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Greenwood regeneration status in community forests of Chiti, Lamjung, Nepal

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Abstract

Forest regeneration is the process by which new tree seedlings become entrenched after forest trees have been harvested or destroyed by fire, insects, or diseases. The process is key to sustainable forestry and can be accomplished through natural regeneration, which occurs when new seedlings or sprouts are produced by trees left on or near the site. The study is to calculate the regeneration status of the tree species in community-managed forests. The sampling points were generated by using the random table. The sample quadrate size was taken $20^m \times 20^m$ for a tree, 5m×5m for a sapling, and $1^m \times 1^m$ for the seedling. In five community forests, altogether 30 quadrates were taken for a tree, 60 nested quadrates were taken for a sapling and 120 nested quadrates were taken for a seedling. The tree layer, sapling layer and seedling layer were differentiated by taking reference tothe Diameter at Breast Height (DBH) class. An individual having DBH ≥ 5cm is considered a tree, an individual having DBH value between 1cm to < 5cm is considered a sapling, and individuals having 1cm to < 5cm DBH are considered as a seedling. The DBH distribution curve was obtained by plotting diameter class in x- axis and density on y- axis. All studied community forests are mixed forest dominated by tree species Castanopsis indica, Diospyros embryopteris (Diospyros malabarica), Shorea robusta, and Schima wallichii (Schima wallichii choisy). The regeneration potential of the Tilahar community forest(CF) is found high despite high grazing and other human intervention. The DBH class distribution curve of tree species is found as inverse J-shape, indicating that the overall forest has a sustainable regeneration.

Keywords: Community forest, Regeneration, DBH, Natural resources, Chiti

Introduction

Natural regeneration refers to the natural process by which plants replace or re-establish themselves utilizing self-sown seed or vegetative recovery by sprouting from stumps, rhizomes, or roots (Petrie 1999). The natural regeneration dynamics of the forest is an extremely complex process that depends on environmental factors: rainfall, temperature, topographic, edaphic and light conditions (Gerhardt & Hytteborn 1992, Tekle & Bekele 2000, McLaren & McDonal 2003) and also factors such as seed viability and dormancy, seed predation and herbivory (Khurana & Singh 2001). Information on natural regeneration potential leads to conservation measures of biological diversity (Verma *et al.* 1999). It is an important indicator for evaluating the overall condition of the forest ecosystem (Rahman *et al.* 2011).

Forest regeneration is the process by which new tree seedlings become established after trees have been harvested or have died from fire, insects, or diseases. This is the key to sustainable forestry and can be accomplished through natural regeneration, which occurs when new seedlings or sprouts are produced by trees left on or near the site. This is also the process for the existence of species in a community under varied environmental conditions. The successful regeneration of a tree species depends on the ability of its seedlings and saplings to survive and grow (Good & Good 1972). Successful regeneration is perhaps the single most important step toward achieving the long-term sustainability of forests (Saikia & Khan 2013).

Forests are the major rural livelihood assets for the general people. Since the beginning of civilization, various efforts have been made to protect the forest, but in the Nepali context efforts made by the government have been summarized chronologically in the following paragraph. Forests in Nepal support the livelihoods of millions of rural households. In a broader context, the forest also contributes to the national gross domestic product (GDP). Despite its economic, environmental, and socio-cultural potential, the forestry sector has been losing benefits mainly because of conservation-centered management practices. In Nepal, the government earned revenue worth USD 1.11 million from the sale of non-wood forest products which, covered almost 18% of the total revenue of the forest sector in 2002 (Gauli & Hauser 2009). Ninety percent of rural household income is contributed through Non-Timber Forest Production (Bista &Webb. 2006).

The subtropical region of Nepal is the major source of natural resources. The elevation of the mid-mountain region varies from 110 m in the lower river valley to 3300 m. Evergreen Forest is the major source of spring water for a large population depends on

for drinking water. In addition, this region is much richer in biodiversity; hence it is crucial for the Nepali economy. Forest is the dominant land use class in this region and these forests have been managed through the community forest user group (CFUG), hence these kinds of forests are called community forests. These community forests have sustainable regeneration status (Subedi *et al.* 2009, Bhatta & Devkota 2020).

Sub-tropical forests are the most diverse and complex ecosystems on earth, and are also habitats for the most vulnerable and threatened species (Carson & Schnitzer 2011, Deb *et al.* 2015). Due to the lack of scientific study on the regeneration status of trees, different government and non-government programs for forest management, and floral diversity have failed. The increase in people's dependency on the forest for the collection of firewood, forage, livestock grazing, etc. is highly threatening the forest lifecycle. Most of the community forests had undergone these vulnerable conditions. Such activities reduce the forest's resilience and carrying capacity. So, in long run anthropogenic disturbance is hindering more in forest regeneration. This study explores the scientific information about the momentum of species dynamics in the study sites. The objective of the study is to calculate the regeneration status of the tree species in the community-managed forests of a sub-tropical region in the Lamjung district. Thus, this study provides the information about compositional structure and regeneration status of tree species in the study area that will be fruitful for the formation and execution of the forest management policies and activities in the region.

Material and methods

Study area

The study has focused on community forests located at Besisahar, ward no. 11, Lamjung district, Gandaki province. The region lies in the mid-hills of Nepal spanning tropical to trans-Himalayan geo-ecological belts, including the geographical midpoint of the country. The elevation of the study area ranges from 670 m to 1260 m and the slope range varies from 10 degrees to 55 degrees. The area has a hot and moist climate. The temperature ranges from 15^{0c} to 35^{0c} and rainfall occur from 1000 mm to 2000 mm per year. The area of Besisahar -11 is forest dominated area. The study has focused on five community forests of Chiti village. In general, the forests are sub-tropical in nature.

Table 1: General characteristics of community forest in the study sites

Community Forest	Area (ha.)	Altitude (m)	Co-ordinates lat/ long(WGS, 1984)	Dominant species
Deurali	57.67	875	28.19272N/84.43048E	Castanopsis indica
Satipatal	66.77	715	28.19455N/84.43072E	Shorea robusta
Thuliban	24.22	750	28.18941N/84.43639E	Shorea robusta
Tilahar	44.11	960	28.20826N/84.43510E	Schima wallichii
Deurali Thadopakha	19.34	898	28.20589N/84.43890E	Castanopsis indica

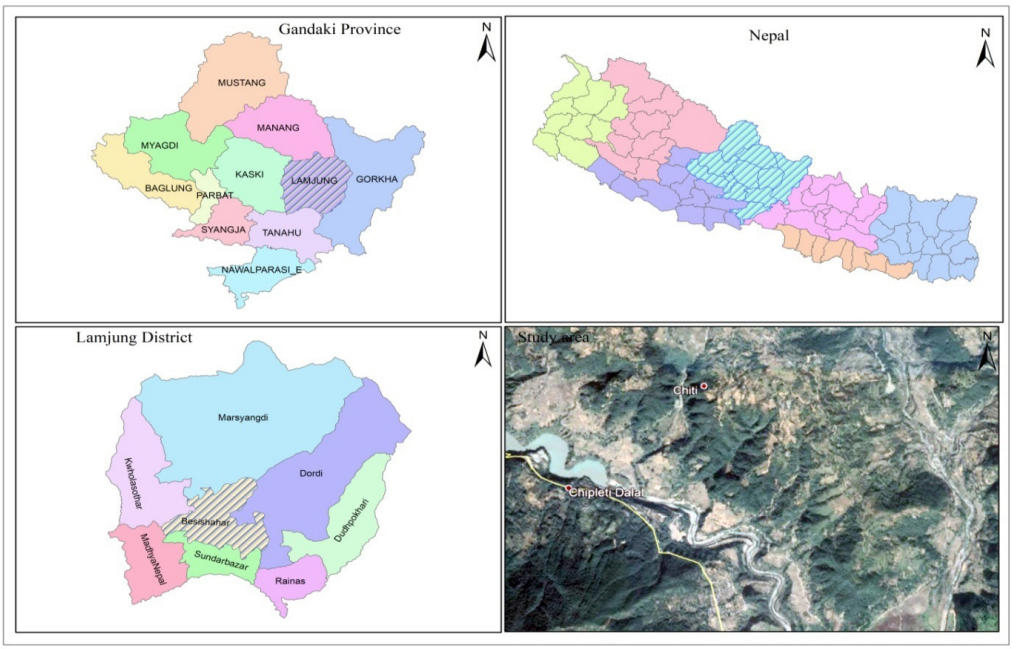

Figure 1: Location map of the study area

Methodology

Tree sampling was done through the square quadrate method. Sample quadrates were laid in simple random methods within the study area. The total number of quadrates in each community forest was fixed by taking the 0.5 percentage sampling intensity according to the community forest guidelines of the Nepali government. The sampling points were generated by using random table. The sample quadrate size was taken 20m×20m for tree, $5^m \times 5^m$ for sapling and 1m×1m for seedlings (Kflay & Kitessa 2014). In each quadrate, sapling and seedling of tree data were taken by using nested methods

i.e., sapling data were taken only two corners diagonally and seedling data were taken in each four corners of the quadrate. In five community forests, altogether 30 quadrates were taken for tree, 60 nested quadrates were taken for sapling and 120 nested quadrates were taken for seedling.

The tree's tree layer, sapling layer, and seedling layer were differentiated by taking reference of DBH class. The individual considered as tree having DBH ≥ 5cm, individual considered as sapling between 1cm to < 5cm DBH and individuals considered as seedling having 1cm to < 5cm DBH (Timilsina *et al.* 2007). For the tree layer, the diameter at breast height (DBH, measured at 137cm above the ground) of each tree measured by using DBH tape, height of tree was measured by using a clinometer, canopy coverage of trees was also measured by using densitometer and cut stumps of tree (if happen) also noted down. In sapling layer, DBH was measured through DBH tape, height was calculated through shuttle radar topography mission digital elevation model - SRTM DEM data, and the data were download from United Sates Geological Society - USGS earth explorer. In seedling layer of tree, the average height of individuals' species in each quadrate was taken through measuring tape, the total numbers of individuals of each species were counted and coverage of each species in each quadrate was noted through expert judgment. Through hand Global Navigation Satellite System- GNSS, the information about elevation, longitude, latitude, and aspects were noted. The slope of sampling locations was measure by using clinometer. Ground coverage of sampling sites was ranked with different parameters by using densitometer.

The seedling, sapling, and tree count, ratio of seedling and sapling respectively with tree as well as tree diameter size class distribution diagrams were made to assess the regeneration status of trees. The regeneration status of individual species was determined by using following criteria given by Shankar (2001): 'good', if seedling > sapling >tree, 'fair', if seedling > sapling ≤ tree, 'poor', if species survives in only sapling stage but not as seedling, 'none', if a species is absent in both in sapling and seedling stage, 'new' if a species has no adult but only sapling or seedling or both.

Ratio of seedling and sapling to tree

The presence of seedling and sapling determine the regeneration status. Therefore, the ratio of seedling and sapling to tree was calculated using the following formula:

Seedling to tree ratio = Total number of seedling/ Number of trees

Sapling to tree ratio = Total number of sapling/ Number of trees

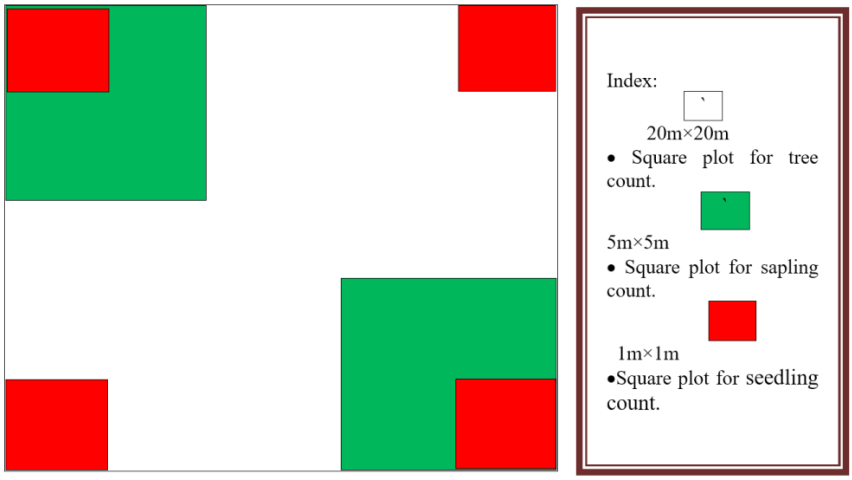

Figure 2: Square plot design to collect data

Diameter class distribution

DBH class distribution was used to predict the overall regeneration status of tree species in the study area. All the trees were divided into DBH class of 10 cm intervals and density of trees in each diameter class was calculated. The DBH distribution curve was obtained by plotting diameter class in x- axis and density on y- axis.

Results

Community forest in Chiti

The local people have Satipatal, Thuliban, Tilahar, Deurali, and Deurali Thadopakha community forests in practice. Each community forest serves 252, 124, 183, 108 and 90 local households respectively. The Sitapatal has 66.77 ha area and Thuliban has only 24.22 ha area. Tilahar and Thuliban forest converted into Community Forest in 1994 and Satipatal, Deurali and Deurali Thdopakha were managed by the community in 2004.

Table 2: Community forest in Chiti

SN	Name of community forest	Area in ha	No of household	Year of handing over to CFUG
1	Satipatal	66.77	252	2003
2	Thuli Ban	24.22	124	1994
3	Tilahar	44.11	183	1994
4	Deurali	57.67	108	2004
5	Deurali Thadopakha	45.21	90	2004

Tree species composition

A total of 177 individuals of tree, 71 individuals of sapling species and 60 individuals of seedling species, and 10 species with their respective families were recorded at Tilahar community forest. Similarly, a total of 271 individuals in tree, where 100 individuals of sapling and 122 individuals of seedling of tree species and 7 species with their respective families were recorded at Satipatal community forest. A total of 195 tree, 73 sapling and 87 seedling of tree species having 6 species with their respective families were recorded from Thuliban Community Forest. Accordingly, a total of 157 tree, 83 are sapling and 59 are seedling tree species having 7 species with their respective families were recorded in Deurali Thadopakha Community Forest. A total of 214 individuals' tree, 103 are sapling and 109 are seedling tree species with having 5 species of their respective families have been recorded at Deurali Community Forest.

Table 3: Composition of tree species in community forests

S.N	Structure	Layer	Tilahar	Satipatal	Thuliban	Deurali Thadopakho	Deurali
1	Density	Tree	737.48	846.875	975	981.25	1214.28
		Sapling	2366.63	2500	2920	4150	2942.86
		Seedling	23450	38125	43500	36875	38928.57
2	Basal area (M2/Ha)	Tree	30.41	39.28	48.32	46.81	51.32
		Sapling	17.51	15.95	16.56	18.35	17.56
		Seedling	11.52	9.78	12.25	16.84	11.23
3	Frequency (%)	Tree	283.33	337.5	300	400	399.99
		Sapling	233.33	250	280	250	342.77
		Seedling	166.68	175	180	200	242.84

Tilahar community forest

Tilahar Community Forest has tree, sapling and seedling with the density of 737.48, 2366.63 and 23450 Individual per hector respectively. The total number of tree, sapling, and seedling are 283.33, 233.33, and 166.68 respectively. The total seedling abundance, sapling abundance, and tree basal area were 11.52, 17.51, and 30.41 square meters respectively.

Satipatal community forest

Satipatal Community Forest has tree, sapling and seedling with a density of 846.875, 2500 and 38125 Ind/ha respectively. The total number of frequencies of tree, sapling and seedling are 337.5, 250 and 175 percentages respectively. The total seedling

abundance, sapling abundance and tree basal area are 16.84, 18.35, and 39.28 square meters respectively.

Thuliban community forest

Thuliban Community Forest has tree, sapling and seedling with having density of 975, 2920 and 43500 Ind/ha respectively. The total frequency of tree, sapling and seedling was 300, 280 and 180 percentages respectively. The total seedling abundance, sapling abundance and tree basal area was 12.25, 16.56, and 48.32 square meters respectively.

Deurali Thadopakha community forest

Deurali Thadopakha Community Forest has tree, sapling and seedling having density of 981.25, 4150 and 36875 Ind/ha respectively. The total frequency of tree, sapling and seedling have 400, 250 and 200 percentages respectively. The total seedling abundance, sapling abundance and tree basal area was 9.78, 15.95 and 46.81 square meters respectively.

Deurali community forest

Satipatal Community Forest has tree, sapling and seedling having density of 1214.28, 2942.86, and 38928.57 Ind/ha respectively. The total frequency of tree, sapling and seedling have 399.99, 242.77 and 242.84 percentages respectively. The total seedling abundance, sapling abundance, and tree basal area were 9.78, 15.95 and 39.28 square meters respectively.

Tree species population

Tilahar community forest

Castanopsis indica, Diospyros embryopteris (Diospyros malabarica), *Schima wallichii* and *Pinus roxburghii* had high density in Tilahar Community Forest. *Myrica esculenta* had 25 Ind/ha tree density and 533.33 Ind/ha seedling density. *Sapium insigne* (Falconeria insignis) had 66.66 Ind/ha sapling density. Similarly, *Trichilia connaroides* (Heynea trijuga) had density of 66.66 and 416.66 Ind/ha in sapling and seedling respectively. Shorea robusta had density of 1250 Ind/ha seedling. Tree, sapling and seedling density of species are shown in the Table 4.

Table 4: Tree, sapling and seedling density of Tilahar community forest

S.N	Species name	Tree density	Sapling density	Seedling density
1	Castanopsis indica	158.33	1166.66	7500
2	Diospyros embryopteris (Diospyros malabarica)	8.33	266.66	2083.33
3	Shorea robusta	0	0	1250
4	Schima wallichii (Schima wallichii choicy)	254.16	633.33	8333.33
5	Trichilia connaroides (Heynea trijuga)	0	66.66	416.66
6	Myrica esculenta	25	0	533.33
7	Fraxinus floribunda	0	0	0
8	Pinus roxburghii	291.66	166.66	3333.33
9	Sapium insigne (Falconeria insignis)	0	66.66	0
10	Dalbergia sissoo	0	0	0

Satipatal community forest

In the Satipatal Community Forest, *Castanopsis indica, Diospyros embryopteris, Shoera robusta, Schima wallichii, Sapium insigne* and *Bujhauro* (local name) had recorded its all form i.e., tree, seedling, and sapling. *Trichilia connaroides* had recorded in sapling and seedling. Tree, sapling, and seedling density of species in Satipatal community forest are shown in the Table 5.

Table 5: Tree, sapling, and seedling density of species in the Satipatal community forest

S.N	Species name	Tree density	Sapling density	Seedling density
1	Castanopsis indica	53.12	625	6250
2	Diospyros embryopteris (Diospyros malabarica)	50	525	7500
3	Shorea robusta	625	900	17500
4	Schima wallichii	103.12	350	5625
5	Trichilia connaroides (Heynea trijuga)	0	50	625
6	Myrica esculenta	0	0	0
7	Fraxinus floribunda	0	0	0
8	Pinus roxburghii	0	0	0
9	Sapium insigne (Falconeria insignis)	6.25	25	312.5
10	Dalbergia sissoo	0	0	0
11	Bujhauro(local name)	9.37	25	312.5

Thuliban community forest

In a Thuliban Community Forest, *Castanopsis indica, Diospyros embryopteris, Shoera robusta* and *Schima wallichii* had recorded all form i.e., tree, seedling and sapling. *Trichilia connaroides* had 120 and 1000 Ind/ha densities in sapling and seedling respectively. *Dalbergia sissoo* had density of 5 and 500 Ind/ha in tree and seedling. Tree, sapling and seedling density of species in Thuliban community forests are shown in the Table 6.

Table 6: Tree, sapling, and seedling density of species in Thuliban community forest

S.N	Species name	Tree density	Sapling density	Seedling density
1	Castanopsis indica	290	1240	10500
2	Diospyros embryopteris	80	840	9500
3	Shorea robusta	490	450	12500
4	Schima wallichii	110	240	9500
5	Trichilia connaroides	0	120	1000
6	Myrica esculenta	0	0	0
7	Fraxinus floribunda	0	0	0
8	Pinus roxburghii	0	0	0
9	Sapium insigne	0	0	0
10	Dalbergia sissoo	5	0	500

Deurali Thadopakha community forest

In the Deurali Thadopakha Community Forest, *Castanopsis indica, Diospyros embryopteris, Schima wallichii, Fraxinus floribunda*, and *Myrica esculenta* had density on tree, sapling and seedling. *Trichilia connaroides* had density of 250 and 1875 Ind/ha in sapling and seedling respectively. *Shorea robusta* had 625 Ind/ha seedling density but not recorded its tree and sapling number. Tree, sapling and seedling density of species in Deurali Thadopakho community forest are shown in the Table 7.

Table 7: Tree, sapling, and seedling density of species in Deurali Thadopakho community forest

S.N	Species name	Tree density	Sapling density	Seedling density
1	Castanopsis indica	468.5	1900	15000
2	Diospyros embryopteris	25	250	1250
3	Shorea robusta	0	0	625
4	Schima wallichii	262.5	550	7500
5	Trichilia connaroides	0	250	1875
6	Myrica esculenta	125	400	3750
7	Fraxinus floribunda	100	800	6875

Deurali community forest

In the Deurali Community Forest, *Castanopsis indica, Diospyros embryopteris, Shorea robusta, Schima wallichii* and *Trichilia connaroides* had recorded in its all form i.e., tree, seedling and sapling. Other species are not found in sampled plot. Tree, sapling and seedling density of species in Deurali Thadopakho community forest are shown in Table 8.

Table 8: Tree, sapling and seedling density of species in Deurali community forest

S.N	Species name	Tree density	Sapling density	Seedling density
1	Castanopsis indica	158.33	1166.66	7500
2	Diospyros embryopteris	8.33	266.66	2083.33
3	Shorea robusta	0	0	1250
4	Schima wallichii	254.16	633.33	8333.33
5	Trichilia connaroides	0	66.66	416.66
6	Myrica esculenta	25	0	533.33
7	Fraxinus floribunda	0	0	0
8	Pinus roxburghii	291.66	166.66	3333.33
9	Sapium insigne	0	66.66	0

Regeneration status

Tilahar community forest

The regeneration status of individual species is carried out by comparing its population structure i.e., tree, sapling and seedling density. *Castanopsis indica, Diospyros embryopteris*, and *Schima wallichii* had good regenerations. *Shorea robusta* and *Trichilia connaroides* had new regeneration. *Myrica esculenta* and *Pinus roxburghii* had fair regeneration. *Sapium insigne* had poor regenerations.

Table 9: Regeneration status of Tilahar CF

S.N	Species name	Tree density	Sapling density	Seedling density	Regeneration status
1	Castanopsis indica	158.33	1166.66	7500	Good
2	Diospyros embryopteris	8.33	266.66	2083.33	Good
3	Shorea robusta	0	0	1250	New
4	Schima wallichii	254.16	633.33	8333.33	Good
5	Trichilia connaroides	0	66.66	416.66	New
6	Myrica esculenta	25	0	533.33	Fair
7	Fraxinus floribunda	0	0	0	
8	Pinus roxburghii	291.66	166.66	3333.33	Fair
9	Sapium insigne	0	66.66	0	Poor

Satipatal community forest

The regeneration status of individual species was carried out by comparing their population structure i.e., tree, sapling, and seedling density. *Castanopsis indica,*

Diospyros embryopteris and *Schima wallichii* had good regenerations status. *Shorea robusta* and *Trichilia connaroides* also had good regeneration. *Myrica esculenta* and *Pinus roxburghii* had fair regeneration. *Sapium insigne* had poor regenerations in the Satipatal Community Forest.

Table 10: Regeneration status of Satipatal CF

S.N	Species name	Tree density	Sapling density	Seedling density	Regeneration status
1	Castanopsis indica	158.33	1166.66	7500	Good
2	Diospyros embryopteris	8.33	266.66	2083.33	Good
3	Shorea robusta	0	0	1250	New
4	Schima wallichii	254.16	633.33	8333.33	Good
5	Trichilia connaroides	0	66.66	416.66	New
6	Myrica esculenta	25	0	533.33	Fair
7	Fraxinus floribunda	0	0	0	
8	Pinus roxburghii	291.66	166.66	3333.33	Fair
9	Sapium insigne	0	66.66	0	Poor
10	Dalbergia sissoo	0	0	0	

Thuliban community forest

The regeneration status of individual species was carried out by comparing their population structure i.e., tree, sapling, and seedling density. *Castanopsis indica, Diospyros embryopteris* and *Schima wallichii* had good regenerations. *Shorea robusta* had fair regeneration. *Trichilia connaroides* had fair regeneration. *Sapium insigne* had poor regenerations in Thuliban Community Forest.

Table 11: Regeneration status of Thuliban CF

S.N	Species name	Tree density	Sapling density	Seedling density	Regeneration status
1	Castanopsis indica	290	1240	10500	Good
2	Diospyros embryopteris	80	840	9500	Good
3	Shorea robusta	490	450	12500	Fair
4	Schima wallichii	110	240	9500	Good
5	Trichilia connaroides	0	120	1000	New
6	Myrica esculenta	0	0	0	
7	Fraxinus floribunda	0	0	0	
8	Pinus roxburghii	0	0	0	
9	Sapium insigne	0	0	0	
10	Dalbergia sissoo	5	0	500	New

Deurali Thadopakha community forest

The regeneration status of individual species was carried out by comparing its population structure i.e., tree, sapling and seedling density. *Castanopsis indica, Diospyros embryopteris, Myrica esculenta, Fraxinus floribunda* and *Schima wallichii* had good regenerations. *Shorea robusta* and *Trichilia connaroides* had fair regeneration status in Deurali Thadopakho Community Forest.

Table 12: Regeneration status of Deurali Thadopakho C*F*

S.N	Species name	Tree density	Sapling density	Seedling density	Regeneration status
1	Castanopsis indica	468.5	1900	15000	Good
2	Diospyros embryopteris	25	250	1250	Good
3	Shorea robusta	0	0	625	New
4	Schima wallichii	262.5	550	7500	Good
5	Trichilia connaroides	0	250	1875	New
6	Myrica esculenta	125	400	3750	Good
7	Fraxinus floribunda	100	800	6875	Good

Deurali community forest

The regeneration status of individual species was carried out by comparing their population structure i.e., tree, sapling, and seedling density. *Castanopsis indica, Diospyros embryopteris, Shorea robusta, Trichilia connaroides* and *Schima wallichii* had good regenerations.

Table 13: Regeneration status of Deurali CF

S.N	Species name	Local name	Tree density	Sapling density	Seedling density	Regeneration status
1	Castanopsis indica	Katush	400	1171.42	16428.57	Good
2	Diospyros embryopteris	Tindu	3.57	314.28	1785.71	Good
3	Shorea robusta	Sal	160.71	285.71	6785.71	Good
4	Schima wallichii	Chilaune	150	542.85	7500	Good
5	Trichilia connaroides	Ankhatare	500	628.57	6428.57	Good

DBH class distribution

Tilahar CF maximum tree density lies 300 ind/ha between (16-25) cm class and the trend going to decrease in tree density with increasing DBH class but first (5-15) cm DBH class had lower tree density 208.33 than (16-25) cm class.

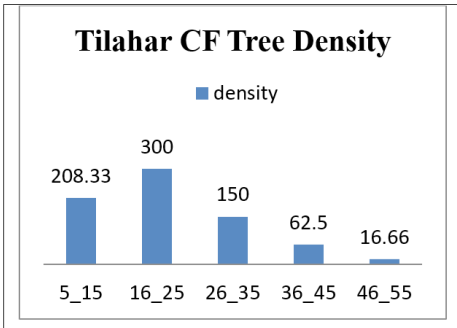

Figure 3: DBH class distribution of tree in Tilahar CF

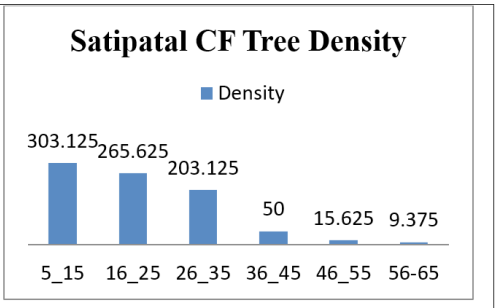

Figure 4: DBH class distribution of tree in Satipatal CF

Satipatal CF maximum tree density lies 303.125 Ind/ha between (5-15) cm class and trend going to decrease in tree density with increasing DBH class with minimum tree density 9.375 between class 56-65.Thuliba CF maximum tree density lies 405 ind/ha) between the (16-25) cm class and trend going to decrease in tree density with increasing DBH class but the first (5-15) cm DBH class had lower tree density 295 than the (16-25) cm class.

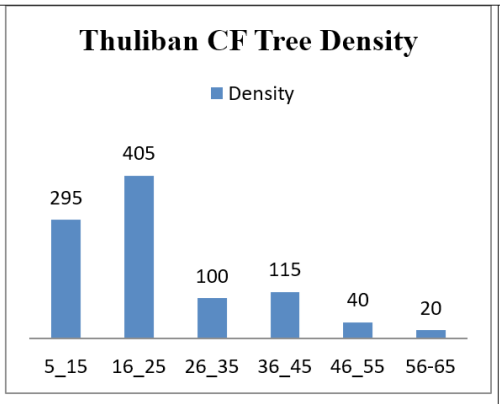

Figure 5: DBH class distribution of tree in Thuliban CF

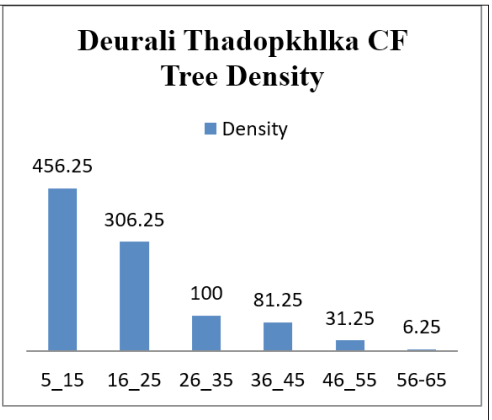

Figure 6: DBH class distribution of tree in Deurali Thadopakho CF

Deurali Thadopakha community forest

Deurali Thadopakha CF maximum tree density lies 456.25 ind/ha) between (5-15) cm class and decreasing tree density with increasing DBH class. Deurali CF maximum tree

density lies 317.875 ind/ha between (5-15) cm class and the trend going to decrease in tree density with increasing DBH class.

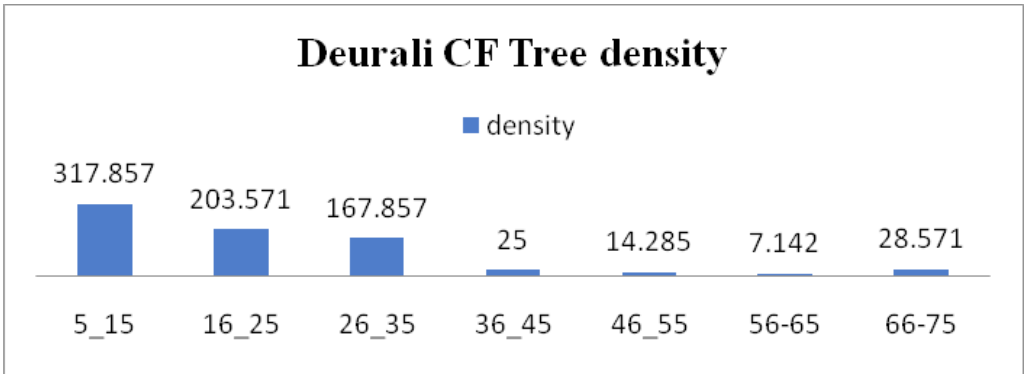

Figure 7: DBH class distribution of tree in Deurali CF

Discussion

Structural composition

The seedling density of five Community forests varies from 25000 Ind/ha (Tilahar CF) to 43500 Ind/ha (Thuliban CF). The result is higher than 1867-10137 Ind/ha reported from west Himalaya (Gairola *et al.* 2008) and 270-1790 Ind/ha reported from the natural oak mixed forest of Kamaun Himalaya (Lodhiyal *et al.* 2013) due to *Sal* forest has a higher number of their 38 seedling by comparing to other species but its sapling number highly decrease. The sapling density of five community forests ranges varies from 2366.67 Ind/ha (Tilahar CF) to 4150 Ind/ha (Deurali Thadopakha CF). The result is between the 2200-8333 Ind/ha reported from west Himalaya (Gairola *et al.* 2008) and between the value 365-14040 Ind/ha reported from an oak mixed forest of Kamaun Himalaya (Lodhiyal *et. al.* 2013). The total density of the tree species in the study area ranged from 737.5 Ind/ha (Tilahar CF) to 981.25 Ind/ha (Deurali Thadopakha CF) which was very lower than in the Churia forest of Rupandehi district (1092 – 1153 plants/ha) But this value was higher than the value reported for sal forest by Giri, Aryal, Bhattarai, Ghimire, Shrestha & Jha 1999) in Bardiya National Park (258 – 384 plants/ha).

The lower total tree density in the present study area than the reported values for tropical forests might be due to the past over-exploitation of the studied forest. The average tree density in the mid-mountain from the current study was 980.17 Ind/ha which is higher than the value (786.5 Ind/ha and 773.5 Ind/ha) reported by Bhuju & Ohsawa, (2001) and Bhuju & Younzon, (2004) from Churiya region of eastern and central Nepal respectively. That implies the Community Forest gains positive momentum in forest conservation and that verifies mid-mountain CFs from the increment of overall forest

tree species densities. Field data collected for seedling, sapling, and trees from the subtropical region of Nepal, November to March showed high seedling as well as the gap between the trees (Sapkota *et al.* 2009). But data for this study was collected in August and number of seedlings showed high due to the rainy season and the best seedling season in a subtropical forest in Nepal which result found against (Sapkota *et al.* 2009).

The basal area of this study range varies from 30.41 m^2 /ha (Tilahar CF) to 51.32m2 / ha (Deurali CF). The average basal area of tree species in the mid-mountain region was 40.86 m^2 /ha which was higher (37.38 m^2 /ha and 33.1 m^2 /ha) than reported by Bhuju & Younzon, (2001) and Bhuju & Younzon, (2004) from Churiya region of eastern and central Nepal respectively. TCF has lower but remaining other CF have higher tree basal area than 35 m^2 /ha reported from tropical forest (Midgleya & Niklas 2004), these values are higher than 21.35- 27.5 m^2 /ha reported from pure and undisturbed forests respectively in lesser Hindukush Himalaya (Ahmed *et al.* 2009; Khan *et al.* 2011). The present result is lower than the value 56.2 m^2 /ha reported from Sal forest of Gorakhpur, India. Sal-dominated forest's tree basal area i.e., Satipatal CF (39.28 m^2 / ha) and Thuliban CF (48.32 m^2 /ha) have a higher value than 30.62 m^2 /ha reported from sal forest of Lamjung.

Regeneration

An inverse J-shaped form distribution of stem indicates a good regenerating capability of the forest. Studies on the size-class structure of forest stand required the full tally method over substantial areas to receive representative results (Schmelz & Lindsey, 1965). Koop (2012) and Piovesan *et al.* (2005) suggested that 25–40 ha area was required to represent the shifting pattern of the forests. Therefore, small areas might not truly reflect the proportions of the successional stages and over-represent certain structural features.

Altogether at least 5 to 9 species of tree were recorded in five community forests. Some of the plant species were unidentified so local names are given in tables. This study showed *Catasnopsis indica* as the most dominant species. Three of five community forests are dominated by *Catasnopsis indica*. Tilahar CF is found dominated by *Schima wallichhi* and Satipatal CF by *S. Robusta*. The existence of *Castanipsis-Schima* dominance at this altitude is similar to the findings by Badu, Nuberg, Cedamon, & Sharma, (2019) at an elevation of 1000 to 3000 m a.s.l. In Deurali community forest, all species are found to be in good regeneration status. *C. Indica, Diospyros embryopteris* and *S. Wallichii* are in good regeneration status in all community forests of study. *C.*

indica and *S. wallichii* indicates reverse J- shaped structure and this is the indication of sustainable regeneration (Shrestha 2005).

The natural regeneration of flora is critical to the sustainable management of tropical forests (Medjibe *et al.* 2014). Therefore, understanding the plant regeneration processes and their dynamics is vital for planning and management activities (Mwavu & Witkowski 2009, Puhlick *et.al.* 2012, Yang *et al.* 2014).

DBH distribution of trees gives a better indication and used to represent the population structure of the forest (Saxena *et al.* 1984). The present study shows Deurali Thadopakh CF, Deurali CF, and Satipatal CF have reverse J-shape curves. But, a lower number of (5-15) cm class than (16-25) cm in Tilahar CF and Thuliban CF and other class has decreasing order with increasing class. A reverse J-shaped class diagram indicates sustainable regeneration (Vetaas 2000) and future communities may be sustained (Sarkar & Devi 2014). But at the species level, the regeneration of particular tree species has a different level. The same species also have different levels of regeneration in different forests. That implies species compositional structure varied the regeneration level of species. S. Robusta is found best regeneration status among all species but it is found new regeneration in Tilahar and Deurali Thadopakho CF and found fair regeneration in Thuliban CF.

Saxena and Singh (1984) stated the presence of a high number of seedlings indicates fair regeneration. This study also found thesame result that Shorea robusta had fair regeneration in Thuliban CF with a high number of seedlings (12500 Ind/Ha) concerning tree (490 Ind/Ha) and sapling (450 Ind/Ha) Pinus roxburghii in Tilahar CF had found a high number of seedling (3333.33Ind/Ha) with fair regeneration.

Conclusion

All studied community forests are mixed forests dominated by tree species *Castanopsis indica, Diospyros embryopteris* (Diospyros malabarica), *Shorea robusta*, and *Schima wallichii* (Schima wallichii choisy). The regeneration potential of the Tilahar CF is found high. The structural compositions of tree species vary from forest to forest due to the variation in different environmental conditions. The overall density of tree, sapling and seedling in study area indicates a good and incremental scenario in comparison to other similar types of forests in the mid-mountain. DBH class distribution curve of tree species found as inverse J-shape that indicates the overall forest has a sustainable regeneration. Tilahar CF and Thuliban CF have a slight deviation from the inverse J-shape due to the lower number of (5-15) cm DBH class. This can be attributed to the higher disturbance level. Where forest has sustainable regeneration while wide variation occurs at the

individual species level. Mainly top three to four dominant species maintain the overall forest regeneration. For seedling germination and development, canopy cover has a significant negative relationship and is taken as a predicting factor. The ground slope has significant negative relation with seedling germination and establishments.

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