PLANT SCIENCE TODAY
Vol 13(sp1): 01–08
https://doi.org/10.14719/pst.12590

eISSN 2348-1900

RESEARCH ARTICLE

Evaluation of soil and biomass carbon stock across different land use systems in the Vitalapura sub-watershed, Kadur taluk, Chikkamagaluru district-Karnataka, India

Sushma N[1*], Ganapathi[1], Ravikumar D[1], SB Salimath[1], Sridhar R[2] & RD Barker[3]

[1]Department of Soil Science, College of Agriculture Shivamogga, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Iruvakki 577 412, Karnataka, India

[2]Department of Fruit Science, College of Horticulture Mudigere, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Iruvakki 577 412, Karnataka, India

[3]Department of Agricultural Engineering, College of Horticulture Babbur Farm Hiriyur, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Iruvakki 577 412, Karnataka, India

*Correspondence email - sushmanagaraj.work@gmail.com

Received: 05 November 2025; Accepted: 06 December 2025; Available online: Version 1.0: 21 January 2026

Cite this article: Sushma N, Ganapathi, Ravikumar D, Salimath SB, Sridhar R, Barker RD. Evaluation of soil and biomass carbon stock across different land use systems in the Vitalapura sub-watershed, Kadur taluk, Chikkamagaluru district-Karnataka, India. Plant Science Today. 2026;13(sp1):01–08. https://doi.org/10.14719/pst.12590

Abstract

Carbon stock assessment studies at the watershed level remain limited due to the absence of standardized methodologies, leading to inconsistent and incomparable estimates across ecosystems. The present study evaluated carbon stock distribution across major land cover types in the Vitalapura sub-watershed of Kadur Taluk, Chikmagaluru District, using high-resolution QuickBird satellite imagery (0.61 m) combined with ground-truthing. The identified land cover categories included agricultural land (21.82 %), coconut plantation (16.67 %) and forest (0.45 %). Statistical analysis revealed significant variations in biomass and carbon pools among these land covers. Forests recorded the highest above ground biomass (104.29 Mg ha^{-1}), below ground biomass (28.16 Mg ha^{-1}) and total carbon stock (208.29 Mg C ha^{-1}), while agricultural lands showed the lowest values. Soil organic carbon (SOC) was also greatest in forests (146.04 Mg ha^{-1}) and least in agricultural land (77.88 Mg ha^{-1}). Although forests had the highest per-hectare carbon stock, their limited spatial extent restricted their contribution to only 2 % of the total carbon stock. By contrast, coconut plantations and agricultural land, owing to their wider distribution, contributed 56 and 42 % of the total carbon stock, respectively. These findings demonstrate the critical role of land cover in regulating carbon sequestration potential. The study highlights the significance of coconut plantations as a major carbon pool in the sub-watershed and the comparatively reduced contribution of forests due to their limited area. Overall, the results emphasise the need for sustainable land use planning and management strategies that enhance carbon storage, conserve existing forest patches and optimise agricultural and plantation systems for improved carbon sequestration in the region.

Keywords: carbon sequestration; carbon stock; land use; soil organic carbon

Introduction

Vegetation and forests are integral components of the Earths' biosphere, playing a pivotal role in regulating the global carbon cycle. Through the process of photosynthesis, forests sequester atmospheric carbon dioxide (CO_2), a major greenhouse gas and store it in biomass and soil. This sequestration not only mitigates the impact of climate change but also influences energy and mass exchanges, thereby sustaining life on the planet (1). However, the escalating levels of CO_2 and other greenhouse gases in the atmosphere, primarily due to fossil fuel combustion, industrialisation and deforestation over the past 150 years, have intensified the greenhouse effect, leading to global warming and climate disruptions (2).

The Earths' carbon cycle is governed by complex interactions among its primary carbon reservoirs-vegetation, soil and oceans. These reservoirs can function as carbon sinks, absorbing more carbon than they release, or as sources, releasing stored carbon back into the atmosphere, depending on various factors such as land use, management practices and ecological conditions (3). Vegetation and soil are particularly dynamic reservoirs, with their carbon content being heavily influenced by land management practices and land use changes. Globally, forests play a crucial role in mitigating climate change by acting as carbon sinks. They absorb approximately 16 billion MT of CO_2 annually and currently store about 861 GT of carbon in their biomass and soils (1). This storage capacity is equivalent to nearly a centuries worth of current annual fossil fuel emissions. However, the ability of forests to sequester carbon is being threatened by deforestation, forest degradation and climate change. In 2023, global CO_2 emissions from fossil fuels reached a record high of 37.4 BT, underscoring the urgent need for effective carbon management strategies (2).

Carbon stock assessment is an essential tool for quantifying the amount of carbon stored across various land uses, including agriculture, forestry, horticulture and urban areas within a watershed. Such assessments provide valuable insights into how land management practices affect carbon dynamics and help in identifying strategies to enhance carbon sequestration (4, 5). For instance, a study focusing on watershed carbon stocks found that carbon storage increased by approximately 15.9 teragram from 1980 to 2020, with factors such as fractional vegetation cover and mean annual temperature influencing carbon stocks (4). By understanding the spatial distribution and magnitude of carbon stocks, carbon stock assessment supports the development of effective carbon management strategies, facilitates climate change mitigation and promotes sustainable ecosystem management.

Carbon sequestration plays a crucial role in mitigating climate change by capturing and storing atmospheric CO_2 in vegetation and soils. Forest ecosystems act as major carbon sinks, helping to offset greenhouse gas emissions and stabilise global temperatures (6). Maintaining high soil organic carbon (SOC) is vital for improving soil health, fertility and long-term carbon storage. Forest soils, with minimal disturbance and rich organic inputs, store more carbon than managed lands. Thus, enhancing forest carbon pools is essential for reducing climate abnormalities and promoting ecosystem resilience (6, 7).

Despite the recognized importance of forests as major carbon sinks, there remains a limited quantitative understanding of how different forest types and soil depths contribute to soil organic carbon storage under varying management and disturbance regimes. In particular, region-specific data on the distribution, stability and drivers of forest soil carbon pools are scarce, constraining accurate carbon budgeting and the development of effective climate-mitigation strategies (7).

Materials and Methods

The present study was conducted in the Vitalapura sub-watershed, located within the Lower Tungabhadra catchment of the Krishna Basin in Karnataka, India. The sub-watershed lies entirely within Chikkamagaluru district and extends geographically from 13°35′00″ N to 13°37′00″ N latitude and 76°12′00″ E to 76°15′00″ E longitude (Fig. 1). Geologically, the study area is dominated by the Peninsular Gneissic Complex, which is uniformly distributed across the sub-watershed. Stratigraphic analysis indicates that the lithological formations belong to the Archean and Proterozoic eras, reflecting multiple stages of geological evolution. The dominant rock types include granite (76.36 %) and migmatites with granodiorite-tonalitic gneiss (23.63 %).

The terms land use and land cover (LULC), though often used interchangeably, represent distinct concepts. Land cover refers to the physical features present on the Earth's surface, whereas land use denotes human activities associated with these features. While field-based land cover mapping is feasible for small and easily accessible areas, such approaches become impractical in regions with limited accessibility. Advances in geospatial technologies, coupled with the reduced cost of satellite data, have made remote sensing (RS) and geographic information system (GIS) techniques effective tools for generating spatial information on natural resources. In the present study, LULC information was derived using high-resolution QuickBird satellite imagery (0.61 m spatial resolution), supplemented by ground truth verification (Fig. 2 and Table 1).

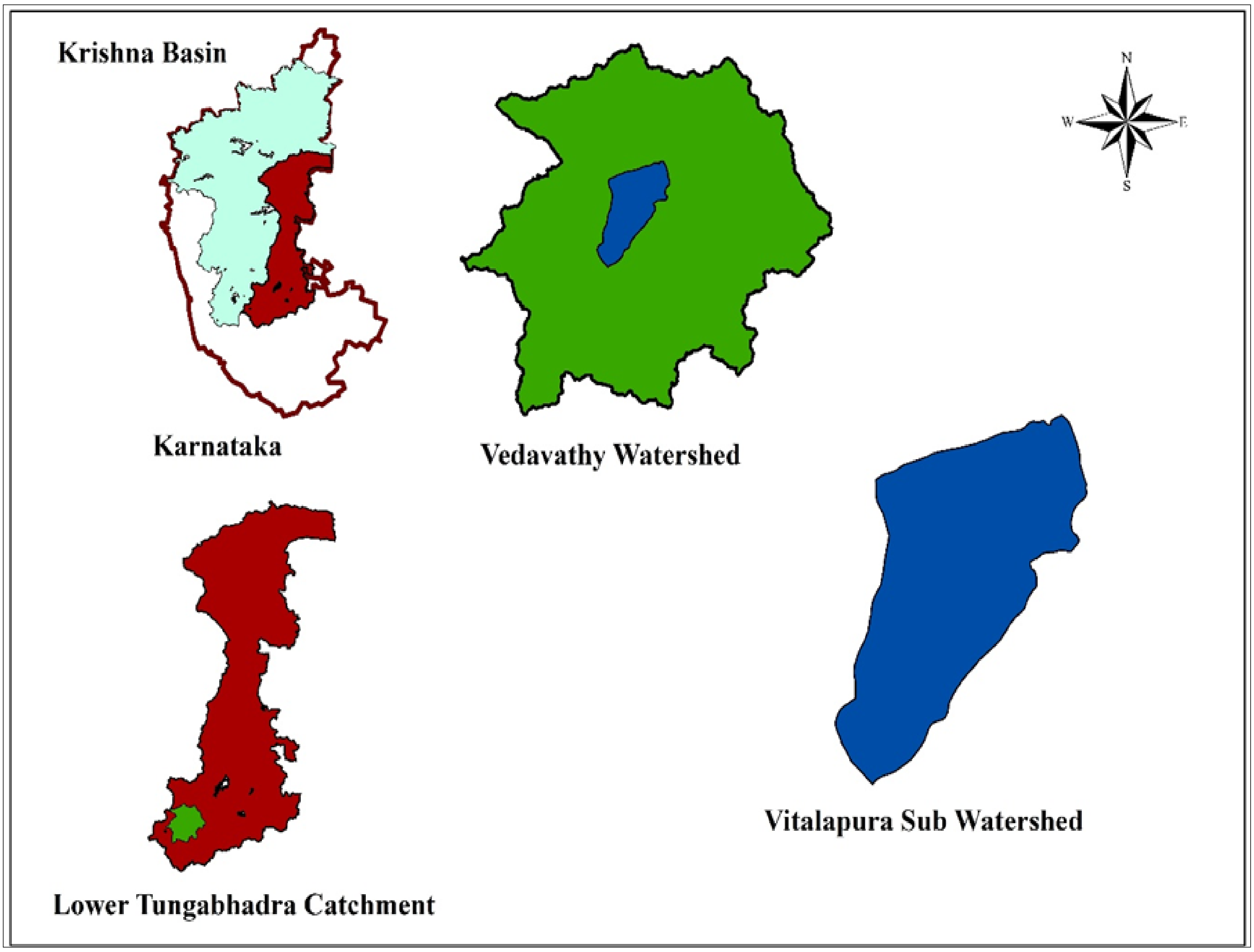

Fig. 1. Location map of the study area.

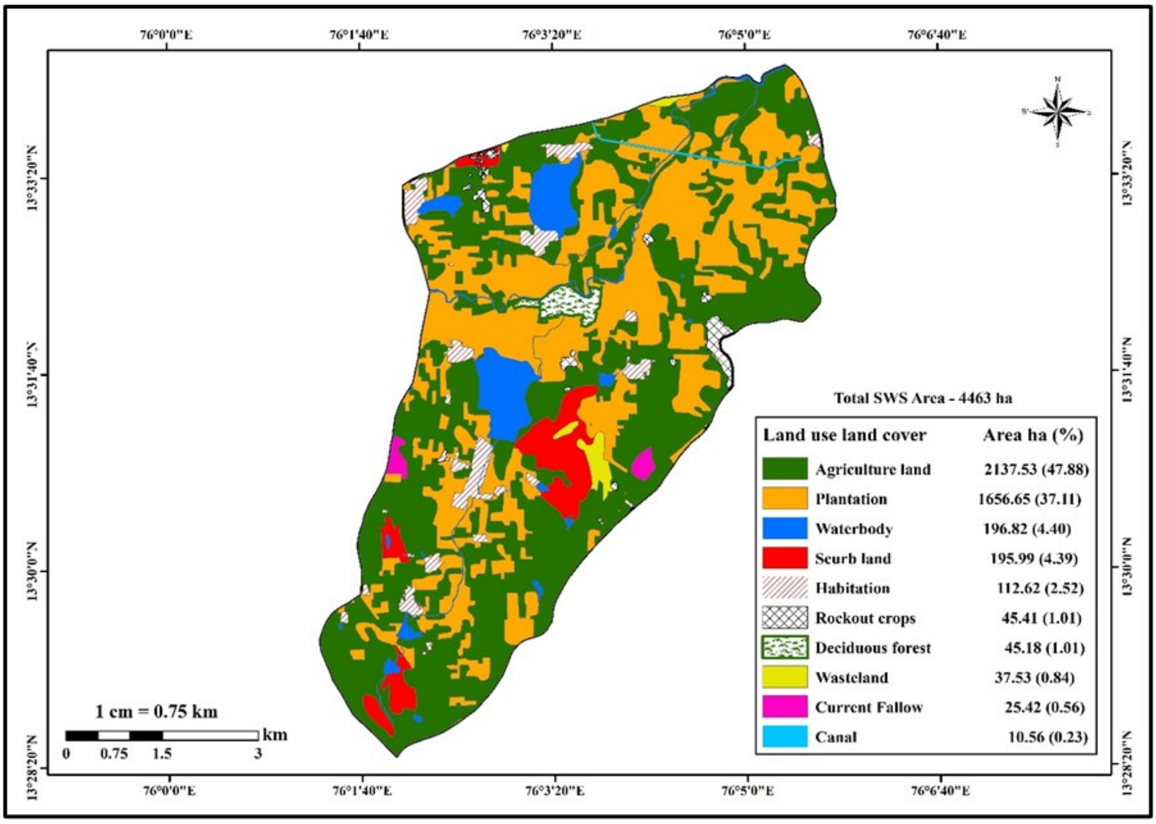

Fig. 2. Current land use land cover map of the Vitalapura sub-watershed.

Table 1. Location map of the study area

Land use land cover type	Area (ha)	Area (%)
Agriculture land	2137.53	47.88
Plantation	1656.65	37.11
Water body	196.82	4.40
Scrub land	195.99	4.39
Habitation	112.62	2.52
Rock out crops	45.41	1.01
Deciduous forest	45.18	1.01
Waste land	37.53	0.84
Current fallow	25.42	0.56
Canal	10.56	0.23

Note: % of TGA= percentage of total sub-watershed area

For carbon stock assessment, major land cover categories- namely forest, plantation (coconut/arecanut) and agricultural land were identified. A total of ten sampling plots, each measuring 20 × 20 m, were randomly distributed within each land cover type to capture spatial heterogeneity. The spatial distribution of the sampling plots is illustrated in Fig. 3. Standard field procedures were followed to estimate biomass components within each land cover category, as prescribed by the International Centre for Research in Agroforestry (ICRAF) (8). Field data collection and biomass estimation were carried out using standard instruments and equipment to ensure accuracy and consistency in measurements across all sampling plots.

Instruments used in the study

The instruments employed during fieldwork included a global positioning system (GPS), Ravi altimeter, soil auger and weighing balance. A hot air oven was used for drying herb and shrub samples prior to biomass estimation. The layout of the sampling plots established for biomass estimation across different land use systems is shown in Fig. 4.

Carbon stock in major land cover types

Agriculture (based on the current Rabi or Kharif crop)

To estimate crop biomass, a destructive method was used. Plots of 1 × 1 m were laid on four corners and the centre of the 20 × 20 m square plot. Agriculture crops in the sample plots were harvested and the fresh weight was taken. From each of these five subplots of 1 × 1 m, one kg of crop was taken and oven dried further recorded the dry biomass (9).

$$\text{Above ground biomass (AGB) (Mg ha}^{-1}\text{) dry weight} = \frac{\text{Dry weight of the sub - sample}}{\text{Fresh weight of the sub - sample}} \times \text{Fresh weight of whole sample} \quad \text{(Eqn. 1)}$$

Below ground biomass (BGB) suggests that the below ground biomass is close to 27 % of the total AGB. So, below ground biomass is obtained by multiplying AGB by 0.27 (10).

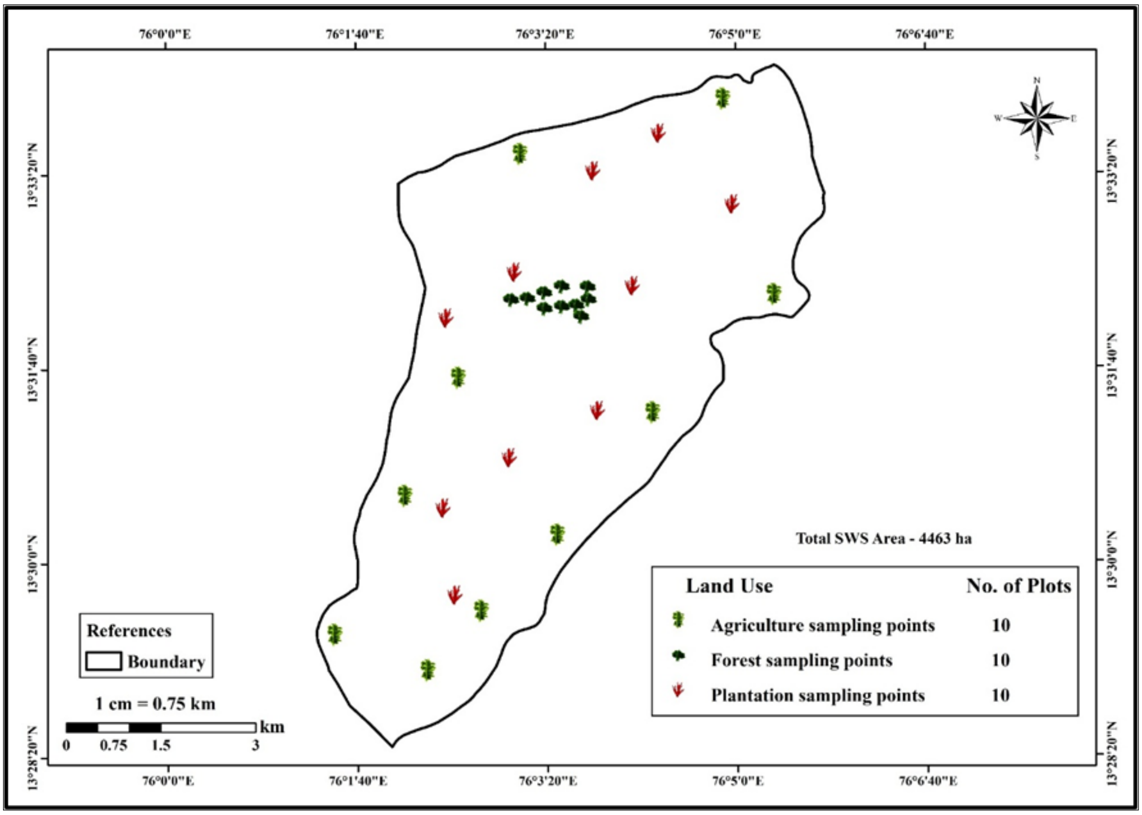

Fig. 3. Spatial distribution of sample plots for carbon stock in the Vitalapura sub-watershed.

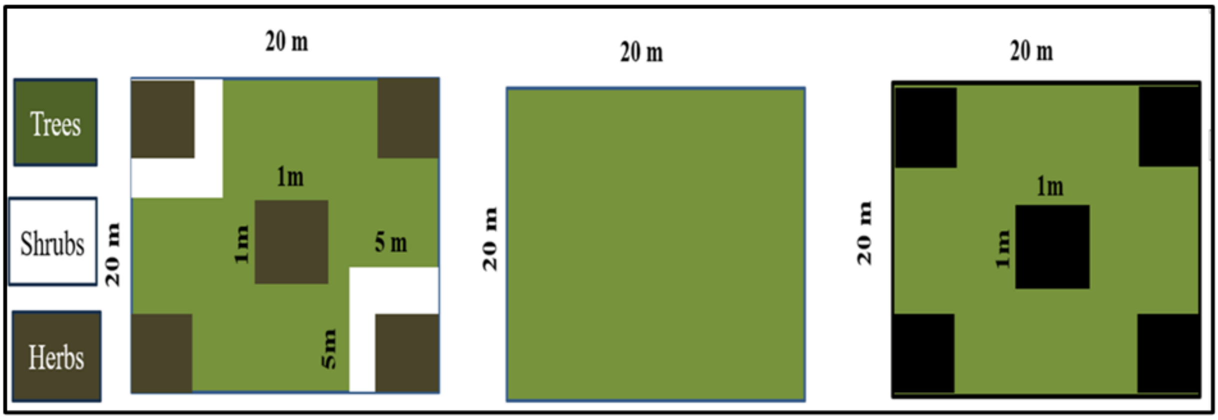

Fig. 4 (A-C). Diagrams showing the sampling method in forest, plantation and agricultural land use, respectively.

Total biomass (Mg ha^{-1}) = AGB + BGB (Eqn. 2)

Where, AGB = Above ground biomass and BGB = Below ground biomass

The total carbon stock is determined by multiplying the total biomass by a factor of 0.47 and expressed in Mg C ha^{-1} (11).

Carbon stock = Total biomass x 0.47 (Eqn. 3)

The organic carbon concentration in the soil was converted to total SOC (Eqn. 4) (12).

$$\text{Total soil organic carbon stock} = \frac{\%\,\text{SOC}}{100}\,(\text{BD x 2000}) \qquad \text{(Eqn. 4)}$$

Where, SOC= Soil organic carbon and BD = Bulk density

Total carbon stock =

Total biomass carbon stock + Total organic carbon stock (Eqn. 5)

Biomass estimation of trees

The biomass of trees was estimated by a non-destructive method. In the forest total of 10 sample plots of 20 × 20 m were laid randomly. Height and girth breast height at breast height of all the trees having girth breast height (GBH) above 10 cm were measured. Height was measured using a Ravi altimeter and GBH was measured using a tape at a height of 1.37 m from the ground surface (12). Species-specific volume equations were used to derive the volume of trees. Volume is multiplied by species-specific wood density to get the biomass.

Biomass estimation of shrubs

The biomass of shrubs was estimated using a destructive method. Two quadrats, each of 5 × 5 m size were laid in each of the sample plots. All shrubs in the sample plot were harvested, oven-dried and the dry weight was estimated (12).

Biomass estimation of herbs

A destructive method was followed for biomass estimation of herbs (12). Two quadrats, each of 1 m × 1 m, were laid in each of the sample plots. All herbs in the sample plot were harvested, oven-dried and the dry weight was taken.

The formula for estimation of above ground biomass and volume is described below.

Above ground tree biomass =

Volume x Specific gravity x BEF (Eqn. 6)

Where, BEF= Biomass expansion factor

Volume = Basal area x Height x Form factor (Eqn. 7) (13)

Where, Form factor = 0.33

The species-specific wood density for tree biomass was collected from International Centre for Research in Agroforestry (ICRAF) and global wood density database.

AGB = AGTB + Shrub biomass + Herb biomass (Eqn. 8)

Where, AGB= Above ground biomass, AGTB= Above ground tree biomass

Estimation of below ground tree biomass: Below-ground biomass is close to 27 % of the total above-ground biomass (Eqn. 9).

BGB (Mg ha^{-1}) = AGB x 0.27 (Eqn. 9)

Where, BGB = Below ground biomass, AGB= Above ground biomass

The organic carbon concentration in the soil was converted to total SOC stock is same as Eqn. 4.

Plantation (coconut /arecanut)

10 random square plots of 20 × 20 m were laid for estimation of the above ground standing biomass; a non-destructive method was adopted. Trees in the plot were measured, i.e., girth (cm) was measured at 1.3 m height from the base using measuring tape and height (m) was measured using Ravi altimeter and was recorded for each plot. The diameter (d) was calculated by dividing π (3.14) by the actual marked girth of the species and 50 composite soil samples were collected at five varying depths (14).

Carbon stock estimation

Above ground biomass (AGB) was estimated by multiplying the height, girth and factor 41.141412 (15).

AGB (Mg ha^{-1}) = Height (m) x Girth (m^2) x4 1.141 (Eqn. 10)

Estimation of BGB: Below ground biomass is close to 50 % of the total AGB as per equation 11 (16).

BGB (Mg ha^{-1}) = AGB x 0.5 (Eqn. 11)

Statistical analysis

Plenty of commercial and open-source software are present in the RS and GIS domain for image analysis and land and water resource studies. They are well equipped with modern tools and techniques, with that absolute and near real- time problems can be solved in less time. For this study, we have used ArcGIS 10.8 for the preparation of land use land cover for carbon pool assessment, OPSTAT was used and subjected to one-way analysis of variance (ANOVA) statistical analysis. And post hoc analysis of DMRT test was conducted to find the significant difference in various land use systems as treatment.

Results

Carbon stock in major land cover types

The statistical one-way analysis revealed that there were significant differences in above ground biomass in various land covers in the sub-watershed area, as outlined in Table 2. The highest above ground biomass was recorded in the forest at 104.29 Mg ha^{-1} and the least was observed in agricultural land cover at 0.27 Mg ha^{-1}. A similar trend was followed in the BGB parameter also. The findings indicated that the highest below ground biomass value of 28.16 Mg ha^{-1} was observed in the forest, while the lowest value of 0.07 Mg ha^{-1} was observed in agricultural land cover. There was a significant difference observed among all land covers, as shown in Table 2. The total biomass parameter has significant differences in all the land covers. Notably, the highest total biomass was present in the forest at 132.45 Mg ha^{-1} and the least was observed in agricultural land cover at 0.35 Mg ha^{-1} (Table 2).

In terms of the above ground carbon stock showed significant differences were shown among all the land covers of the sub-watershed area. While forest land cover recorded the highest value at 62.25 Mg C ha^{-1}, the least above ground carbon stock was recorded in agricultural land cover at 0.16 Mg C ha^{-1}, as represented in Table 2. In the SOC parameter, the highest SOC level of 146.04 Mg ha^{-1} was recorded in the forest, while the least was observed in agricultural land cover at 77.88 Mg ha^{-1} (Table 2). There was no significant difference between the coconut plantation and agricultural land cover.

The results showed significant differences in the total carbon stock in all major land cover types of the sub-watershed area, among these, the highest carbon stock of 208.29 Mg C ha^{-1} was observed in forest, while the lowest value of 78.04 Mg C ha^{-1} was recorded in agricultural land cover, as presented in Table 2. It can be inferred from the study that in the Vitalapura sub-watershed area, the coconut plantation contributed the highest share of the carbon pool (56 %). Followed by agricultural land cover (42 %) and forest (2 %), owing to its smallest extent of area.

Discussion

Area under LULC

The area of Kadur taluk, Chikkamagalur district resulted in 47.88 % of the area categorised under agriculture, followed by plantation of the

Table 2. Carbon stocks in major land cover types of the Vitalapura sub-watershed

Major land cover types	Above ground biomass (Mg ha^{-1})	Below ground biomass (Mg ha^{-1})	Total biomass (Mg ha^{-1})	Total biomass carbon stock (Mg ha^{-1})	Soil organic carbon stock (Mg ha^{-1})	Total carbon stock (Mg ha^{-1})
Forest	104.29^{a}	28.16^{a}	132.45^{a}	62.25^{a}	146.04^{a}	208.29^{a}
Coconut plantation	93.15^{b}	25.15^{b}	118.30^{b}	55.60^{b}	83.055^{b}	138.66^{b}
Agriculture	0.27^{c}	0.07^{c}	0.35^{c}	0.16^{c}	77.88^{b}	78.04^{c}
CD at 5 %	10.00	2.70	12.70	5.97	15.11	13.89
SEm ±	3.34	1.57	4.24	1.99	5.04	4.63

*Figures with similar letters as superscripts do not differ significantly at $p \leq 0.05$

area 37.11 % and deciduous forest of the area 1.01 % as major land cover types of the sub-watershed area (Fig. 2). Research has demonstrated similar findings in their study that devised the LULC information of each parcel and mapped it using high-resolution satellite data of QuickBird, along with the data collected during ground truth verification in the Koranahalli sub-watershed (17).

Carbon stock in major land cover types

The highest above ground biomass was recorded in forest land use with 104.29 Mg ha^{-1}. This can be attributed to GBH and tree height in the forest. Research has demonstrated similar findings in the scrub type of forest in the Bagalkot district (18). The least AGB was observed in agricultural land cover type at 0.27 Mg ha^{-1} (Fig. 5). A similar trend was followed in the below ground biomass parameter, where the highest was reported from the forest with 28.16 Mg ha^{-1}, while the least value of 0.07 Mg ha^{-1} was observed in agricultural land cover type (Fig. 6).

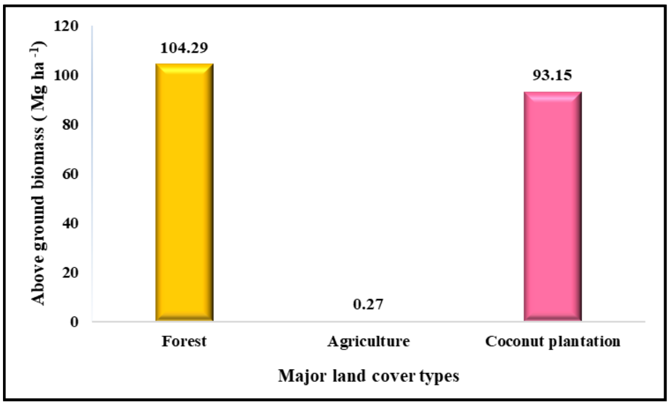

Fig. 5. Above ground biomass (Mg ha^{-1}) in major land uses of the Vitalapura sub-watershed.

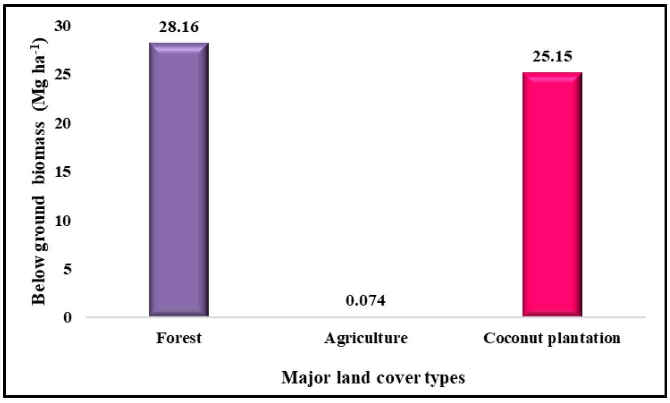

Fig. 6. Below ground biomass (Mg ha^{-1}) in major land uses of the Vitalapura sub-watershed.

Research has demonstrated similar findings in the previous study (19). The total biomass content in different land uses is shown in Fig. 7. In the case of the above ground carbon stock parameter, similar results were obtained, i.e., the highest was found to be in forest (62.25 Mg C ha^{-1}), whereas the lowest was recorded in agricultural land cover type (0.16 Mg C ha^{-1}). It is highly dependent on the species, density and height of the trees' species. Carbon storage can be high in complex forestry land use systems and productivity depends on many factors such as tree age, structure and management. The results of the study were also comparable with previous findings (20). Above ground biomass is higher in natural forests mainly due to their diverse species composition, which includes a mix of tree species with varying growth forms, sizes and ecological roles. This diversity allows efficient use of light, water and nutrients through niche complementarity, leading to greater overall biomass accumulation. In contrast, plantations are often monocultures or have low species diversity, resulting in limited structural complexity and lower total biomass.

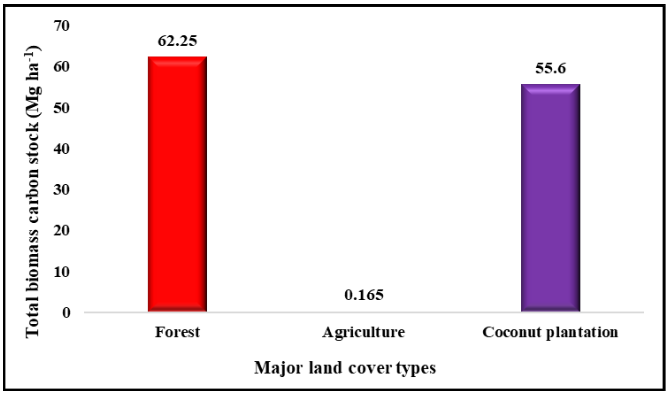

Fig. 7. Total biomass carbon stock in major land uses of the Vitalapura sub-watershed.

In terms of SOC parameter, results revealed a distinct contrast in forest land use compared to coconut plantations and agricultural land use. However, coconut plantation and agricultural land use systems were not significantly different from each other in the SOC status. Research has demonstrated similar findings in their study (21). Additionally, concerning land use distinctions, the forest areas exhibited the highest soil organic carbon, measuring 146.04 Mg ha^{-1}. The highest values in SOC concentrations within soils under such land use systems can be attributed to higher influx of leaf litter, subsequent decomposition and the turnover of roots from trees. Research has demonstrated similar findings in their study (22). The lowest SOC content was reported in agricultural land cover, at 77.88 Mg ha^{-1} (Fig. 8). Research has demonstrated the similar findings in previous study (23). Forest soils contain higher SOC because they experience minimal human disturbance, allowing organic matter to accumulate over time. Continuous input of diverse litter-leaves, roots and woody debris- enhances both the quantity and stability of carbon. The litter in forests is often rich in lignin and decomposes slowly, promoting long-term carbon storage. A diverse microbial and fungal community, including mycorrhizae, aids in carbon stabilisation within soil aggregates. Additionally, the forest canopy maintains a stable microclimate that slows decomposition and preserves SOC.

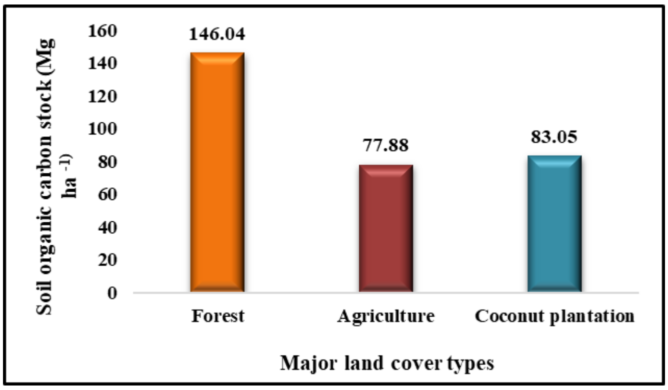

Fig. 8. Soil organic carbon stock (Mg ha^{-1}) in major land uses of the Vitalapura sub-watershed.

Generally, carbon stock distribution varies widely across biomes, with tropical forests storing the highest biomass carbon due to dense vegetation and large tree size, while boreal forests and grasslands hold greater proportions of carbon in soils because of slow decomposition and deep root systems. Tundra and peatlands also have high soil carbon stocks due to cold, anaerobic conditions that limit organic matter breakdown. Soil organic carbon (SOC) stock represents the carbon stored in soil organic matter, influenced by litter input, root turnover and decomposition rates, whereas biomass organic carbon stock refers to carbon stored in living plant biomass both above and below ground. Typically, global SOC ranges from 80-700 Mg C ha^{-1}, with higher values in cold and moist regions, while biomass carbon peaks in tropical forests (24).

In total, the combination of all the parameters resulting in the carbon stock, highest was recorded in forest with 208.29 Mg C $ha^{-1,}$ accounting for (2 %) of carbon stock in the watershed area and the least was in the agriculture land cover type with 78.04 Mg C ha^{-1} accounting for (42 %) of the carbon stock in the watershed area. This is mainly attributed to the fact that the forest occupied a smaller extent of the area. Coconut plantation accounted for 56 % of the carbon stock of the watershed to a larger extent than

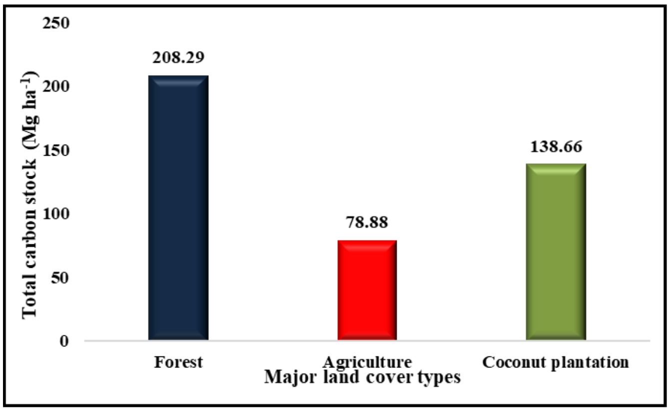

Fig. 9. Total carbon stock (Mg ha^{-1}) in major land uses of the Vitalapura sub-watershed.

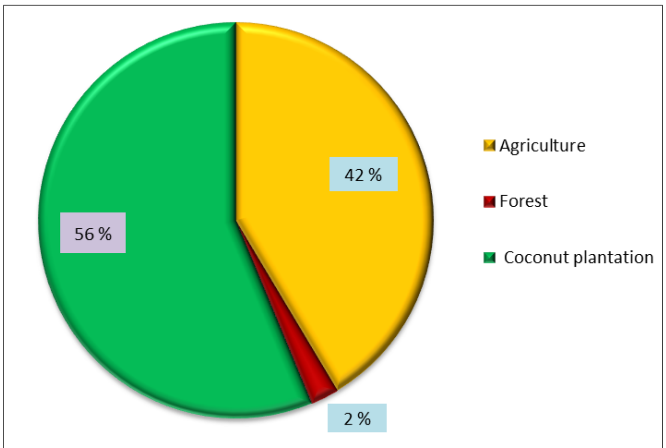

Fig. 10. Total percentage of carbon stock in major land uses of the Vitalapura sub-watershed.

comparable agricultural land and forest cover type (Fig. 9 & 10). Research has demonstrated similar findings in their study (25).

Since in the study area, forest land cover area is only 1.01 % hence it contributes only 2 % of carbon in the sub-watershed area, but when it comes to a hectare basis, forest land use contributes a higher amount of carbon stock when compared to the other land uses. Plantations and agricultural land use contribute a higher percentage of carbon in the sub-watershed, i.e., 56 and 42 %, respectively, because of the higher percentage of area, but the carbon stock per hectare is less when compared to the forest land use.

The comprehensive findings of the study indicated a remarkable similarity between all the land cover types. These findings played a significant role in understanding the productive landscapes and also contemplating the role of conserving diverse flora for mitigating climate change impacts. Presently, agricultural land cover type exhibits a lower carbon pool compared to other land cover types, posing the necessity of deliberately introducing a substantial number of native trees with higher biomass productivity to enhance overall biomass within these landscapes at watershed levels for sustainable management of the watershed area in the context of climate change.

Conclusion

Although forests store the most carbon per unit area, plantations and agricultural lands dominate the watershed-scale carbon balance because of their larger spatial extent. Therefore, conservation of the existing forest patches alongside sustainable management of coconut plantations and integration of trees in agricultural landscapes is essential to enhance carbon sequestration. Strengthening soil health and adopting agroforestry practices can further increase biomass and SOC, ensuring improved carbon storage and resilience of the sub-watershed ecosystem under changing climatic conditions.

Acknowledgements

This study was part of the REWARD project (Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga) funded by the World Bank and Government of Karnataka and Centre of Excellence on Watershed Management, GKVK, Bangalore. The authors duly acknowledged the technical and financial support.

Authors' contributions

SN contributed to drafting the original manuscript and to reviewing the data collection, as well as to the preparation of tables and figures. G contributed to the review and correction of the data collection and to the preparation of tables and figures. RD, SBS, SR and RDB conducted the review and corrections and supervised the overall process. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used QuillBot in order to improve language and readability, with caution. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

References

1. Pan Y, Birdsey RA, Fang J, Houghton R, Kauppi L, Kurz WA, et al. The enduring world forest carbon sink. Nature. 2024;614(7948):489-94. https://doi.org/10.1038/s41586-024-07602-x

2. International Energy Agency (IEA). CO_2 emissions in 2023: executive summary [Internet]. Paris: IEA; 2024 [cited 2026 Jan 3]. Available from: https://www.iea.org/reports/co2-emissions-in-2023/executive-summary

3. Woodwell Climate Research Center. Global forest carbon storage, explained [Internet]. Woods Hole (MA): Woodwell Climate Research Center; 2024 [cited 2026 Jan 3]. Available from: https://www.woodwellclimate.org/global-forest-carbon-storage-explained/

4. Qiu H, Zhang J, Liu S, Li Y. Watershed carbon yield derived from gauge observations. Scientific Data. 2023;10(1):1-9. https://doi.org/10.1038/s41597-023-02162-7

5. Zhang J, Liu S, Qiu H. Mechanisms for carbon stock driving and scenario analysis in watershed ecosystems. Environ Sci Pollut Res. 2024;31(5):234-45. https://doi.org/10.1007/s11356-024-12947-x

6. Lal R. Soil carbon sequestration impacts on global climate change and food security. Science. 2004;304(5677):1623-7. https://doi.org/10.1126/science.1097396

7. Pan Y, Birdsey RA, Fang J, Houghton R, Kauppi PE, Kurz WA, et al. A large and persistent carbon sink in the world's forests. Science. 2011;333(6045):988-93. https://doi.org/10.1126/science.1201609

8. World Agroforestry Centre (ICRAF). Carbon sequestration potential of agroforestry systems for climate change mitigation. Nairobi: International Centre for Research in Agroforestry; 2011. p. 1–45.

9. Rahangdale CP, Koshta LD. Biomass production and carbon sequestration potential under different land-use systems in Jabalpur district of Madhya Pradesh. Adv Life Sci. 2016;5(21):9638-42.

10. Anonymous. Climate change: synthesis report. Intergovernmental panel on climate change. Geneva: IPCC; 2000. p. 123-4.

11. Sharma S, Rana VS, Prasad H, Lakra J, Sharma U. Appraisal of carbon capture, storage and utilization through fruit crops. Front Environ Sci. 2021;9:700768. https://doi.org/10.3389/fenvs.2021.700768

12. Yirdaw M. Carbon stock sequestered by selected tree species plantations in Wondo Genet College, Ethiopia. J Earth Sci Clim Change. 2018;9(5):1-5. https://doi.org/10.4172/2157-7617.1000483

13. Anonymous. Land use, land-use change and forestry: a special report of the intergovernmental panel on climate change. Cambridge: Cambridge University Press; 2007. p. 339-88.

14. Bohre P, Chaubey OP, Singhal PK. Biomass accumulation and carbon sequestration in *Dalbergia sissoo* Roxb. Int J Biol Sci Biotechnol. 2003;4:29-44.

15. Naresh KS, Kasturibai KV, George J. Method for non-destructive estimation of dry weight of coconut stem. J Plantation Crops. 2008;36(3):296-9.

16. Pearson T, Brown S, Ravindranath NH. Integrating carbon benefits estimates into GEF projects. Washington (DC): Global Environment Facility; 2005. p. 1-56.

17. Ravikumar D, Govindaraju. Assessment of soil fertility status of Koranahalli sub-watershed in Tarikere taluk using nutrient index approach. Earth Resour Conserv Manag. 2019;14(6):47-52.

18. Devagiri GM, Khaple A, Anithraj HB, Kushalappa CG, Krishnappa AK, Mishra SB. Assessment of tree diversity and above-ground biomass in coffee agroforest-dominated tropical landscape of India's Central Western Ghats. I J Forest Res. 2019;2019:1-11. https://doi.org/10.1155/2019/9652014

19. Jafarian Z, Tayefeh SA. Carbon sequestration potential in dry-farmed wheat in Kiasar region. J Agric Sci. 2013;23(1):32-41.

20. Sarangle S, Rajasekaran A, Benbi DK, Chauhan SK. Biomass and carbon stock, carbon sequestration potential under selected land-use systems in Punjab. For Res Eng Int J. 2018;2(2):75-80. https://doi.org/10.15406/freij.2018.02.00042

21. Bhagya, Maheswarappa HP, Surekha, Bhat R. Carbon sequestration potential in coconut-based cropping systems. Indian J Hortic. 2017;74(1):1-5.

22. Zhao P, Liu J, Wang Q, Zhang Y, Chen X. Forest aboveground biomass estimation using airborne LiDAR: a systematic review and meta-analysis. J For. 2025;123:389-412.

23. Gupta DK, Bhatt RK, Keerthika A, Mohamed MBN, Shukla AK, Jangid BL. Carbon sequestration potential of *Hardwickia binata* Roxb.-based agroforestry in hot semi-arid environment of India: an assessment of tree density impact. Curr Sci. 2019;116(1):112-16.

24. Chisanga K, Bhardwaj DR, Pala NA, Thakur CL. Biomass production and carbon stock inventory of high-altitude dry temperate land-use systems in North-Western Himalaya. Ecol Process. 2018;7(1):1-13. https://doi.org/10.1186/s13717-018-0137-7

25. Jobbágy EG, Jackson RB. The vertical distribution of soil organic carbon and its relation to climate and vegetation. Ecol Appl. 2000;10(2):423-36. https://doi.org/10.1890/1051-0761(2000)010[0423:TVDOSO]2.0.CO;2

Additional information

Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

Reprints & permissions information is available at https://horizonepublishing.com/journals/index.php/PST/open_access_policy

Publisher's Note: Horizon e-Publishing Group remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Indexing: Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS, UGC Care, etc
See https://horizonepublishing.com/journals/index.php/PST/indexing_abstracting

Publisher information: Plant Science Today is published by HORIZON e-Publishing Group with support from Empirion Publishers Private Limited, Thiruvananthapuram, India.