



# Distribution of Carbon Stocks under Different Land Use Systems of Somawarpet Taluk, Kodagu District, India

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## Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

## Article Information

DOI: 10.9734/IJECC/2023/v13i92473

## Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/102828>

Original Research Article

Received: 22/05/2023

Accepted: 25/07/2023

Published: 31/07/2023

## ABSTRACT

A study was conducted in Somawarpet taluk of Kodagu district in Karnataka in the aim the soil carbon stocks under different land use systems namely natural forest land use, coffee based agroforestry and paddy systems. Soil samples were collected at different depths like 0-20, 20-40, 40-60 and 60-80 cm with five replications under each land use systems. Natural Forest showed the highest mean value of Potassium Dichromate Oxidizable Carbon content of 18.06g kg<sup>-1</sup>, followed by coffee system with o Potassium Dichromate Oxidizable Carbon content of 13.86 g kg<sup>-1</sup> and the

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lowest mean value ( $8.23 \text{ g kg}^{-1}$ ) was found in paddy land use system. The highest mean value of bulk density (BD) was found in paddy land use system ( $1.33 \text{ Mg m}^{-3}$ ). In all the land use systems BD content increases with increasing soil depth. The highest soil carbon stock mean value of  $4140.23 \text{ t ha}^{-1}$  was noticed in natural forest, followed by coffee land use system ( $3267.38 \text{ t ha}^{-1}$ ) and lowest value of  $2171.45 \text{ t ha}^{-1}$  of carbon stock content was observed under paddy land use system. In all the land use systems Potassium Dichromate Oxidizable Carbon content and carbon stock content was decreasing with increasing soil depth.

*Keywords: Land use systems; soil organic carbon; natural forest; coffee based agroforestry; carbon cycle; potassium dichromate oxidisable carbon.*

## 1. INTRODUCTION

One of the environmental issues that the modern world is dealing with is global warming. The most significant contributing component is determined to be carbon emissions [1]. The ecosystem has experienced significant carbon emissions as a result of this development. It is commonly recognized that vegetation has a significant role in the dynamics of ecosystems. Because of this, there is a growing interest in managing our soil properly to counteract the steadily rising atmospheric  $\text{CO}_2$  concentration. The atmosphere, oceans, fossil fuel reserves, and terrestrial systems all serve as natural carbon sinks on a global scale. Carbon is stored in terrestrial systems in the form of rocks and sediments, marshes, forests, swamps, and soils used for agriculture. The rising levels of atmospheric carbon dioxide may be countered by soil as a potential carbon sink. If soil organic carbon (SOC) breakdown rates are reduced and more crop biomass is annually returned to the soil, atmospheric  $\text{CO}_2$  can be absorbed in agricultural soils [2]. Soil organic carbon status which determines nutrient availability, the biological activity, Soil aggregate stability, soil structure, bulk density, plant available water content, Soil organic carbon content required in land use planning, fertilizer recommendation, irrigation management and different crop modeling studies. Mapping of soil carbon at high resolution is of great importance for natural resources management. Since the spatial variation of soil carbon is controlled by complex interactions.

Carbon sequestration is the net removal of atmospheric carbon dioxide and its long-term (thousands of years) storage in terrestrial systems as living carbon pools. The soil has significant role in carbon cycle. The soil organic carbon stock acts as a major part of the terrestrial carbon reservoir than the atmospheric carbon [3] with storage of about 1500Pg to

2000Pg C (1 Pg =  $10^{15}$  g or 1 Pg = 1 billion tonnes) in the top 100 cm depth layer in the world soils [4]. Since there is twice as much carbon in soil as there is in the atmosphere, changes in the soil carbon pool have a major impact on the atmosphere's chemical makeup [5]. The only means to remove a significant amount of the primary greenhouse gas ( $\text{CO}_2$ ) into the biological system is by absorption from the atmosphere into the physiological system and plant biomass, and then into the soil [6].

The term "soil carbon" describes all of the carbon present in the soil, including both inorganic and biological forms. Among the several ecosystems in India, forests have the potential to have the greatest impact on climate change through the sequestration or emission of carbon, a significant greenhouse gas; biological growth, which can raise forest stocks; or deforestation, which can raise carbon emissions.

The quantification of SOC stocks relies on understanding the spatial variability of SOC stocks in a landscape, which in turn requires identification of its controlling factors including, land use and land cover (LULC) types [7-9]. Many studies have reported large SOC stocks under forest compared to grassland and agricultural land [10,11, 9,12].

A huge amount of carbon is stored in forests [13]. According to FAO [14] the total forest carbon stocks of the world is 652 Giga tonnes ( $161.8 \text{ t ha}^{-1}$ ). Carbon is captured in its vegetation, litter and soil. Coffee based agroforestry has emerged for potential carbon sequestration, compensating for deforestation by sequestering carbon and assisting in the fight against climate change. The amount of biomass, type of vegetation, nutrient management approaches, and other conservation strategies all affect the nutrient status of different land use systems. The large amount of biomass is produced and added to soil continuously from diverse tree species in natural

forest, coffee agroforestry and Paddy land use in Somawarpet taluk of Kodagu District. This creates continuous cycle between above ground biomass and below ground root biomass by different tree species and contributing to soil organic carbon pool and its fertility status. The above mentioned land use systems has greater role in carbon sequestration to sustain the ecological safety. The above mentioned land use systems are major land use systems at Somawarpet taluk, Kodagu district. So, to know the carbon stock in these land use systems study has been conducted.

## 2. MATERIALS AND METHODS

The study area covered Somawarpet taluk of Kodagu district in Karnataka. The latitude and longitude coordinates of Somawarpet taluk, Kodagu district are 12°59' N latitude and 75°84' E longitudes. Location map of study area presented in Fig. 1. The climate of this region may be broadly termed as tropical except at the

higher ranges of the hills where it is sub-tropical. The annual precipitation of Somawarpet taluk is 1569.8 to 2862.71 mm with a mean of 1944.40 mm.

A study was undertaken to know the distribution pattern of soil carbon stock under three land use systems of the Somawarpet, Kodagu district as follows, Natural forest (*Hopeaponga*, *Ficus benjamina*, *Terminalia paniculata*, *Terminalia tsjeriam-cottam*, *syzygiumcumini* etc.), Coffee based agroforestry- (predominantly Robusta coffee (*Coffea acanephora*) was grown under native tree species of *Acrocarpus fraxinifolius*, *Dalbergialatifolia*, *Lagerstroemia microcarpa* and *Syzygiumcumini*), and paddy land use system (Plate 1). The 60 representative soil samples were collected from 0 to 20 cm, 20 to 40 cm, 40 to 60 cm and 60 to 80 cm depth from different land use systems with five replications. The analysis of soil samples for the organic carbon content and carbon stock content was done using standard procedures.

### 2.1 Methods of Soil Analysis

**Potassium Dichromate Oxidizable Carbon (PDOC):** Determination of Potassium Dichromate Oxidizable Carbon was carried out by wet oxidation method by [15].

Estimation of potassium dichromate oxidizable carbon was done by wet oxidation method [15]. Weigh 0.5 g of 0.2 mm sieved soil sample in 500 ml capacity conical flask. Add 10 ml of 1N K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> solution and 20 ml of concentrated H<sub>2</sub>SO<sub>4</sub> in a conical flask and gently mix and keep away for 30 minutes. After 30 minutes, add 200 ml of distilled water, 10 ml H<sub>3</sub>PO<sub>4</sub>, about 0.2 g of NaF and 8 to 10 drops of diphenylamine indicator to it. Contents were titrated against standard ferrous ammonium sulphate until it becomes bright green. Blank titration was run by following all the above steps without soil and calculated using the following formula,

$$\text{PDOC ((g kg}^{-1}\text{))} = \frac{(\text{Blank TV} - \text{Sample TV}) \times \text{N. of FAS} \times 0.003 \times 1000}{\text{Weight of soil (g)}}$$

**Bulk Density (BD):** Bulk density was determined using clod method by dipping an air dried, pre-weighed paraffin coated clod into a beaker of water, measuring the volume displacement and calculated as described by Black (1965). Bulk density was expressed as Mg m<sup>-3</sup>.

#### Soil Organic Carbon stock

Changes in Soil Organic Carbon (SOC) generally occur over many years and it is often difficult to identify small changes. The SOC contents stock in soil (t ha<sup>-1</sup>) was calculated using equation [16].

$$\text{Soil Carbon stock (t ha}^{-1}\text{)} = \frac{\text{Area(m}^2\text{)} \times \text{BD (Mg m}^{-3}\text{)} \times \text{Depth (cm)} \times \text{PDOC (g kg}^{-1}\text{)}}{1000}$$

Where,

Area: 10000 m<sup>2</sup>

BD: Bulk Density at each depth

Depth: Depth interval considered (0-20, 20-40, 40-60 and 60-80 cm)

PDOC: Potassium Dichromate oxidisable carbon in g kg<sup>-1</sup>



**Natural Forest**



**Coffee Based Agroforestry**



**Paddy Land Use System**

**Plate 1. Different land use system in the study area**

### 3. RESULTS AND DISCUSSION

Among different land use systems the Potassium Dichromate Oxidisable Carbon (PDOC) value ranged from 11.43 to 23.10 g kg<sup>-1</sup> in natural forest, 8.96 to 17.31 g kg<sup>-1</sup> in coffee system and 3.95 to 11.11 g kg<sup>-1</sup> in paddy system respectively (Table 1). Natural forest recorded higher mean PDOC value of 18.06 g kg<sup>-1</sup>, followed by coffee

system with mean PDOC value of 13.86 g kg<sup>-1</sup> and the lowest mean value was found in paddy land use system (8.23 g kg<sup>-1</sup>). In all the land use systems PDOC content was decreasing with increasing soil depth. Increase in PDOC of forest soil due to continuous addition of biomass through leaf litter and roots. Similar results reported by Geo Jose [17]. The lower mean organic carbon status (8.23 g kg<sup>-1</sup>) content in

paddy land might be attributed to lower vertical mixing of soils and also due to the inadequate organic substrate from the farming system. The highest potassium dichromate oxidizable organic carbon (PDOC) status is recorded in the natural forest was attributed to the long term addition of carbon over more than 25-50 years in these soils coupled with minimum physical disturbance to surface soil as compared to agriculture and horticulture land use systems. Similar results are also reported by Brij et al. [18] and Yao et al. [19].

The highest mean value of bulk density (BD) was found in paddy land use system (1.33 Mg m<sup>-3</sup>) followed by coffee based agroforestry (1.19 Mg m<sup>-3</sup>) and the lowest mean value was found in natural forest (1.16 Mg m<sup>-3</sup>). In all the land use systems BD content increases with increasing soil depth (Table 1).

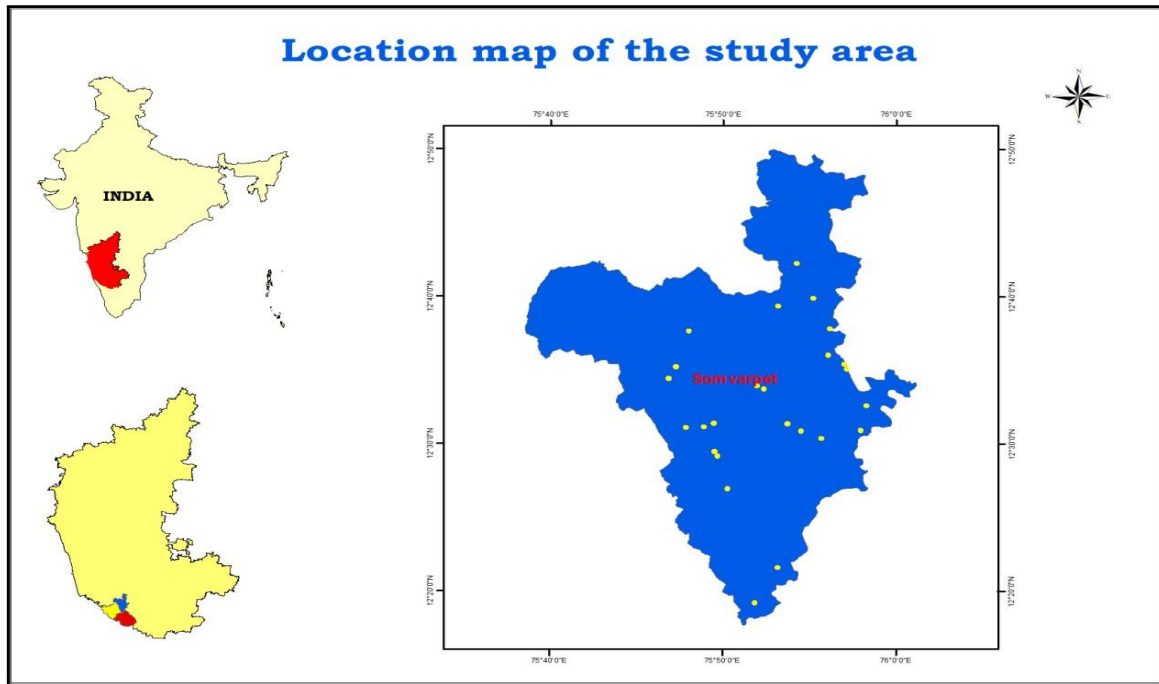
Influence of different land use systems on carbon stock in different land use systems were presented in Fig. 2. Highest carbon stock potential was observed in Natural forest (4140.23t ha<sup>-1</sup>) followed by coffee based agroforestry (3267.38t ha<sup>-1</sup>) and lowest value of carbon stock potential was observed in paddy land (2171.45 t ha<sup>-1</sup>). In all the land use systems carbon stock content was decreasing with increasing soil depth. Among different land use

systems the carbon stock value ranged from 2766.06 to 5035.80 g kg<sup>-1</sup> in natural forest, 2257.92 to 3912.96 g kg<sup>-1</sup> in coffee based agroforestry, and 1106.56 to 2822.96 g kg<sup>-1</sup> in paddy land use system respectively. Indicating higher organic carbon turnover through decomposition of leaf litter and due to the quality and quantity of biomass turnover. The larger the biomass turn over higher would be the carbon stock. Roy et al. [20] also found increase in organic carbon status with addition of organic matter through leaf litter in forest land use system. The larger carbon stock observed under natural forest might be due to dense vegetation and depositions of plant leaf litters with least disturbance of the natural forest such as forest fire, grazing and also anthropogenic pressure is totally restricted and less temperature fluctuations due to canopy cover. Hence the carbon stock will be more in natural forest. These results of present study are in agreement with findings of Tchienkoua and Zech [21].

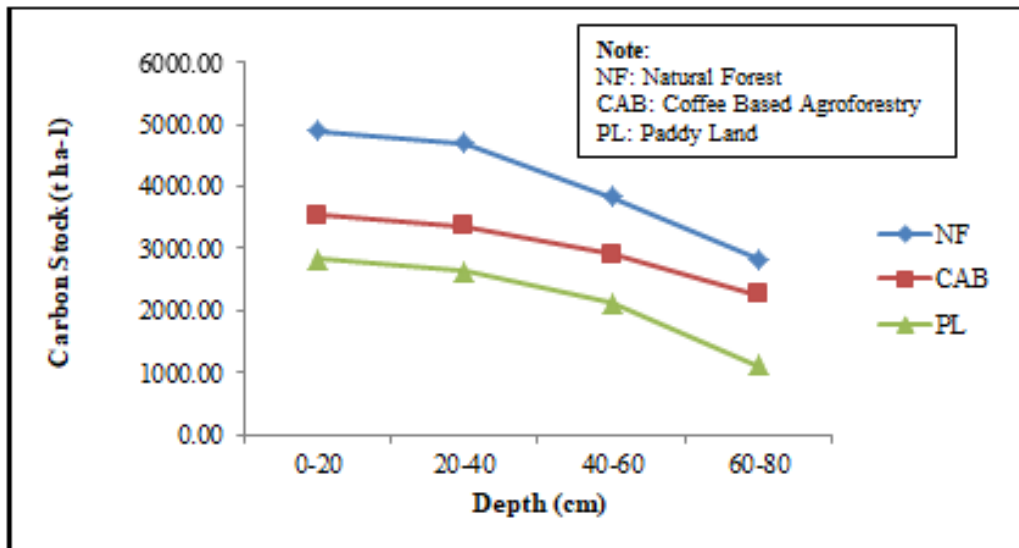
The lowest mean value of carbon stock was found in paddy land use system 2171.45t ha<sup>-1</sup> of carbon due to lower soil organic carbon stock which is due to exposer of soil to light and more utilization of nutrients by the crops, a similar result was found in Lal and Puget [22]; Han et al. [23][24].

**Table 1. List of variables in Cropping Systems**

Cropping Systems	Depth (cm)	PDOC (g kg <sup>-1</sup> )	BD (Mg m <sup>-3</sup> )	Carbon stock (t ha <sup>-1</sup> )
NF	0-20	23.1	1.09	5035.80
	20-40	21.36	1.14	4869.17
	40-60	16.34	1.19	3889.87
	60-80	11.43	1.21	2766.06
	<b>Range</b>	<b>11.43-23.10</b>	<b>1.09-1.21</b>	<b>2766.06-5035.80</b>
	<b>Mean</b>	<b>18.06</b>	<b>1.16</b>	<b>4140.23</b>
CBA - I	0-20	17.31	1.13	3912.96
	20-40	16.05	1.16	3723.6
	40-60	13.12	1.21	3175.04
	60-80	8.96	1.26	2257.92
	<b>Range</b>	<b>8.96-17.31</b>	<b>1.13-1.26</b>	<b>2257.92-3912.96</b>
	<b>Mean</b>	<b>13.86</b>	<b>1.19</b>	<b>3267.38</b>
PL	0-20	11.11	1.27	2822.96
	20-40	10.06	1.31	2634.67
	40-60	7.8	1.36	2121.6
	60-80	3.95	1.4	1106.56
	<b>Range</b>	<b>3.95-11.11</b>	<b>1.27-1.40</b>	<b>1106.56-2822.96</b>
	<b>Mean</b>	<b>8.23</b>	<b>1.33</b>	<b>2171.45</b>



**Fig. 1. Location map of study area**



**Fig. 2. Soil carbon stock content under different land use systems**

#### 4. CONCLUSION

The present investigations have shown that, soil organic carbon content was highest in natural forest compared to other land use systems. Soil organic carbon significantly varies among different land use systems as well as with increase in depth and increase in soil carbon storage may be possible through proper management of land use system. It is concluded that, the highest carbon sequestration potential

was observed in natural forest followed by coffee land use system. The study revealed that land use and its management influence soil organic carbon stocks by biomass accumulation and level of decomposition at high temperatures, its microclimate and control on soil erosion. Forest land-use system, associated with good ground and canopy cover, significantly increased the soil organic carbon content and stock compared to land-use systems.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. Dopp KA. Global Warming, Carbon Emissions, and Atmospheric Carbon. Carbon Emissions, and Atmospheric Carbon; 2016.
2. USDA-NRCS. Soil Organic Matter. United States Department of Agriculture Natural Resources Conservation Service (USDA-NRCS) Soil Health – Guides for Educators; 2014.
3. Grace J. Understanding and managing the global carbon cycle. *J. Ecol.* 2004;92:89-202.
4. Wang Y, Yu J, Lil Y, Dong H, Zhou D, Han G, Wu H, Wang G, Mao P, Gao Y. Soil organic carbon storage changes in coastal wetlands of the modern yellow river delta from 2000 to 2009. *Bio geoscience.* 2012;9: 2325-2331..
5. Feller C, Bernoux M. Historical advance in the study of global terrestrial soil organic carbon sequestration. *Waste manag.* 2008;28:734-740.
6. Ramachandran AS, Jayakumar RM, Haroon AB, Rochkiasamy DI. Carbon sequestration estimation of carbon stock in natural forests using geospatial technology in Eastern Ghats of Tamil nadu, India. *Curr. sci.* 2007;92(3):323-331.
7. Sitaula BK, Bajracharya RM, Singh BR, Solberg B. Factors affecting organic carbon dynamics in soils of Nepal/Himalayan region—a review and analysis. *Nutrient cycling in Agroecosystems.* 2004;70:215-229.
8. Smith P. Land use change and soil organic carbon dynamics. *Nutrient Cycling in Agroecosystems.* 2008;81:169-178.
9. Saha D, Kukal SS, Sharma S. Landuse impacts on SOC fractions and aggregate stability in typic ustochrepts of Northwest India. *Plant and Soil.* 2011;339:457-470.
10. Abbasi MK, Zafar M, Khan SR. Influence of different land-cover types on the changes of selected soil properties in the mountain region of Rawalakot Azad Jammu and Kashmir. *Nutrient Cycling in Agroecosystems.* 2007;78:97-110.
11. Yang Y, Xie J, Sheng H, Chen G, Li X, Yang Z. The impact of land use/cover change on storage and quality of soil organic carbon in midsubtropical mountainous area of southern China. *Journal of Geographical Sciences.* 2009;19:49-57.
12. Dorji T, Odeh IO, Field DJ, Baillie IC. Digital soil mapping of soil organic carbon stocks under different land use and land cover types in montane ecosystems, Eastern Himalayas. *Forest Ecology and Management.* 2014;318:91-102.
13. Salleh MN, Cyril P, Abdul HA. Tropical forestry and carbon sequestration. Presented at workshop on emission trading and clean development mechanism (CDM) in Asia 2001, held on 7-8 June, 2001 in Singapore; 2001.
14. FAO (Food and Agriculture Organization of the United Nations), 2010. FRA 2010 Terms and definitions. <http://www.fao.org/forestry/site/fra2005terms/en>.
15. Walkley A, Black IA. an examination of the digestion method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Sci.* 1934;37:29-38.
16. Manjunatha M, Devakumar A, Niveditha M. Carbon sequestration in litter and soil of coffee based agroforestry systems in central western ghats of Kodagu district of Karnataka. *Environ. Eco.,* 2012;30:985-987.
17. Geo Jose. Organic carbon distribution in soils under long term rice cropping systems in coastal and southern dry zones of Karnataka, M.Sc. (Agri.) Thesis, Univ. Agric. Sci., Bangalore (India); 2006.
18. Brij LL, Manish KP, Pramod J, Biswas AK. Soil organic carbon pools and indices under different land use system in vertisols of central India. *J. Indian Soc. Soil Sci.* 2012;60(2):125 -131.
19. Yao M, Angui PKT, Konate S, Tondoh JE. Effects of land use types on soil organic carbon and nitrogen dynamics in Mid-West Cote d'Ivoire. *European J. Sci. Res.* 2010;40(2): 211-222.
20. Roy PK, Samal NR, Roy MB, Mazumdar A. Soil carbon and nutrient accumulation under forest plantations in Jharkhand state of India. *Clean – Soil, Air, Water.* 2010;38(8):706–712.
21. Tchienkoua M, Zech W. Organic carbon and plant nutrient dynamics under their land use in the highlands of west Cameroon Agric. Ecosyt. *Environ.* 2004;104: 673-679.
22. Lal R, Puget P. Soil organic carbon and nitrogen in a Mollisol in central Ohio as

- affected by tillage and land use. Soil and Tillage Res. 2005;80:211- 213.
23. Han F, Wei HJ, Zheng F, Du X, Zhang. Estimating soil organic carbon storage and distribution in a catchment of Loess Plateau, China, Geoderma. 2010;154:261–266.
24. Gupta PK. Soil, water, plant and fertilizer analysis. Text Book. Agrobios Publishers, India; 2007.

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