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A Comparative Study of Biomass and Carbon Stock in Tropical and Temperate Forests of Ilam District in Nepal

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Quantification of biomass and carbon is imperative in optimizing ecological and low-carbon emission-oriented economic benefits of forestland. This study quantified stock densities of carbon in two distinct forests, viz., tropical and temperate. We selected two Community Forests (CFs) with predominance of *Shorea robusta* in the tropical and *Castanopsis* sp. in the temperate region of Ilam district (Chure and Mid-hill). Data were gathered using stratified systematic sampling with a 1% sampling intensity. It was discovered that the overall stock (carbon) in the Tropical and Temperate CFs was 95 Mg ha^{-1} and 75.59 Mg ha^{-1}, respectively. Tropical forests exhibited a higher level of biomass (202.14 Mg ha^{-1}) relative to temperate forests (169.34 Mg ha^{-1}). The biomass carbon in tropical forests was 1.19 times greater (per hectare) compared to temperate forests. Interestingly, analysis revealed an absence of significant differences in carbon sequestration between the two forests under study with respect to diameter and height class. The study shows that both tropical and temperate forest stands sequester a significant amount of carbon, and appropriate management can yield additional benefits.

Keywords: Carbon sequestration, *Castanopsis*, Community Forest, *Shorea robusta*

Maintaining and increasing carbon stocks in forests worldwide is a crucial part of the global effort to combat climate change (UN, 2017; Raihan, 2024). The total amount of carbon within a pool at a specific time is different from sequestration, which is the process that accumulates carbon in pools outside of the atmosphere (FAO, 2011). Forest ecosystems are both sources and sinks of atmospheric carbon dioxide (Huang et al., 2020). They are among the most important options for carbon sequestration and play a crucial role in regulating the global carbon cycle (Salunkhe et al., 2018; Nugroho et al., 2022).

As a natural process, the captured carbon is primarily absorbed as biomass (Jindal et al., 2008). The majority of terrestrial carbon is stored in tree trunks, branches, foliage, and roots, which are collectively referred to as biomass (Muradian et al., 2013; Suryawanshi et al., 2014). Unlike many plants and crops, forests can accumulate carbon over long periods, such as decades or centuries. Forest ecosystems store between 20 and 100 times more carbon per unit area compared to agricultural lands. (Brown & Pearce, 1994). In this way, forests play a crucial role in carbon sequestration, offering long-term potential for carbon storage as a sink. Estimating the total biomass and soil carbon stored in a forest is essential because it benefits the local population both economically and ecologically (Shrestha, 2009).

The REDD+ program aims to reduce emissions from deforestation and forest degradation by improving forest carbon stock assessment and monitoring, supporting reforestation projects, and helping developing countries meet global climate goals through reward-based systems (Muradian et al., 2013). Since 2008, Nepal has made significant progress in preparing for REDD+. However, Nepal faces significant challenges to effective participation because there is limited research on the scientific methods for measuring carbon stocks, monitoring changes over time, and establishing baseline scenarios for emission reduction evaluation (Acharya et al., 2009). Nepal's goal is to achieve net zero emissions between 2020 and 2030 and become entirely net

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zero by 2045 (Pradhan et al., 2018; Shakya et al., 2023). The key to lowering carbon emissions is management that focuses on increasing forests' role as carbon sinks.

Numerous studies show that Nepal's community-managed forests have significant potential for sequestering carbon (Carlson & Curran, 2009; Karky & Skutsch, 2010). Users of the forests are increasingly interested in learning about and utilizing the potential for carbon sequestration in this environment. Currently, more than 23000 Community Forest User Groups (CFUGs) have been established, representing 2.4 million households, or 35% of Nepal's total population, and they are responsible for managing 24,90,194 hectares of national forest that can store carbon (MoFE, 2020). Hope remains that, over time, the financial resources to support countries like Nepal in implementing climate mitigation and adaptation strategies will become more accessible (UNFCCC, 2015).

The geographical, physiographic, and cultural diversity of Nepal's terrain is reflected in its mainly agricultural and forested landscape. Because of its extensive physiographic features and wide climatic variations, Ilam district is exceptionally diverse in its plant species. Many tree species can transform a large amount of atmospheric carbon dioxide into biomass. This provides multiple benefits, both directly and indirectly, by sequestering atmospheric carbon dioxide in biomass and helping to reduce climate change. Since temperate (*Alnus, Castanopsis,* and others) and tropical (*Shorea robusta*) forests both store and reduce carbon emissions, they can be key allies in the effort to fight rising atmospheric carbon dioxide levels. The capability of its forests to store atmospheric carbon can help determine potential compensation for countries that need to protect forests beyond their own needs.

In Nepal, few studies directly focus on estimating carbon stocks in different forest categories. Research shows that carbon sequestration rates vary significantly among forest types and locations. For example, sub-tropical Sal forests in central Nepal sequester about 2.6 Mg ha^{-1} of carbon annually (Thapa-Magar & Shrestha, 2015). Similarly, riverine forests in the central tropical region and *Alnus nepalensis* forests in the central and western mid-hills have higher sequestration rates, ranging from 1.30 to 3.21 Mg ha^{-1}per year (Baral et al., 2009). Still, information on carbon stocks across various forest ecosystems in Nepal remains limited. Considering different physiographic zones in studying biomass and carbon yields valid comparative results. Therefore, the study aims to measure biomass carbon in two forest types and compare their roles in offsetting atmospheric carbon.

Materials and methods

Study area

The sites are located within two CFs in Ilam district (26°54′42.12″ N and 87°55′12.72″ E), Nepal: Pasupati Community Forest in Mai municipality, wards no. 1 & 2, and Deumai Namuna Community Forest in Deumai municipality, ward no. 1 (Figure 1). These two Community Forests represent the tropical and temperate regions. Pashupati Community Forest lies in the eastern tropical zone (200m-300m above mean sea level), while Deumai Namuna Community Forest is in the lower temperate zone (2100m-2700m above mean sea level). Pashupati Community Forest covers 200 hectares, and Deumai Namuna Community Forest spans 155.07 hectares. Tropical terai Sal (*Shorea robusta*) mixed hardwoods are the main tree species in Pashupati CF, whereas mixed species dominate in Deumai Namuna CF.

Data collection

Data collection for this study was based on the Community Forestry Inventory Guidelines (MoFSC, 2004). The data were collected using a stratified systematic sampling method with 1% sampling intensity. Stratification was conducted based on physical boundaries as documented in the Operational Plan of the forests, which divided the forest into different blocks. A total of 30 sampling plots were established in Deumai Namuna CF and 40 in Pashupati CF, with a consistent plot-to-plot distance of 224 meters. To measure the above-ground biomass of trees, poles, saplings, and seedlings, sample plots with concentric circular shapes and varying radii were selected and set up within the sampling area.

A 12.61-meter radius was designated as the outermost plot to evaluate above-ground tree biomass (AGTB). Above-ground pole biomass (AGPB) was measured within the subsequent inner plot with a 5.64-meter radius. Similarly, a 2.82-meter radius inner plot was established for counting regeneration. In these sample plots, measurements of DBH at 1.3 meters and total heights of poles, trees, and saplings were taken using diameter tapes and Suunto clinometers.

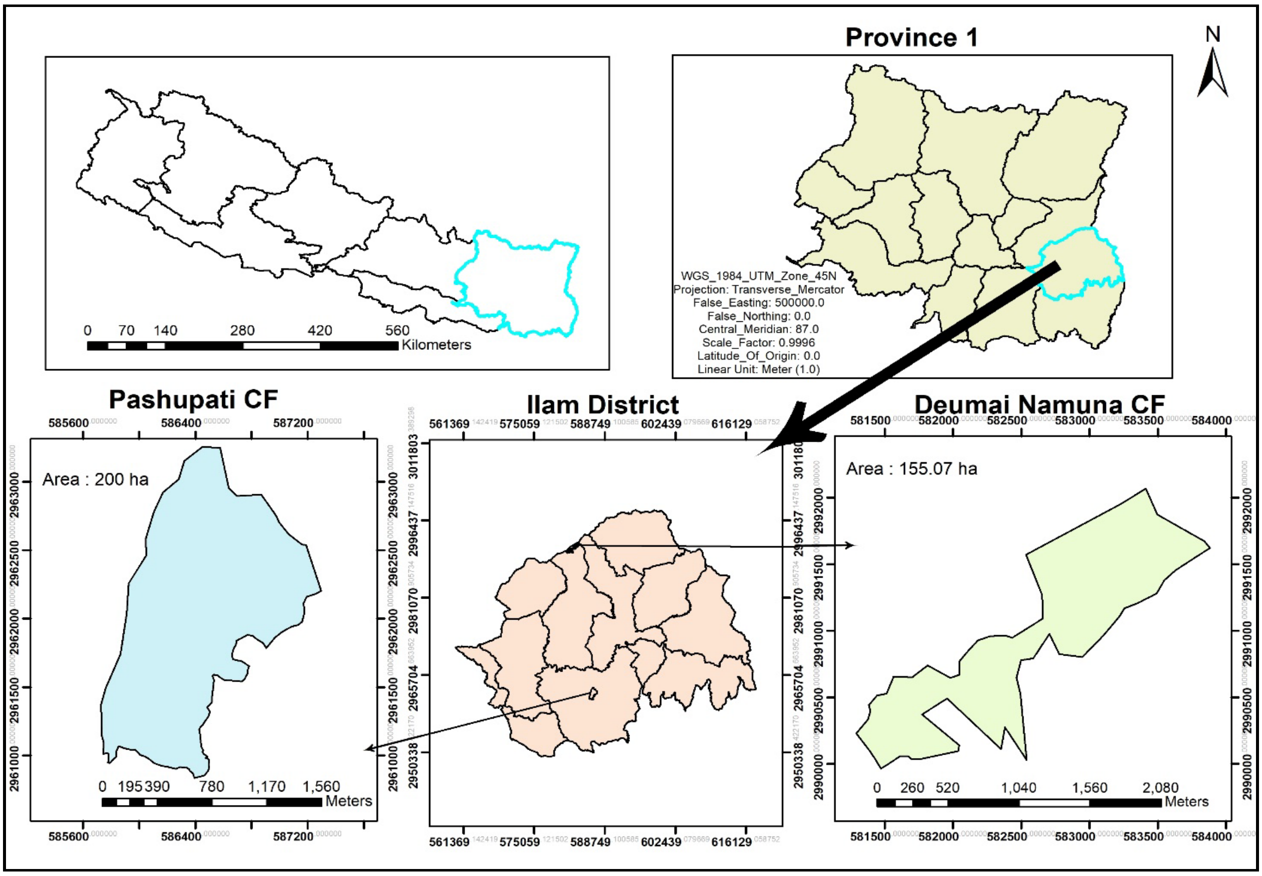

Figure 1: Map of Study Area

Data analysis

A simplified standard regression model incorporating DBH, height, and wood density was used to estimate tree biomass for calculating biomass and carbon stock according to the community forest carbon measurement guideline, which is based on average annual rainfall (Chave et al., 2005; Subedi et al., 2010). For species with unknown wood density, the empirical biomass equation developed by Zianis (2008) for global use was employed.

$$AGTB = 0.0509 * \rho D2 H \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

(Chave et al., 2005).

$$AGTB = a\,(dbh)b \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

(Zianis, 2008)

Where,
AGTB = Above-ground Tree Biomass (kg);
ρ = specific gravity of wood (g/cm^3),
D = dbh = diameter of the tree at breast height (cm);
H = height of the tree (meters).
a = 0.1424 and b= 2.3679

The aboveground biomass of saplings was estimated using a logarithmically transformed allometric formula (Tamrakar, 2000).

$$Log\,(AGSB) = a + b\,log\,(D) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

(Cairns et al., 1997; Tamrakar, 2000)

Where,
AGSB = above-ground sapling biomass (kg);
Log = natural logarithm
a = intercept of sapling allometry (no unit)
b = slope of sapling allometry (no unit)
D = stem diameter (cm)

Root to shoot ratios of 0.26 for the temperate region (Cairns et al., 1997) and 0.21 for lowland tropical forests (Malhi et al., 2014) were used to determine below-ground root biomass (BGRB). A default biomass-to-carbon conversion factor of 0.47 was employed to calculate carbon stock density. (IPCC, 2006). Overall, carbon was estimated by aggregating the carbon content from all distinct storage pools.

Results

Species richness

The forest was more diverse in the temperate region than in the tropical region in the Ilam district. During the inventory, the mid-hill forest contained a greater number of species than the Chure forest. In the field study, 22 species were recorded in Deumai Namuna CF, whereas 17 species were documented in Pashupati CF. Major species in Pashupati CF of the tropical zone included *Shorea robusta* (Sal), *Terminalia alata* (Saj), *Schima wallichi* (Chilaune), *Lagerstroemia parviflora* (Botdhayero), and *Adina cordifolia* (Karma). In Deumai Namuna CF of the temperate zone, dominant species were *Castanopsis* sp. (Kattus), *Quercus semecarpifolia* (Khasru), *Alnus nepalensis* (Utis), *Rhododendron arboreum* (Laligurans), and *Quercus lamellosa* (Bajrath) (see Figure 2 and Figure 3).

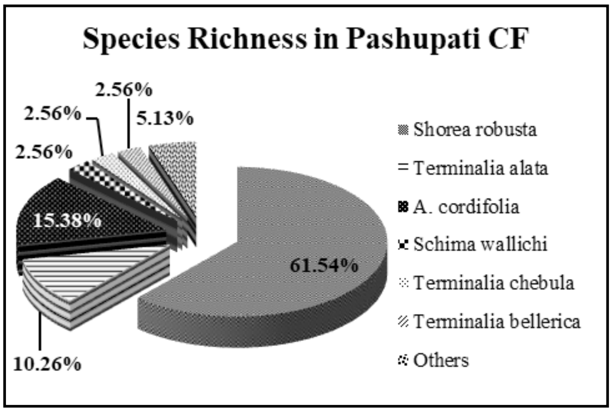

Figure 2: Species richness in Pashupati CF

Forest type and status

Tropical Sal (*Shorea robusta*) mixed hardwood and temperate mixed forest formed the significant part of the study area. Tree densities varied notably in the CFs examined. Pashupati CF had 44 trees and 103 poles per hectare, while Deumai Namuna CF had 55 trees and 193 poles per hectare. *Shorea robusta*

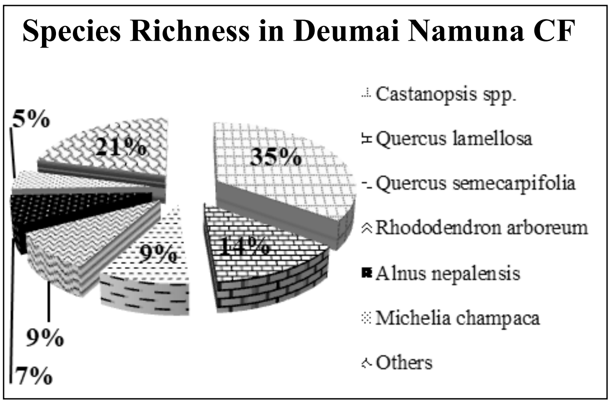

Figure 3: Species richness in Deumai Namuna CF

was the dominant species in Pashupati CF, whereas *Castanopsis indica* was the main species in Deumai Namuna CF. There was considerable variation in average diameter (p=0.38, α=0.05) and average height (p=0.20, α=0.05) among major species both CFs. General statistics for diameter and height in the two CFs are shown in Tables 1 and 2.

Biomass and carbon stock

Table 3 shows the biomass stock density of the two different forest types.

Carbon stock estimation

Overall vegetation carbon stock was calculated by adding the above-ground biomass carbon and below-ground biomass carbon of the two forest regions, showing that the mean carbon density was higher in the tropical forest (95 Mg/ha) than in the temperate forest (75.59 Mg/ha) (Table 4).

Table 1: Statistics of diameter and height of major species in Pashupati CF

Species	DBH (cm)			Height (m)		
	Average	Minimum	Maximum	Average	Minimum	Maximum
Shorea robusta	48.73	2.00	92.00	18.80	4.00	29.00
Terminalia alata	63.75	48.00	84.00	24.25	21.00	27.00
Schima wallichi	28.50	6.00	87.00	13.29	6.00	25.00
Lagerstormia parviflora	22.13	4.00	41.00	11.25	8.00	15.00
Adina cordifolia	70.00	51.00	93.00	21.50	15.00	25.00
Others	24.40	17.33	29.46	11.64	9.67	13.33
Overall	42.92	21.39	71.08	16.79	10.61	22.39

Table 2: Statistics of diameter and height of major species in Deumai Namuna CF

Species	DBH (cm)			Height (m)		
	Average	Minimum	Maximum	Average	Minimum	Maximum
Castanopsis indica	41.63	5.50	80.53	14.82	5.00	22.00
Quercus semecarpifolia	25.64	4.50	57.30	11.65	6.00	18.00
Alnus nepalensis	27.40	4.00	73.21	13.25	5.00	18.00
Rhododendron arboretum	29.30	6.00	56.02	11.69	7.00	15.00
Quercus lamellosa	55.64	9.00	89.13	17.38	8.00	22.00
Others	22.60	13.74	34.29	11.23	8.44	14.35
Overall	33.70	7.12	65.08	13.34	6.57	18.23

Table 3: Above-ground and below-ground biomass of CFs

CF	AGTB (Mg/ha)	AGPB (Mg/ha)	AGSB (Mg/ha)	Total AGB (Mg/ha)	BGB (Mg/ha)	Total Biomass (Mg/ha)	Total Carbon (Mg/ha)
Deumai Namuna CF	94.50	34.02	5.88	134.40	34.94	169.34	79.59
Pashupati CF	144.41	18.66	3.99	167.05	35.08	202.14	95.00

Note: AGTB- Above-ground tree biomass, AGPB- Above-ground pole biomass, AGSB- Above-ground sapling biomass, AGB- Above-ground biomass, BGB- Below-ground biomass

Table 4: Carbon stock in tropical and temperate forests

CFs	Aboveground Carbon stock (Mg/ha)	Belowground Carbon Stock (Mg/ha)	Total Carbon Stock (Mg/ha)
Pashupati CF	78.51	16.49	95
Deumai Namuna CF	63.17	16.42	75.59

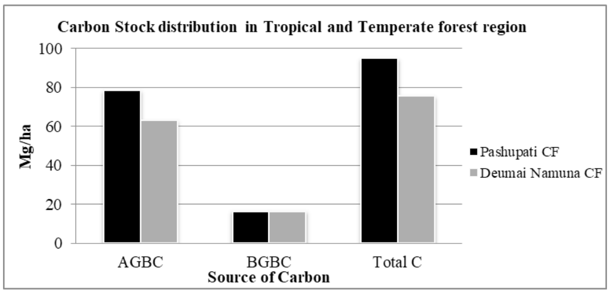

Figure 4: Aggregated stock (carbon) in varied carbon pools of differing forest regions

Carbon stock distribution with respect to DBH class and height class

In the tropical region, carbon stock was highest in the DBH class of 70-80 cm (26.52 Mg/ha), while in the temperate zone, the highest carbon stock was found in the 20-30 cm DBH class (14.15 Mg/ha). Similarly, the lowest amount of carbon stored was 0.83 Mg/ha in the 30-40 cm DBH class of the tropical forest and 2.48 Mg/ha in the 0-10 cm DBH class of the temperate forest (Figure 5).

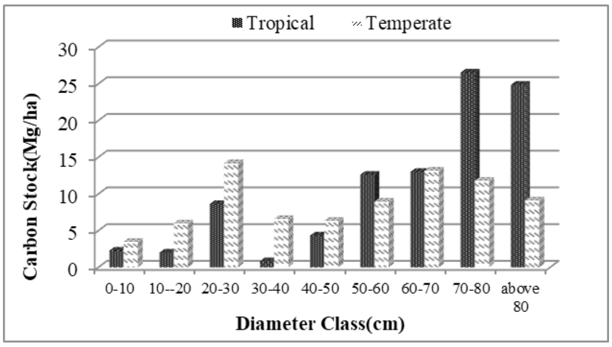

Figure 5: Carbon Stock with respect to DBH class

In Pashupati CF of the tropical zone, the highest carbon stock was in the 25-30 meter height class (38.77 Mg/ha), while in Deumai Namuna CF of the temperate zone, the highest carbon stock was in the 15-20 meter height class (31.78 Mg/ha). Similarly, the lowest stocking was found in the 0–5 m height class in both forests (Figure 6).

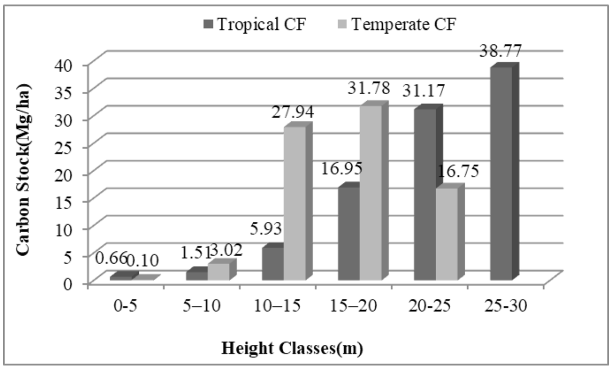

Figure 6: Carbon Stock with respect to Height class.

Carbon sequestered by different species

In Pashupati CF, which is a tropical forest, *Shorea robusta* (Sal) contributed the highest amount of carbon sequestration with a carbon stock of 63.01%. It was followed by *Adina cordifolia, Terminalia alata, Schima wallichi, Lagerstromia parviflora, T. chebula,* and *T. belerica*, which accounted for 12.61%, 9.78%, 4.51%, 2.59%, 2.04%, and 0.58% of the total carbon stock from trees, poles, and saplings, respectively. Similarly, other species contributed for 4.87% to carbon sequestration (Figure 7).

In Deumai Namuna CF, i.e., temperate forest, *Castanopsis* sp. (katus) stored the highest amount of carbon at 33.19%, followed by *Quercus lamellosa, Q. semecarpifolia, Alnus nepalensis, Rhododendron arboretum, Symplocos theifolia,* and *Michelia* sp. (Chanp), which sequestered 17.80%, 9.08%, 6.86%, 4.87%, 3.42%, and 1.46% of the total carbon stored by trees, poles, and saplings, respectively. Similarly, other species accounted for 27.33% of carbon sequestration (see Figure 8).

Carbon stocks comparison between tropical and temperate forests

The recorded carbon stock values from sample plots were analyzed to compare tropical and temperate

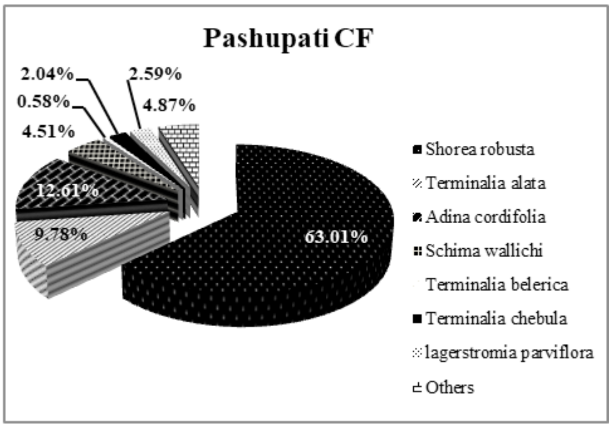

Figure 7: Carbon stock percentage in different species of tropical forest

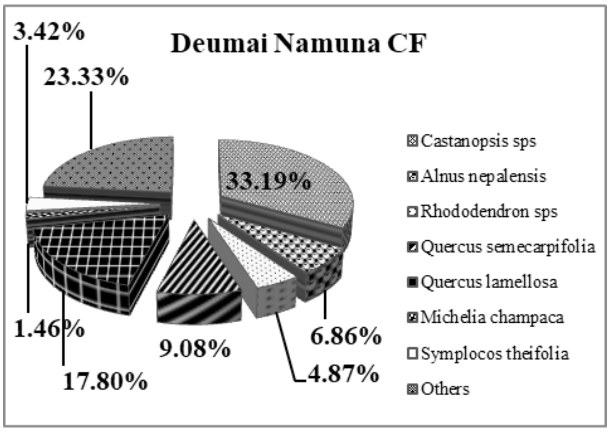

Figure 8: Carbon stock percentage in different species of temperate forest

forests. Welch's t-test showed no significant statistical differences in average carbon stock between the two forest types (t = 1.771, df = 63, p = 0.0814). Additionally, no significant relationship was found between carbon stock and diameter class. (t = 0.498, p = 0.6291) or height class (t = 0.01, p = 0.993) within either forest type (Table 5). These results suggest that variations in diameter and height classes do not significantly affect carbon stock differences between tropical and temperate forests.

Discussions

Biomass and carbon stock were higher in tropical forest than in temperate forests. As diameter increased , the biomass of the tree was also increased, indicating a direct positive relationship between DBH and biomass across tree components (Supriya Devi & Yadava, 2009). The amount of aboveground biomass in a forest is influenced by factors such as forest age, tree density, species type, and wood density (Shrestha & Devkota, 2013; Zhang et al., 2013; Sun et al., 2016). Therefore, the higher biomass value in the tropical region was due to the prevalence of older trees with larger diameters and greater heights. Additionally, tropical regions contained species with higher wood densities. Despite higher stem density in the temperate region, biomass was lower, as increased stem density does not necessarily lead to greater tree biomass (Khadanga & Jayakumar, 2020). Overall, forest biomass is considered an essential primary source of carbon stock.

The total biomass of the tree component was 169.34 Mg/ha in CFs of Chure (tropical) and and 202.14 Mg/ha in the mid-hill (temperate) regions. Shrestha (2009) reported a similar biomass amount of 183.29 Mg/ha in *Shorea robusta* forests, while the *Schima-Castanopsis* Forest studied had a much lower biomass of 80.4 Mg/ha. The Forest Resource Assessment published by DFRS in 2015 showed that the average aboveground biomass of Nepal is 172.21 Mg/ha in Chure and 143.26 Mg/ha the Mid-Hill regions, which aligns with this study. Baral et al. (2009) observed that the above-ground carbon content of *Shorea robusta* forests in the Mahabharat foothills was higher at 97.86 Mg/ha, while the *Schima-Castanopsis* and *Alnus nepalensis* forests had 76.24 Mg/ha and 76 Mg/ha, respectively. However, these data are from central Nepal, where variations in elevation, stand age, soil, and climate can influence the amount of carbon stored by the forests (Shrestha & Singh, 2008; Dar & Sundarapandian, 2015; Thapa-Magar & Shrestha, 2015). This study found that both forests sequester nearly equal amounts of carbon in their tree components. This result closely matches the national inventory carried out by the Department of Forest Research and Survey (DFRS, 2015), which reported an average carbon stock of 97.69 Mg/ha in the Chure region and 79.42 Mg/ha in the Middle Mountains. In contrast, Mandal et al. (2013) estimated an aboveground carbon stock of 116.72 Mg/ha and a belowground carbon stock of 15.12 Mg/ha in Mahottari District, which differs from the findings of this study.

Table 5: Carbon stocks comparison between tropical and temperate forest

S.N.	Forest	Test Parameters	t-value	P-value
1	Tropical Temperate	Carbon stock vs. Diameter Class	0.498	0.6291
2	Tropical Temperate	Carbon stock vs. Height Class	0.01	0.993

Shorea robusta had the most extensive carbon stock in tropical forests among the species studied. Chand et al. (2018) noted that *Shorea robusta* had the highest carbon pool among forest species. They also reported that carbon stock was higher in larger DBH classes (>80 cm and 70-80 cm) in the tropical region, which aligns with this study. However, in the temperate region, the highest carbon stock was found in the 20-30 cm diameter class, consistent with the forests of Golapara District, Assam (Rabha, 2014). In the temperate region, *Castanopsis* sp. sequesters the highest amount of carbon, and concluded that *Castanopsis* contributed the highest amount of carbon in the forest due to its dominance (Tripathi et al., 2018). Overall, the carbon pool in tropical *Shorea robusta*-dominated forests was higher than in temperate *Castanopsis-Quercus* forests. It is reported that both biomass and carbon stock decrease with increasing altitude (Moser et al., 2007; Sheikh et al., 2012). Although in some cases, carbon storage shows a positive correlation with altitude (Alves et al., 2010; Pragasan, 2022).

Conclusion

As a source of biomass and an essential carbon sink, tropical forests play a crucial role in addressing the world's environmental crisis. The carbon stored in forests showed variation across altitude, forest type, age, and wood density. Tropical forests store relatively more biomass carbon than temperate forests, due to the abundance of trees with larger diameters and heights. However, the temperate forests were more diverse than the tropical forests of Ilam district. No significant statistical differences were reported in the carbon accumulated by these forests in terms of diameter and height classes. Additionally, the presence of hardwood species with higher wood-specific gravity in tropical forests resulted in greater carbon stock. The study indicates that CFs in Nepal sequester a substantial amount of carbon, which may benefit future REDD+ initiatives. However, this research was limited to the biomass and carbon reservoirs of both temperate and tropical forests. Estimation of soil organic carbon was not included, even though soil contains a significant amount of carbon. This omission could affect the accuracy of the total carbon stock estimated in these forests. Broader studies covering larger geographical areas and diverse ecological zones are necessary to understand these findings better. Further research should also focus on soil organic carbon to enable stronger conclusions.

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Author's contribution

AP: Conceptualization, methodology, field work, validation, formal analysis, writing original draft, writing review & editing; **KPD**: Conceptualization, methodology, formal analysis, writing review & editing; supervision; **MJ**: Methodology, field work, formal analysis, writing review & editing; **STM**: Methodology, formal analysis, writing review & editing; **RK**: Methodology, validation, formal analysis, writing original draft, writing review & editing, correspondence.

Conflict of interests

The authors declare no conflict of interests.

References

Acharya, K. P., Dangi, R. B., Tripathi, D. M., Bushley, B. R., Bhandary, R. R., & Bhattarai, B. (2009). *Ready for REDD? Taking stock of experience, opportunities and challenges in Nepal*. Nepal Foresters' Association.

Alves, L. F., Vieira, S. A., Scaranello, M. A., Camargo, P. B., Santos, F. A. M., Joly, C. A., & Martinelli, L. A. (2010). Forest structure and live aboveground biomass variation along an elevational gradient of tropical Atlantic moist forest (Brazil). *Forest Ecology and Management, 260*(5), 679–691. https://doi.org/10.1016/j.foreco.2010.05.023

Baral, S. K., Malla, R., & Ranabhat, S. (2009). Above-ground carbon stock assessment in different forest types of Nepal. *Banko Janakari, 19*(2), 10–14.

Brown, K., & Pearce, D. (1994). The economic value of non-market benefits of tropical forests: Carbon storage. In *The economics of project appraisal and the environment* (pp. 102–123). Earthscan. https://www.cabdirect.org/cabdirect/abstract/19940604516

Cairns, M. A., Brown, S., Helmer, E. H., & Baumgardner, G. A. (1997). Root biomass allocation in the world's upland forests. *Oecologia, 111*(1), 1–11. https://doi.org/10.1007/s004420050201

Carlson, K. M., & Curran, L. M. (2009). REDD pilot project scenarios: Are costs and benefits altered by spatial scale? *Environmental Research Letters, 4*(3), 031003. https://doi.org/10.1088/1748-9326/4/3/031003

Chand, H. B., Singh, H., & Chhetri, R. (2018). Carbon sequestration potential in Sahid Smriti community forest: A case study of Terai region of Nepal. In *Proceedings of the International Conference on Agriculture and Allied Sciences: The Productivity, Food Security and Ecology* (pp. 108–113).

Chave, J., Andalo, C., Brown, S., Cairns, M. A., Chambers, J. Q., Eamus, D., Fölster, H., Fromard, F., Higuchi, N., Kira, T., Lescure, J.-P., Nelson, B. W., Ogawa, H., Puig, H., Riéra, B., & Yamakura, T. (2005). Tree allometry and improved estimation of carbon stocks and balance in tropical forests. *Oecologia, 145*(1), 87–99. https://doi.org/10.1007/s00442-005-0100-x

Dar, J. A., & Sundarapandian, S. (2015). Variation of biomass and carbon pools with forest type in temperate forests of Kashmir Himalaya, India. *Environmental Monitoring and Assessment, 187*(2), 55. https://doi.org/10.1007/s10661-015-4299-7

DFRS. (2015). *State of Nepal's forests* (Forest Resource Assessment Nepal, Publication No. 5). Government of Nepal.

FAO. (2011). *FAO glossary of terms*. FAO. http://www.fao.org/faoterm

Huang, L., Zhou, M., Lv, J., & Chen, K. (2020). Trends in global research in forest carbon sequestration: A bibliometric analysis. *Journal of Cleaner Production, 252,* 119908. https://doi.org/10.1016/j.jclepro.2019.119908

IPCC. (2006). *Good practice guidelines for national greenhouse gas inventories*. IPCC.

Jindal, R., Swallow, B., & Kerr, J. (2008). Forestry-based carbon sequestration projects in Africa: Potential benefits and challenges. *Natural Resources Forum, 32*(2), 116–130. https://doi.org/10.1111/j.1477-8947.2008.00176.x

Karky, B. S., & Skutsch, M. (2010). The cost of carbon abatement through community forest management in Nepal Himalaya. *Ecological Economics, 69*(3), 666–672. https://doi.org/10.1016/j.ecolecon.2009.10.004

Khadanga, S. S., & Jayakumar, S. (2020). Tree biomass and carbon stock: Understanding the role of species richness, elevation, and disturbance. *Tropical Ecology, 61*(1), 128–141. https://doi.org/10.1007/s42965-020-00070-0

Malhi, Y., Farfán Amézquita, F., Doughty, C. E., Silva-Espejo, J. E., Girardin, C. A. J., Metcalfe, D. B., Aragão, L. E. O. C., Huaraca-Quispe, L. P., Alzamora-Taype, I., Eguiluz-Mora, L., Marthews, T. R., Halladay, K., Quesada, C. A., Robertson, A. L., Fisher, J. B., Zaragoza-Castells, J., Rojas-Villagra, C. M., Pelaez-Tapia, Y., Salinas, N., … Phillips, O. L. (2014). The productivity, metabolism and carbon cycle of two lowland tropical forest plots in south-western Amazonia, Peru. *Plant Ecology & Diversity, 7*(1–2), 85–105. https://doi.org/10.1080/17550874.2013.820805

Mandal, R. A., Dutta, I. C., Jha, P. K., & Karmacharya, S. (2013). Relationship between carbon stock and plant biodiversity in collaborative forests in Terai, Nepal. *ISRN Botany, 2013,* Article 625767. https://doi.org/10.1155/2013/625767

MoFE. (2020). *Current status of community-based forest management models in Nepal*. Ministry of Forests and Environment, Singhadurbar, Kathmandu.

MoFSC. (2004). *Community forest resource inventory guideline*. Department of Forests.

Moser, G., Hertel, D., & Leuschner, C. (2007). Altitudinal change in LAI and stand leaf biomass in tropical montane forests: A transect study in Ecuador and a pan-tropical meta-analysis. *Ecosystems, 10*(6), 924–935. https://doi.org/10.1007/s10021-007-9063-6

Muradian, R., Arsel, M., Pellegrini, L., Adaman, F., Aguilar, B., Agarwal, B., Corbera, E., Ezzine de Blas, D., Farley, J., Froger, G., Garcia-Frapolli, E., Gómez-Baggethun, E., Gowdy, J., Kosoy, N., Le Coq, J. F., Leroy, P., May, P., Méral, P., Mibielli, P., … Urama, K. (2013). Payments for ecosystem services and the fatal attraction of win-win solutions. *Conservation Letters, 6*(4), 274–279. https://doi.org/10.1111/j.1755-263X.2012.00309.x

Nugroho, Y., Suyanto, S., Makinudin, D., Aditia, S., Yulimasita, D. D., Afandi, A. Y., Harahap, M. M., Matatula, J., & Wirabuana, P. Y. A. P. (2022). Vegetation diversity, structure and composition of three forest ecosystems in Angsana coastal area, South Kalimantan, Indonesia. *Biodiversitas Journal of Biological Diversity, 23*(5). https://doi.org/10.13057/biodiv/d230547

Pradhan, B. B., Shrestha, R. M., Pandey, A., & Limmeechokchai, B. (2018). Strategies to achieve net zero emissions in Nepal. *Carbon Management, 9*(5), 533–548. https://doi.org/10.1080/17583004.2018.1536168

Pragasan, L. A. (2022). Tree carbon stock and its relationship to key factors from a tropical hill forest of Tamil Nadu, India. *Geology, Ecology, and Landscapes, 6*(1), 32–39. https://doi.org/10.1080/24749508.2020.1742510

Rabha, D. (2014). Aboveground biomass and carbon stocks of an undisturbed regenerating Sal (*Shorea robusta* Gaertn. f.) forest of Goalpara district, Assam, northeast India. *International Journal of Environment, 3*(4), 147–155. https://doi.org/10.3126/ije.v3i4.11743

Raihan, A. (2024). A review of forest's contribution to mitigating climate change. In *Proceedings of the International Conference on Forests and Climate Change.*

Salunkhe, O., Khare, P. K., Kumari, R., & Khan, M. L. (2018). A systematic review on the aboveground biomass and carbon stocks of Indian forest ecosystems. *Ecological Processes, 7*(1), 17. https://doi.org/10.1186/s13717-018-0130-z

Shakya, S. R., Nakarmi, A. M., Prajapati, A., Pradhan, B. B., Rajbhandari, U. S., Rupakheti, M., & Lawrence, M. G. (2023). Environmental, energy security, and energy equity (3E) benefits of net-zero emission strategy in a developing country: A case study of Nepal. *Energy Reports, 9,* 2359–2371. https://doi.org/10.1016/j.egyr.2023.01.053

Sheikh, M. A., Kumar, S., & Kumar, M. (2012). Above- and below-ground organic carbon stocks in a sub-tropical *Pinus roxburghii* Sargent forest of the Garhwal Himalayas. *Forestry Studies in China, 14*(3), 205–209. https://doi.org/10.1007/s11632-012-0305-0

Shrestha, B. P. (2009). Carbon sequestration in broad leaved forests of mid-hills of Nepal: A case study from Palpa district. *The Initiation, 3,* 20–29.

Shrestha, B. P., & Devkota, B. P. (2016). Carbon stocks in the oak and pine forests in Salyan district, Nepal. *Banko Janakari, 23*(2), 30–36. https://doi.org/10.3126/banko.v23i2.15478

Shrestha, B. M., & Singh, B. R. (2008). Soil and vegetation carbon pools in a mountainous watershed of Nepal. *Nutrient Cycling in Agroecosystems, 81*(2), 179–191. https://doi.org/10.1007/s10705-007-9148-9

Subedi, B. P., Pandey, S. S., Pandey, A., Rana, E. B., Bhattarai, S., Banskota, T. R., Charmakar, C., & Tamrakar, R. (2010). *Guidelines for measuring carbon stocks in community-managed forests*. ANSAB, FECOFUN, ICIMOD, & NORAD.

Sun, X., Wang, G., Huang, M., Chang, R., & Ran, F. (2016). Forest biomass carbon stocks and variation in Tibet's carbon-dense forests from 2001 to 2050. *Scientific Reports, 6,* 34687. https://doi.org/10.1038/srep34687

Supriya Devi, L., & Yadava, P. S. (2009). Aboveground biomass and net primary production of semi-evergreen tropical forest of Manipur, north-eastern India. *Journal of Forestry Research, 20*(2), 151–155. https://doi.org/10.1007/s11676-009-0026-y

Suryawanshi, M. N., Patel, A. R., Kale, T. S., & Patil, P. R. (2014). Carbon sequestration potential of tree species in the environment of North Maharashtra University campus, Jalgaon (MS), India. *Bioscience Discovery, 5*(2), 175–179.

Tamrakar, P. R. (2000). *Biomass and volume tables with species description for community forest management*. His Majesty's Government of Nepal, Ministry of Forests and Soil Conservation.

Thapa-Magar, K. B., & Shrestha, B. B. (2015). Carbon stock in community-managed hill Sal (*Shorea robusta*) forests of central Nepal. *Journal of Sustainable Forestry, 34*(5), 483–501. https://doi.org/10.1080/10549811.2015.1025082

Tripathi, S., Thapa, C. B., Sharma, A., & Paudel, G. (2018). Biomass carbon content in Schima-Castanopsis forest of mid-hills of Nepal: A case study from Jaisikuna community forest, Kaski. *International Journal of Environment, 6*(4), 72–83. https://doi.org/10.3126/ije.v6i4.18911

UN. (2017). *United Nations strategic plan for forests, 2017–2030*. UN.

UNFCCC. (2015). *Paris COP 21: Information hub*. http://unfccc.int/focus/climate_finance/items/7001.php

Zhang, C., Ju, W., Chen, J. M., Zan, M., Li, D., Zhou, Y., & Wang, X. (2013). China's forest biomass carbon sink based on seven inventories from 1973 to 2008. *Climatic Change, 118*(3), 933–948. https://doi.org/10.1007/s10584-012-0666-3

Zianis, D. (2008). Predicting mean aboveground forest biomass and its associated variance. *Forest Ecology and Management, 256*(6), 1400–1407. https://doi.org/10.1016/j.foreco.2008.07.002