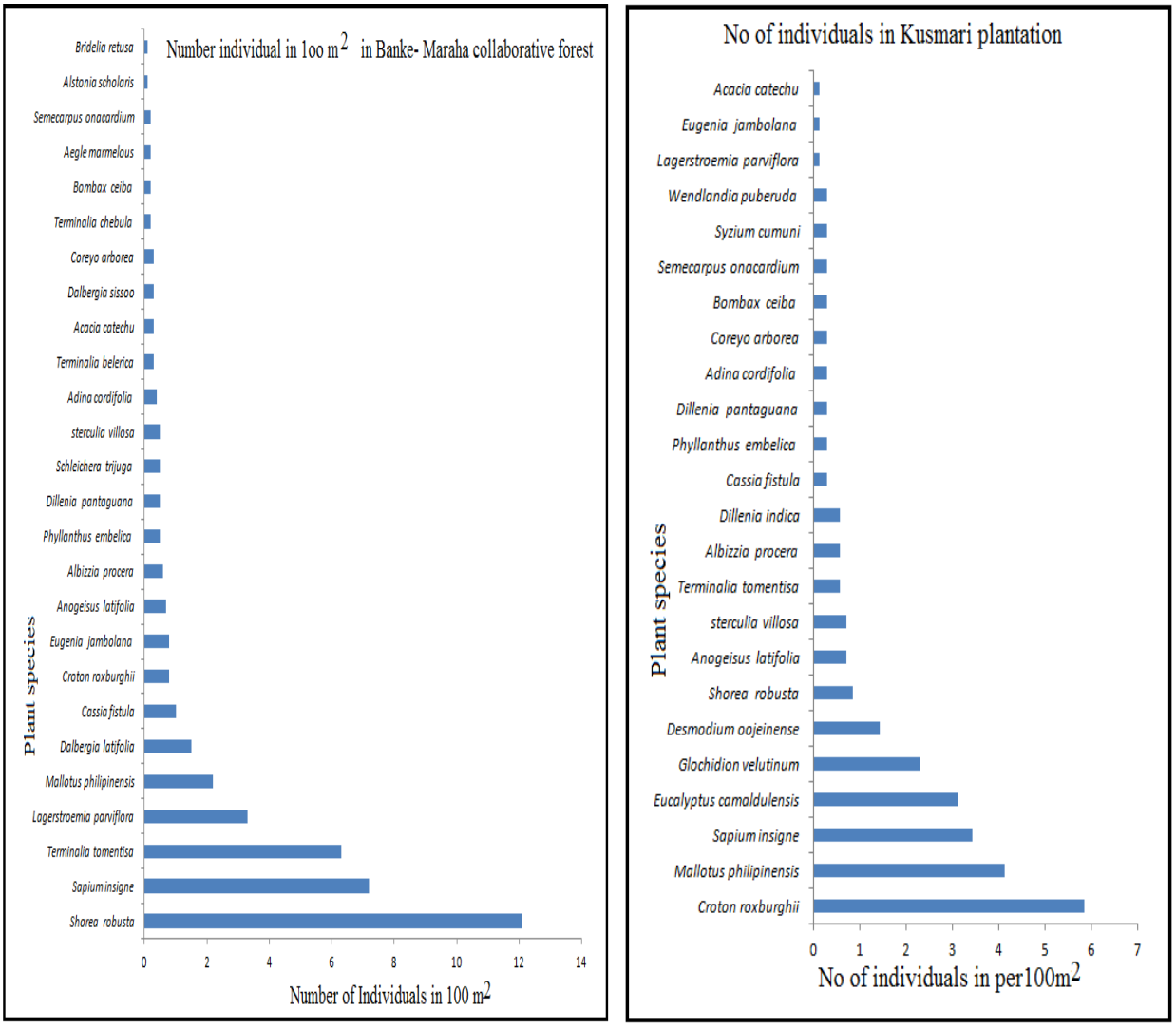

Figure 3: Number of individuals/100 m^2 in Banke-Maraha CFM and Kushmari plantation

Species ranking according to species abundance

It was found that *Shorea robusta* was dominant species in Banke-Marha natural CFM while this species was at 7th position at Kushmari plantation site. In the plantation site, *Croton roxburghii* and *Mallotus philipinensis* came into existence as ranking 1st and 2nd. Moreover, some species like *Dalbergia latifolia, Schleichera trijuga, Dalbergia sissoo, Terminalia belerica, Terminalia chebula, Alstonia scholaris* and *Bridelia retusa* were not found at plantation site (Figure 3).

If the plantation is left undisturbed for long duration, biodiversity could be maintained but it might not guarantee to rejuvenate the valuable species like *Shorea robusta* as dominant i.e. with ranking 1st. The regular forest management operation could help rejuvenate *Shorea robusta,* but it could disfavor biodiversity restoration.

Statistical analysis

The hypotheses were set to test whether there was difference in plant biodiversity between Banke-Maraha CFM (a natural forest) and Kushamari plantation site. For this purpose, t-test was computed. The result showed that there were no significant differences in biodiversity at 5% significance level in both cases as values of t- tabulated > t-calculated (Table 4).

Table 4: Comparison of biodiversity

Types	t-tab	t-cal, α=5%
Differences in undergrowth biodiversity between Banke-Maraha CFM vs Plantation site	1.72	1.59
Differences in tree biodiversity between Banke-Maraha CFM vs Plantation site	2.35	0.04

Conclusion and recommendation

The basal area and growing stock of these sites were different and the pole-staged plants were only found in plantation site, while trees were dominant in collaborative forests resulting in the higher growing stock per unit pole/tree in the natural forest than in the plantation site. The biodiversity index showed biodiversity was revived in the plantation site which could compete with the natural forest. Thus, plantation site was found to be having the higher biodiversity than that in the natural forest. However, valuable species like *Shorea robusta*, could not be restored as dominant species although local communities prefer this species for varieties of uses. This study provided some database of variation in the growing stocks and biodiversity contributing to the establishment of the benchmark, which requires further studies in different types of forests at national and sub-national levels.

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References

1. Amatya SM, Shrestha KR; Nepal Forestry Handbook. Forest Research Support Programme for Asia and the Pacific. Food and Agriculture Organization of the United Nations, Bangkok, 2002.
2. Belbase N; National Implementation of the Convention on Biological Diversity: Policy and Legislative Requirements. IUCN Nepal, Kathmandu, Nepal, 1999.
3. Brockerhoff EG, Berndt LA, Jactel H; Role of exotic pine forests in the conservation of the critically endangered New Zealand ground beetle *Holcaspis brevicula* (Coleoptera: Carabidae). Newzealand Journal of Ecology, 2005; 29:37–43
4. Conservation International; Linking Forests, Climate Change and Biodiversity. Conservation International. Crystal Drive, Suite 500 Arlington, VA 22202, USA (703), 341. 2400, 2011.
5. Dutta IC, Mandal RA, Acharya N; Potential Income of Community Forests from Forest Carbon Sequestration. International Symposium on Mountain Resource Management in a Changing Environment (MRMCE), Kathmandu, Nepal, 2012.
6. GoN/MFSC; Nepal Biodiversity Strategy. Government of Nepal, Ministry of Forests and Soil Conservation, Kathmandu, Nepal, 2002:9-15.
7. Jayaraman K; A Statistical Manual for Forestry Research. Forestry Research Support Programme for Asia and the Pacific (FORSPA). Food and Agriculture Organization of the United Nations Bangkok, 2000: 200-210.
8. Jeffrey S, Chokkalingam U, Poulsen J; The restoration of forest biodiversity and ecological

values. Forest Ecology and Management, 2004; 201: 3–11.
9. MFSC; National Biodiversity Action Plan. His Majesty Government of Nepal, Ministry of Forests and Soil Conservation in support of Global Environment Forum, UNDP, Kathmandu, Nepal, 2000:14-19.
10. Sapkota IP, Tigabu M and Odén PC; Tree diversity and regeneration of community managed Bhabar lowland and Hill Sal forests in central region of Nepal. Swedish University of Agricultural Sciences, Southern Swedish Forest Research Centre, PO Box 101 SE-230 53 Alnarp, Sweden, 2009.
11. Shannon, CE and Weaver, W; The mathematical theory of communication. The University of Illinois Press, Urbana, 1949:117.
12. Shrestha TB; Nepal Country Report on Biological Diversity Kathmandu. The World Conservation Union (IUCN), Kathmandu, Nepal, 1999:37.
13. Simpson, EH; The Interpretation of interaction in contingency tables. Journal of the Royal Statistical Society, Series B, 1951; 13: 238–241.
14. Singh SP, Sah PP, Tyagi V, Jina BS; Species diversity contributes to productivity Evidence from natural grassland communities of the Himalaya, Current Science, 2005; 89: 548- 552.
15. Tewari, A and Karki, BS; Carbon measurement methodology and results. International Center for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal, 2007:39-53.