Study of Phytosociological Parameters and Carbon Stock between Two Community Forest of Different Ecological Regions of Udaypur District of Nepal

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Abstract: This study compared the regeneration status, vegetation diversity, stand structure, and carbon stock of two community-managed forests located in different ecological regions of Nepal. A total of 61 concentric sample plots were investigated by using systematic random sampling with 1 % sampling intensity. The phytosociological parameters of trees and regeneration density were calculated using standard techniques. The aboveground tree carbon was estimated using a non-destructive method. Correlation analysis was performed to assess the variation of carbon stock with biomass, stand density, tree diameter at breast height (DBH), tree height, basal area, and seedling density. Janata community forest (CF) had higher regeneration than the Hazare CF, with a bell-shaped distribution of DBH in Janata CF and an interrupted curve in Hazare CF. Both forests were dominated by *Shorea robusta*. Hazare CF had higher Shannon diversity index, Simpson's index, and evenness index, while Janata CF had higher carbon stock. The observed differences in the studied parameters between the two community forests can be attributed to the difference in ecological factors such as temperature, rainfall, soil nutrient availability, and management practices. Future studies focusing on investigating the underlying factors driving the observed patterns and relationships, such as the effects of disturbance, climate, and management practices on forest structure and function are also needed. These findings have important implications for forest management and conservation policies, especially in the context of climate change mitigation and biodiversity conservation.

Keywords: *Sustainable forest management, Vegetation diversity, Carbon sequestration, Biodiversity conservation*

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1. Introduction

Forests are one of the most important terrestrial ecosystems on the planet, providing numerous benefits to both humans and the environment (Brockerhoff et al., 2017). They are home to a diverse range of plant and animal species, many of which are endemic to specific forest types. Forests also provide a wide range of ecosystem services, including climate regulation, water conservation, soil conservation, and carbon sequestration (Bauhus et al., 2010; Thompson et al., 2011; Brockerhoff et al., 2013; Decocq et al., 2016; Liang et al., 2016; Mori et al., 2017). However, forests worldwide are under threat from human activities, such as deforestation, land-use change, and climate change (Liaison, 2013; Thapa, 2021).
In Nepal, community forestry program has been recognized as a model for community-based natural resource management (Ghimire and Lamichhane, 2020). There are 22519 community forests in Nepal, covering 2,312,545 hectares, and 3,088,259 households are in responsible for maintaining them (Pandey and Pokhrel, 2021). This constitutes to 15.67% of the total area of the country, 34.98% of its total forested area, 56.90% of total Households, and 62.68% of the total population of Nepal being engaged in CF (Pandey and Pokhrel, 2021). Despite the significant number of community forests in Nepal, there is often a lack of detailed information regarding essential technical aspects such as species diversity, stand structure, and carbon stocks (Anup, 2017; Poudyal et al., 2019). These metrics are critical for

understanding the role of forests in providing ecosystem services such as carbon sequestration, soil conservation, and biodiversity conservation (Mandal et al., 2013; Bhandari et al., 2021; Baul et al., 2021). Therefore, there is a growing need for assessments studies in community forests in different regions that can provide detailed information about these technical aspects and their implications for ecosystem services (Paudyal et al., 2017).

Regeneration status refers to the ability of a forest to naturally regenerate itself through the growth of new trees and other vegetation (Chazdon and Guariguata, 2016). Assessing the regeneration status of a forest is an important part of forest management and conservation, as it can help identify areas where intervention may be needed to promote natural regeneration and maintain forest health (Rahman et al., 2020). Species diversity is an essential aspect of forest ecosystems, as it reflects the richness and evenness of the plant and animal species present in a given area (Magurran, 2005). The diversity of forest ecosystems is a critical indicator of their ecological health and resilience (Brockerhoff et al., 2017). The structure of forest ecosystems, including tree density, size distribution, and canopy cover, also plays an important role in supporting forest biodiversity and ecosystem services (Smith, 2016). The carbon stock of forest ecosystems is a crucial component of the global carbon cycle, as forests act as carbon sinks by sequestering carbon from the atmosphere through the process of photosynthesis (Cannell, 1996; Mukul et al., 2021). The diversity, structure, regeneration status and carbon sock of forests are all critical factors that affect their ability to provide these important ecosystem services (Hooper et al., 2005; Isbell et al., 2011; Gamfeldt et al., 2013). For example, forests with higher levels of biodiversity are typically more resilient to environmental changes and disturbances, and are better able to provide a wide range of ecosystem services (Brockerhoff et al., 2017). Similarly, the structure of forests, including the size, shape, and arrangement of trees, also plays a crucial role in determining the types and amounts of resources that are available to wildlife and humans (Smith, 2016). The composition of forests, including the types and proportions of different tree species, also affects their ability to provide important ecosystem services, such as carbon sequestration and habitat for wildlife (Gamfeldt et al., 2013; Forrester and Bauhus, 2016; Marais et al., 2022). Finally, information on regeneration status can be used to guide management strategies such as tree planting, selective logging, and other interventions aimed at promoting natural regeneration and ensuring the long-term sustainability of the forest ecosystem (Chazdon and Guariguata, 2016; Rahman et al., 2020). Therefore understanding the regeneration status, forest diversity, structure, and carbon stock is essential for effective forest management and conservation.

Biophysical measurements of trees such as number of individuals, diameter at breast height (DBH), height, and crown dimensions can be used to determine diversity and stand structure. Destructive methods such as harvesting trees as well and non-destructive methods such as allometric equations and remote sensing and geographic information system (GIS) can be used to estimate above-ground carbon stock (Shi and Liu, 2017). Allometric equations are based on the relationship between tree biomass and easily measured parameters such as DBH and height (Mugasha et al., 2019). These equations are widely used for estimating forest biomass and carbon stock than harvesting method because they are non-destructive and relatively easy to apply (Shi and Liu, 2017). However, the accuracy of allometric equations can be affected by several factors such as species, forest age, and stand structure (Daba and Soromessa, 2019). Therefore combination of methods such as biophysical measurements and allometric equations, are used in this study.

Although there have been many studies conducted on vegetation analysis and carbon stocks in community forests of Nepal, most of them have focused on a single community forest (Aryal et al., 2018; Sharma et al., 2020; Bhatta and Devkota, 2020; Ghimire and Lamichhane, 2021; Joshi et al., 2021), or compared forests within the same region (Joshi et al., 2021). Additionally, there have been also a few studies that have studied forests under different management regimes (Awasthi et al., 2015; Aryal et al., 2021; Ayer et al, 2022; Khatri et al., 2023). Furthermore, only a limited number of studies have specifically examined differences in vegetation and carbon stocks between different ecological regions (Pandey and Bhusal, 2016). As a result, there is a significant research gap in our understanding in context of Nepal that needs to be filled. Studying vegetation and carbon stocks in different ecological regions is important because different regions may have different types of forests, different plant species, and different environmental conditions that can affect how much carbon is stored in the vegetation (Pandey and Bhusal, 2016; Karki et al., 2016). Additionally, understanding the differences in vegetation and carbon stocks between ecological regions can help policymakers and land managers make informed decisions about how to manage forests for carbon sequestration and other ecosystem services. Therefore, the purpose of this study is to address this gap in knowledge and assess the phytosociological parameters such as regeneration status, species diversity, stand structure, and potential carbon stocks of community forests across two ecological regions of Udaypur district of Nepal.

2. Materials and methods

2.1. Description of the study site

The study was carried out in the Janata and Hazare CFs of Katari, Udaypur district of Nepal. It is located in Province no. 1 in the southeastern part of Nepal which lies between 26.8372° N latitude and 86.3213° E longitudes. Both the Mahabharat and Shiwalik hills encircle the Udayapur district from the north and the south, and the two hills converge in the west to create the Udayapur valley. The elevation of the district is moderately steep ranging from lower tropical below

300 m and upper tropical ranging from 300-4000 m. Janta CF covers an area of 132 hac and lies in Mahabharat region at 510-770 m whereas Hazare CF covers a range of 177 ha which lies in Chure region at 550-1100 m elevation. Both CF lies in tropical region having 5-50° slope and northeast slope aspect with red, loose, sandy soil. Temperatures in the region exceed 37 °C during the summer period while winter temperatures range from 7 to 23 °C. Leopard (*Panthera pardus*), Rabbit (*Oryctolagus cuniculus*), Barking deer (*Muntiacus muntjak*), Porcupine (*Hystrix brachyura*) etc. are the most spotted animals whereas parrot (*Psittacidae krameri*), sparrow (*Passer montanus*), Common myna (*Acridotheres tristis*), Black Drongo (*Dicrurus macrocercus*) etc. are the most seen bird species in both CF. The endangered species like Leopard (*Panthera pardus*) and chinese pangolin (*Manis pentadactyla*) are strictly protected in this area.

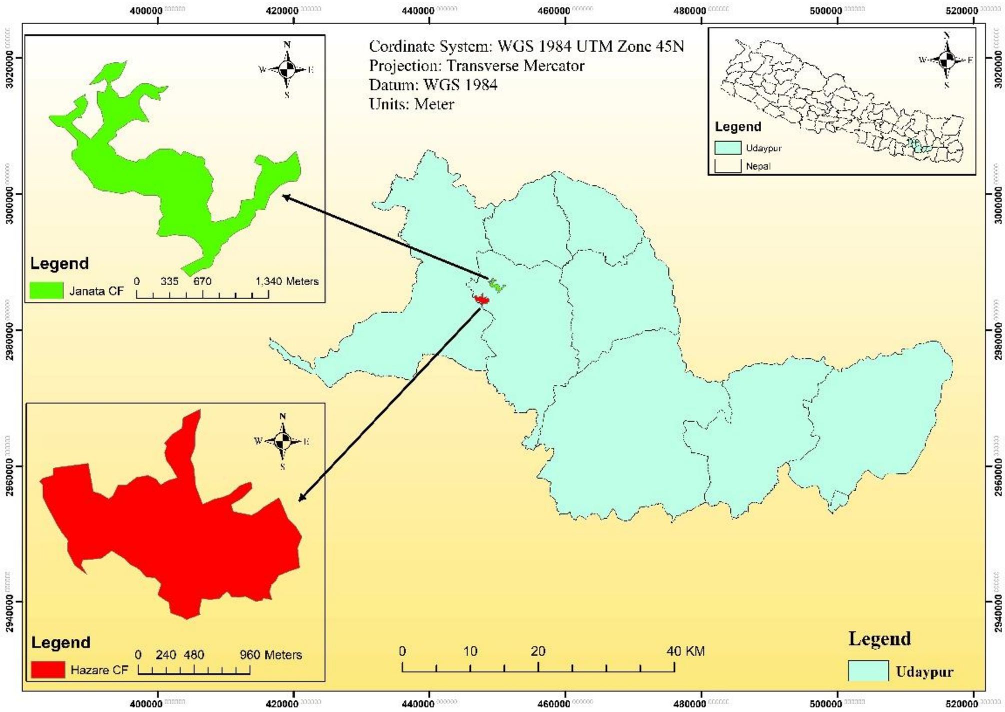

Figure 1: Map of the study area

2.2. Data collection

GPS and Arc Map 10.8 software were used to demarcate the targeted community forest for the research purpose. The study employed a systematic random sampling approach to gather data on plant species diversity and regeneration status. The plants were classified into three categories based on their size - tree (dbh > 10 cm), sapling (dbh < 10 cm and height > 1.0 m), and seedling (height < 1.0 m). A total of 61 circular sample plots, each covering an area of 500 m2 (with a 1% intensity), were established according to the Forest Inventory Guideline recommended by the Government of Nepal (DoF, 2004). Within each sample plot, three concentric plots with radii of 12.62 m, 5.64 m, and 1 m were used to sample trees, saplings, and seedlings, respectively. Diameter at breast height (dbh) and tree height were measured using Diameter Tape and Clinometer respectively.

2.3. Data analysis

The phytosociological parameters of trees including density (D), frequency (F), basal area (m^2), relative density (RD), relative frequency (RF), relative basal area (RBA), and important value index (IVI), were calculated using the Zobel et al. (1987) technique. Similarly, regeneration density (individuals ha^{-1}) was also calculated using Zobel et al. (1987). The number of woody species in each plot was recorded to determine species richness 'S', following Whittaker (1972). The Shannon-diversity Weiner's index (H) (Shannon and Weaver, 1949), Simpson's index 'D' (Simpson, 1949), and Species Evenness (e) (Wilsey et al., 2005) were also evaluated. To analyze the community structure, all plant populations of all species found in all plots were categorized into various size classes based on diameter at breast height (DBH).

In this study, a non-destructive method was used to estimate biomass. The aboveground tree biomass (AGTB) was calculated using the allometric equation provided by Chave et al. (2005), which takes into account the tree diameter at breast height (D), wood specific density (WD) in kg m^{-3}, and tree height (H) in meters for trees (dbh > 10 cm).

$AGTB = 0.0509 \times D^2 \times WD \times H$

To calculate the carbon stock of individual tree species in community forests, the density values of each species across the entire forest were added together. The percentage contribution of carbon stock of each tree species in a forest was then determined by taking the proportional sum of carbon stock per hectare of all species present in the forest and dividing it by the sum of carbon stock of the particular species in the same forest. This method, described by Joshi et al. (2020), allows for the quantification of the contribution of each tree species to the total carbon stock of a forest and provides insight into the relative importance of different species in carbon sequestration efforts.

Carbon stock of tree species (%) = (Sum of carbon stock of tree species (ha) *100)/ Sum of carbon stock of all tree species (ha)

Correlation analysis was performed to access the variation of C stock with biomass, stand density, tree DBH, tree height, basal area and seedling density. Prior to the correlation analysis, the data were tested for the normality (Shapiro-Wilk test, $p > 0.05$). In Janata CF, tree DBH, tree height and seedling density meet the assumption of normality ($p > 0.05$). So, they were correlated by parametric test i.e. Pearson correlation. Carbon, biomass, tree density and basal area were log transformed to meet the assumption of normality ($p > 0.05$). So, they were correlated by parametric test i.e. Pearson correlation. Similarly, in Hazare CF, carbon, biomass, stand density, tree height, and basal area meet the assumption of normality ($p > 0.05$). So, they were correlated by parametric test i.e. Pearson correlation. Tree DBH and seedling density didn't meet the assumption of normality ($p < 0.05$) even after transformation, so they were correlated by Spearman correlation, a non-parametric test.

3. Results and discussion

3.1. Regeneration status

A total of 14 species of seedlings and saplings were recorded, with varying degrees of occurrence in the two forest areas. The total number of seedlings (7385 individuals ha^{-1}) and saplings (138 individuals ha^{-1}) in Janata CF was higher than the total number of seedlings (3629 individuals ha^{-1}) and saplings (86 individuals ha^{-1}) in Hazare CF (Table 1). *Shorea robusta*, the dominant species in both forests, was found in higher numbers in Janata CF with 4769 seedlings and 69 saplings per ha, compared to Hazare CF where it had 2200 seedlings and 63 saplings per ha. Other species that were more abundant in Janata CF than Hazare CF included *Symplocus sps*, *Myrsine capitellata*, and *Cassia fistula*. In contrast, Hazare CF had higher abundance of *Schima wallichi* and *Terminalia tomentosa* with 500 ha^{-1} and 86 seedlings ha^{-1}, respectively, compared to Janata CF where they were not recorded. Additionally, *Alangium salvifolium* and *Buchanania latifolia* were found only in Janata CF, while *Dillenia pentagyna*, *Croton roxburghii*, and *lagerstroemia parviflora* were found only in Hazare CF (Table 1).
Regeneration is a crucial element that shows the community's and species' evolutionary trends and preserves the integrity or resilience of the forest in the long run (Napit, 2015; Bose et al., 2016). *Shorea robusta* and *Schima wallichi* have a higher proportion of seedlings and saplings in both community forests, which indicates that they have dominated the regeneration (Table 1). This may be due to the fact that different species have different ecological preferences, and their growth and survival may be affected by factors such as climate, soil type, and topography (Sapkota et al., 2009; Joshi et al., 2021).

Table 1: Overview of particular species seedlings and saplings regeneration status in Janata and Hazare CFs, Udaypur District, Nepal.

Species Name	Hazare CF		Janata CF	
	Individual ha^{-1}		Individual ha^{-1}	
	Seedlings	Saplings	Seedlings	Saplings
Alangium salvifolium	0	0	231	0
Buchanania latifolia	0	0	154	12
Cassia fistula	400	0	0	0
Dillenia pentagyna	0	0	0	8
Croton roxburghii	57	0	0	0
lagerstroemia parviflora	143	0	0	0
Lyonia ovalifolia	0	0	154	0

Myrsine capitellata	57	3	0	0
Other hill species	343	3	346	0
Schima wallichi	343	6	500	31
Shorea robusta	2200	63	4769	69
Symplocus sps	0	11	154	19
Syzygium cumini	0	0	1077	0.00
Terminalia tomentosa	86	0	0	0.00
Total	3629	86	7385	138

Janata CF has good regeneration condition where as Hazare CF has medium regeneration condition according to criteria suggested by Community Forest Resource Inventory guideline (DoF, 2004): a forest is considered to have poor, medium and good regeneration if it has regeneration (Seedlings and saplings) <2000, 2000-5000 and > 5000 in number per hectare (Pandey et al., 2012). However seedlings and sapling density was found lower than Basyal et al. (2011), Awasthi et al. (2015), Napit (2015) and Joshi et al. (2021). This might be due topography, climate, stand intensity, type of disturbances, and soil nutrients of the study site (Khaine et al., 2018; Joshi et al., 2021).

3.2. DBH distributions

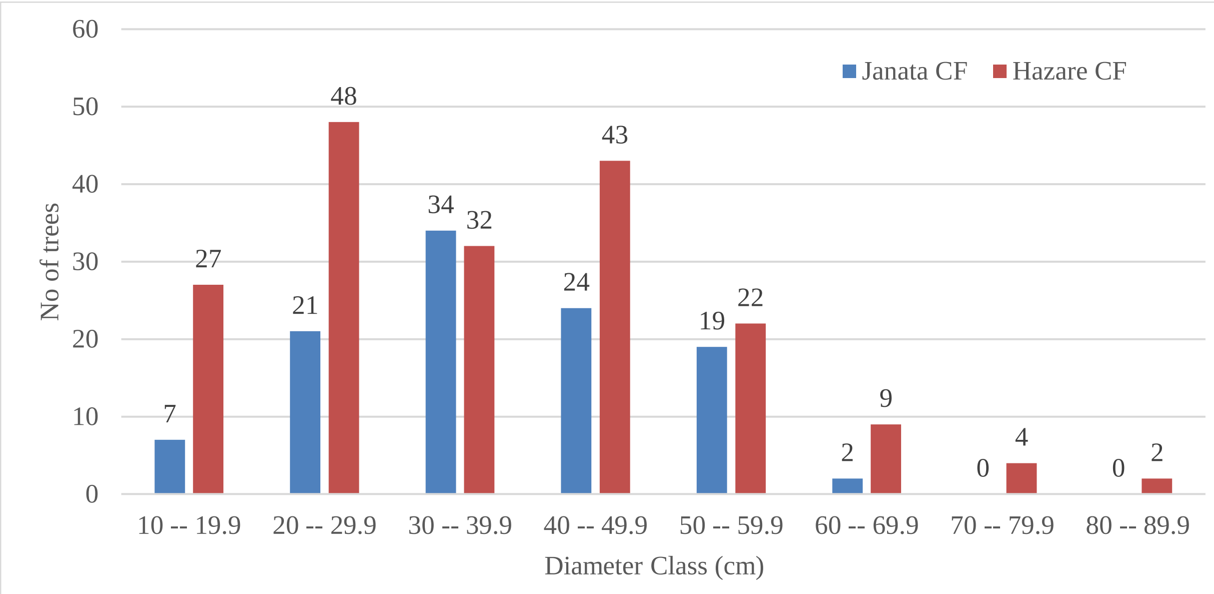

Figure 2: Distribution of DBH in Janata and Hazare CF

The diameter class-wise distribution of trees in a forest is an important indicator of its structural heterogeneity and can provide insights into forest dynamics and functioning (Lutz et al., 2013). The bell-shaped curve observed in Janata CF with the highest peak in the 30-39.9 cm DBH size class indicates mature nature of forest (Clatterbuck et al., 2011; Sharma et al., 2020) with well-structured forest with a wide range of tree diameters and age classes (Figure 2). The current state of the forest may be a result of past disruptions that have decreased its ability to regenerate, as well as the removal of large trees (Nizami, 2012; Dar et al., 2017). On the other hand, the interrupted curve in Hazare CF with the highest peak in the 20-29.9 cm DBH size class indicates that the forest has gaps in its size structure, which could be problematic to regeneration because not all diameter class are represented (Figure 2) (Temgoua et al., 2020). The interrupted pattern in diameter class distribution observed in the Hazare CF suggests that the forest may have experienced some type of disturbance or disruption in its natural regeneration process. Our result is in contrast with the findings of Chauhan et al. (2008), Acharya et al. (2007), Basyal et al. (2011), Awasthi et al. (2015), Manna and Mishra (2017) and Joshi et al. (2021) that indicated an inverse J-shaped curve showing higher number of young trees.

3.3. Community attributes

Both the CF are dominated by *Shorea robusta*, followed by *Schima wallichi* and *Lagerstroemia parviflora* (Table 2 and 3). The importance value index (IVI) of *Shorea robusta* is higher in both forests, with 185.89 and 200.69 in Hazare CF and Janata CF, respectively. *Schima wallichi* also has high IVI in both forests, with 38.94 in Hazare CF and 77.44 in Janata CF. Other species have lower IVI values indicating their lesser ecological significance (Table 2 and 3). The high IVI value of these species may be due to their ability to adapt to the environmental conditions of the forest and to their competitive ability to utilize the available resources (Shameem & Kangroo, 2011). It also suggests that they are preferred by the local communities for their ecological and economic value (Sarkar and Devi, 2014; Das et al., 2017).

Table 2: Frequency, relative frequency (F), density (D), relative density (RD), basal area (BA), relative basal area (RBA) and importance value index (IVI) of plant species in Hazare CF

Species	F %	RF%	D (tree ha^{-1})	RD %	BA (m^2 ha^{-1})	RBA%	IVI
Adina cardifolia	2.86	1.16	0.57	0.53	0.10	0.74	2.44
Buchanania latifolia	14.29	5.81	2.86	2.67	0.20	1.46	9.95
Cassia fistula	8.57	3.49	1.71	1.60	0.09	0.68	5.77
Dillenia pentagyna	2.86	1.16	0.57	0.53	0.07	0.53	2.23
Lagerstroemia parviflora	31.43	12.79	6.29	5.88	0.46	3.46	22.13
Myrsine capitellata	2.86	1.16	0.57	0.53	0.01	0.04	1.74
Other hill species	5.71	2.33	1.14	1.07	0.05	0.39	3.79
Schima wallichi	42.86	17.44	8.57	8.02	1.81	13.47	38.94
Semicarpus anacardum	5.71	2.33	1.14	1.07	0.09	0.64	4.04
Shorea robusta	100.00	40.70	76.00	71.12	9.96	74.07	185.89
Symplocus sps	11.43	4.65	2.29	2.14	0.11	0.80	7.59
Terminalia bellerica	8.57	3.49	1.71	1.60	0.16	1.19	6.28
Terminalia tomentosa	8.57	3.49	3.43	3.21	0.34	2.51	9.21
Total	245.71	100.00	106.86	100.00	13.44	100.00	299.99

Table 3: Frequency, relative frequency (F), density (D), relative density (RD), basal area (BA), relative basal area (RBA) and importance value index (IVI) of plant species in Janata CF

Species	**F %**	**RF%**	**D (tree ha^{-1})**	**RD %**	**BA (m^2 ha^{-1})**	**RBA%**	**IVI**
Anogeissus latifolia	7.69	3.85	1.54	2	0.352	3.344	9.19
Lagerstroemia parviflora	15.38	7.69	3.08	4	0.261	2.480	14.17
Schima wallichi	65.38	32.69	19.23	25	2.079	19.748	77.44
Semicarpus anacardum	11.54	5.77	2.31	3	0.078	0.741	9.51
Shorea robusta	100	50.00	59.23	77	7.760	73.691	200.69
Total	200	100.00	85.38	111	10.53	100.00	311.01

3.4. Biodiversity parameters

The Shannon-Wiener diversity index (H') in the studied area was ranging from 0.9 to 1.21 (Table 4), which is similar to range (0.9- 1.0) reported by (Sharma et al., 2018) in Resunga Sacred Grove, Gulmi. However, our result is significantly lower than the range (2.69-4.53) reported by (Sahu et al., 2012), (1.80-1.91) reported by (Shrestha et al., 2020) in sacred groves in Kathmandu Valley, and Ganesh Community Forest and Ramnagar Community Forest in Nepal tropical (Joshi et al., 2019). This could be due to differences in forest type and management practices, as well as variations in the degree of anthropogenic disturbances such as grazing, logging, and fire that can significantly affect the diversity of the forest (Chapagain et al., 2021). The Simpson's index (D) reflected the difference in species richness, with the Janata forest having a value of 0.87 and Hazare having a value of 2.29. The Evenness Index, on the other hand, indicated that the Janata forest had a slightly higher evenness (e=0.56) compared to the Hazare forest (e=0.47), suggesting a more balanced distribution of species in the Janata forest.

Table 4: Tree Biodiversity parameters in Janata and Hazare Community Forest, Udaypur District, Nepal

Parameters	Janata CF	Hazare CF
Shannon-Wiener Index (H')	0.90	1.21
Simpson's Index (D)	0.87	2.29
Evenness Index (e)	0.56	0.47

3.5. Above ground tree biomass and carbon stock

Mean AGTB and carbon stock in Janata CF were 98.01 ± 7.90 t ha^{-1} and 46.06 ± 3.71 t ha^{-1}, respectively. Similarly, the AGTB and carbon stock in Hazare CF were 64.92 ± 9.70 t ha^{-1} and 30.51 ± 4.56 t ha^{-1}, respectively. As a result, total AGTB and carbon stock were comparatively greater in Janata CF than Hazare CF (Figure 3). This may be due to higher tree density in Janata CF, which could result in a greater AGTB and carbon stock (Joshi et al., 2023). Our Study have reported higher AGTB and carbon stock than Joshi et al. (2023) and lower than Paudel and Bhusal (2016), Karki et al. (2016) and Joshi et al. (2021). This might be due the history of land use, management practices, soil quality, and climate conditions in each area (Rossi et al., 2007).

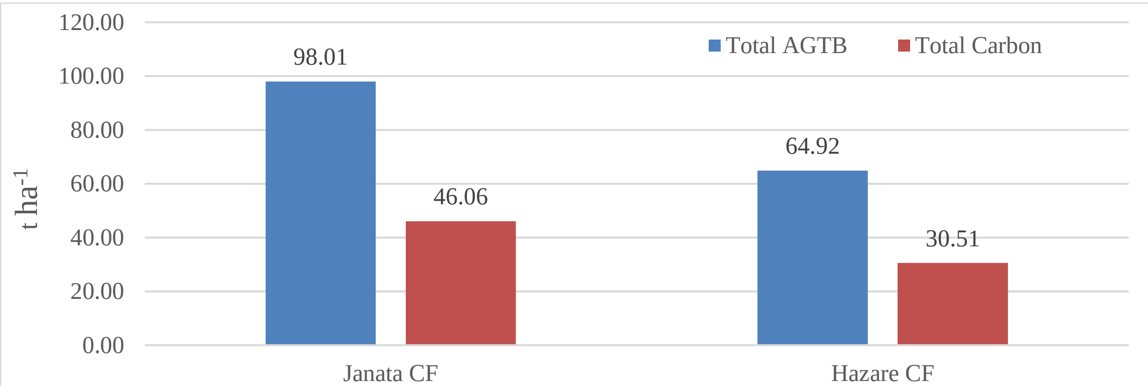

Figure 3: Total AGTB accumulation and carbon stock in both CFs.

The t-test showed that there was significant difference ($p<0.05$) in the carbon stock densities of these pools with respective to the ecological regions; the amount of carbon stock density was found to be significantly higher in the Janata CF than in the Hazare CF (Table 5).

Table 5: Aboveground Tree carbon stock densities in the study areas

Carbon Pool	df	Janata CF	Hazare CF	Mean	p-value	Remarks
Aboveground Tree Carbon stock (t ha^{-1})	40.81	46.06	30.51	38.29	0.0015	*
Remarks: * = significant at p<0.05						

Table 6: The percentage share of species contribution on carbon stock of Janata and Hazare CFs, Udaypur District, Nepal

Janata CF			Hazare CF		
Species	C ± SE	C (%)	Species	C ± SE	C (%)

	(t ha^{-1})			(t ha^{-1})	
Anogeissus latifolia	1.08	2.34	*Adina cardifolia*	0.17	0.56
Lagerstroemia parviflora	1.13	2.45	*Buchanania latifolia*	0.32	1.04
Schima wallichi	7.08	15.36	*Cassia fistula*	0.13	0.41
Semicarpus anacardum	0.16	0.35	*Dillenia pentagyna*	0.12	0.41
Shorea robusta	36.62	79.51	*Lagerstroemia parviflora*	0.99	3.24
			Myrsine capitellata	0.01	0.02
			Other hill species	0.08	0.27
			Schima wallichi	3.58	11.72
			Semicarpus anacardum	0.13	0.43
			Shorea robusta	23.77	77.91
			Symplocus sps	0.15	0.50
			Terminalia bellerica	0.24	0.80
			Terminalia tomentosa	0.83	2.71
Total	46.06 ± 3.71	100.00	Total	30.51± 4.56	100.00

The results indicated that *Shorea robusta* (Sal) was the highest contributor to the carbon stock in both forests, with a contribution of 79.51% (36.62 t ha^{-1}) and 77.91% (23.77 t ha^{-1}) in Janata and Hazare CF, respectively. This could be because *Shorea robusta* are dominant species in both forests, and their abundance could contribute to higher carbon stock. The other tree species also contributed a significantly higher percentage of carbon stock in both CFs (Table 6). This finding is consistent with previous studies, which showed that Sal is the highest contributor to carbon stock in the Terai region of Nepal including the FRA report (2014), Neupane and Sharma (2014) and Joshi et al., (2021).

3.6. Correlation analysis

The forest biometric variables are statistically significant at the 0.05 level (2 tailed). The correlation analysis (Table 7 and 8) showed that the forest C stock in both forest was positively correlated with tree DBH, height, basal area (BA) and biomass. A similar finding was also observed by Thapa-Magar and Shrestha (2015), Shaheen et al. (2016) and Sharma et al. (2020). Thus, tree diameter, height, BA and biomass are the determinant variable for forest C. The negative correlation of stand density with tree DBH and tree height in both CF is in accordance with Nizami et al. (2009), Nizami (2012), Amir et al. (2018) and Sharma et al. (2020). Natural thinning process due to resource competition resulting in lower stand density but allowing the remaining trees to grow bigger and selective removal of big trees by humans for timber extraction or other purposes could be the possible reasons for such negative correlation (Nizami, 2012). Similarly, the positive correlation between DBH and height observed in this study is consistent with previous research by Nizami et al. (2009) and Sharma et al. (2020). This could be attributed to the similar environmental conditions, which influenced their growth rate in a similar manner (Ekoungoulou et al., 2018). The negative correlation between stand density and seedling density in Janata CF could be due to competition among trees for resources such as light, nutrients, and water, leading to reduced availability for seedlings to establish and grow (Jackson, 1994). However, stand density and seedling density were positively correlated in Hazare CF which could be due to the presence of suitable environmental conditions such as light availability, nutrient availability, and soil moisture, as well as management practices such as selective removal of big trees and thinning operations which may have promoted both the growth and survival of both established trees and seedlings.

Table 7: Correlation analysis between the carbon stock (t ha-1), biomass (t ha-1), tree density (trees ha-1), tree DBH (cm), tree height (m), basal area (m2 ha-1) and seedling density (seedlings ha-1) of Janata CF

Variables	Carbon	Biomass	Density	DBH	Height	Basal Area	Seedling Density
Carbon	1	1*	0.66*	0.44*	0.3	0.97*	0.12
Biomass	1*	1	0.66*	0.44*	0.3	0.97*	0.12

Density	0.66*	0.66*	1	-0.34	-0.25	0.76*	-0.06
DBH	0.44*	0.44*	-0.34	1	0.60*	0.34	0.2
Height	0.3	0.3	-0.25	0.60*	1	0.11	0.145
Basal Area	0.97*	0.97*	0.76*	0.34	0.11	1	0.06
Seedling Density	0.12	0.12	-0.06	0.2	0.15	0.06	1
No. of plots. N=26, *Represents the significant difference, p＜0.05							

Table 8: Correlation analysis between the carbon stock (t ha^{-1}), biomass (t ha^{-1}), tree density (trees ha^{-1}), tree DBH (cm), tree height (m), basal area (m^2 ha^{-1}) and seedling density (seedlings ha^{-1}) of Hazare CF

Variables	Carbon	Biomass	Density	DBH	Height	Basal Area	Seedling Density
Carbon	1	1*	0.41*	0.63*	0.48*	0.98*	0.08
Biomass	1*	1	0.41*	0.63*	0.48*	0.98*	0.08
Density	0.41*	0.41	1	-0.31	-0.29	0.48*	0.18
DBH	0.63*	0.63*	-0.31	1	0.74*	0.63*	-0.05
Height	0.48*	0.48*	-0.29	0.74*	1	0.40*	-0.17
Basal Area	0.98*	0.98*	0.48*	0.63*	0.40*	1	0.08
Seedling Density	0.08	0.08	0.18	-0.05	-0.17	0.08	1
No. of plots. N=35, *Represents the significant difference, p＜0.05							

4. Conclusion

In this comparative study, the richness of community-managed forests in terms of regeneration status, vegetation diversity, stand structure, and carbon stock across two ecological regions were explored. The findings indicate that Janata CF and Hazare CF exhibit significant differences in their regeneration, DBH distribution, species diversity, and carbon stock. Janata CF has higher regeneration compared to Hazare CF, which may be attributed to its better forest management practices. The distribution of DBH in Janata CF shows a bell-shaped curve, whereas Hazare CF exhibits an interrupted curve, which may indicate differences in the growth patterns of the dominant species. Both forests are dominated by *Shorea robusta,* which suggests the importance of this species for the overall forest structure and function. However, Hazare CF shows higher species diversity indices, indicating a more diverse forest ecosystem compared to Janata CF. Interestingly, despite lower species diversity, Janata CF has higher carbon stock, which may be attributed to the higher density of *Shorea robusta* in this forest. *Shorea robusta* was found to be the highest contributor to the carbon stock in both forests, highlighting the significance of this species in the carbon sequestration potential of the forests. The difference in ecological factors such as temperature, rainfall, soil nutrient availability, and management practices could be attributed to the observed differences in the studied parameters between the two ecological regions. This study emphasizes the importance of community-managed forests in maintaining biodiversity and ecosystem services and underscores the need for tailored forest management practices based on the specific ecological and social contexts of the forests. It is also recommended to conduct similar studies in other community-managed forests across different ecological regions to better understand the patterns of regeneration, vegetation diversity, stand structure, and carbon stock. Future studies focusing on investigating the underlying factors driving the observed patterns and relationships, such as the effects of disturbance, climate, and management practices on forest structure and function are also needed.

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