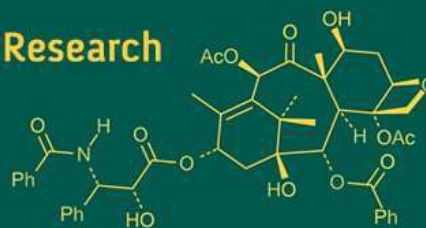
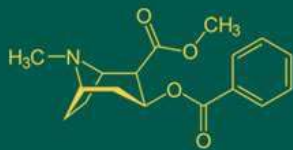


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Biomass and carbon stock assessment under different land use systems of semi-arid region of Bundelkhand, Northern India

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Abstract

The study was conducted in Badokhar Khurd block, Banda district, Bundelkhand region of Uttar Pradesh, using a randomized block design with seven land use systems and four soil layers. Results showed significant differences in aboveground biomass, belowground biomass, total biomass, and carbon stocks among land use systems. The highest carbon stocks were in SPS (8.30 t ha⁻¹ aboveground, 2.16 t ha⁻¹ belowground, and 10.46 t ha⁻¹ total), while the lowest were in NGS (0.51 t ha⁻¹ aboveground, 0.13 t ha⁻¹ belowground, and 0.65 t ha⁻¹ total). Bulk density was highest in agriculture crop-based land-use (1.45 g cm⁻³) and lowest in SPS (1.36 g cm⁻³). Soil organic carbon stocks were highest in SPS (4.97 t ha⁻¹) and lowest in agriculture crop-based land-use (2.63 t ha⁻¹). Overall, SPS had the highest total carbon stock (29.35 t ha⁻¹) while NGS had the lowest (11.87 t ha⁻¹).

Keywords: Carbon stock, mitigation, organic carbon, land use systems

1. Introduction

The planet earth in the twenty first century is facing a serious challenge in the form of climate change which is significantly affecting the global food security. With climate change, desertification will increase and the arid and semi-arid regions will be vulnerable to this change. It is caused mostly by increasing absorptions of greenhouse gases in the atmosphere. Land degradation has a few negative effects, including speeding up climate change and endangering agricultural production, water quality, biodiversity, sustainable development, and human and animal living circumstances (Shivakumar, 2007; Stavi and Lal, 2015) [37, 38]. The provision of suitable food for a growing population while sustaining a stressed-out environment. (Lal, 2005) [21].

Still, carbon dioxide will double in the times 2050, which will beget a 2- 4 °C rise in global temperature, If the current rate of elaboration continues. The global ocean situation will rise by 28-98 cm due to melting of polar ice. Carbon insulation is one of the most important ecosystem services in the period of climate change for lower position the atmospheric accumulation of conservatory gases in particular carbon dioxide. If sustainably managed these lands have the huge capability to sequester carbon both in the foliage and soil systems (Lal, 2015) [22]. A significant source of absorbing atmospheric CO₂ is the conversion of degraded land into various agricultural ecosystems like farmland, forests, alley cropping, grazing land, and other vegetation (Meena *et al.*, 2020a) [24]. The short rotation tree species play a major role in carbon sequestration in the soil reservoir. Despite significant annual CO₂ exchanges between the atmosphere and agricultural regions, it is anticipated that the net flow will be almost balanced when land-use change is taken into consideration (Alscher, 2011) [1]. Trees are considered the largest reservoirs of long-term storage of carbon and in carbon dioxide mitigation of global warming and climate change. (Sarkar, S. and Das, D.K., 2020) [33]. Agroforestry practice is the meaningful arising of trees and crops in interacting combinations commenced to its potentials in the tropics and distinguished it as a practice in search of science (Kumar and Nair, 2011) [19]. Agroforestry systems have potential to sequester carbon through enhanced growth of trees and shrubs. It has been found that the overall (biomass) productivity, soil fertility, soil conservation, nutrient cycling, microclimate

improvement and carbon sequestration potential of an Agroforestry system are usually better than that of an annual cropping system (Dhyani *et al.*, 2009) [12]. Soils hold the largest pool of terrestrial carbon (Scharlemann *et al.*, 2014) [34] and play very crucial role in the global carbon balance. Soil organic carbon (SOC) stocks are estimated to be 1,500±230 Gt C in the first meter of soil, which is nearly twice as much as atmospheric carbon i.e., 828 Gt C as CO₂ (Le Quere *et al.*, 2016) [33].

The Fifth Assessment Report of IPCC: The Intergovernmental Panel on Climate Change has concluded that forest ecosystems could be seriously impacted indeed by moderate global Carbon. therefore, forest ecosystems, which warming of deliver a diversity of ecosystem services vital for humanity, will be negatively impacted. also, forests have the capability in braking down the current trend of global warming by sequestering CO₂ from the atmosphere. It has been estimated that the composition of one- third of the world's forests could be altered due to climate change.

2. Materials and Methods

2.1 Experimental site

The study was conducted 2021-2022 on seven different land use systems in which one pure agriculture wheat crop in the farmer's field at Badokhar khurd block Banda district of Bundelkhand region of Uttar Pradesh state, India (Fig. 1). The site is situated between latitude 24° 53' and 25° 55'N and longitude 80° 07' and 81° 34' E and having an altitude of 168 m above sea level. This region falls under agro-climatic zone-8 of India. Banda district comes under the fourth agro-climatic region of India i.e., central plateau and hills which is termed as semi-arid to dry sub-humid climate. The average annual rainfall is 902.00 mm the climate is typical subtropical penetrated by long and intense summers. About 80% of the annual rainfall is received from South-West monsoon. The temperature of experimental site having as maximum temperature 49 °C in summer season and minimum temperature is 6 °C in winter. May is the hottest month with mercury shooting upto 47 °C. The Black cotton soil is prominent in the central part. Four major type of soil Rakar, Mar, Kabar and Padua are dominant in the district.

2.2 Treatment details

For the conducting this experiment seven land use system viz, 1) Natural grassland (NG); 2) Agriculture (A); 3) Horticulture (H); 4) Silvi-pastoral system (SP); 5) Horti-pastoral system (HP); 6) Agri-silviculture system (AS); 7) Agri-horticulture system (AH) were selected (Fig. 1b).

2.3 Soil sampling

Soil samples were collected from the study site, we collected soil a total of 84 soil samples (4 depth, 3 replication and 7 land use systems). During the collection of soil samples standard protocol was followed. Litter and pebbles from the soil's uppermost surface were completely removed before the sample was taken. Samples were kept in hot oven dried at 70 °C for 24 hours and pass through 2 mm size sieve. The sieved soil was placed in a clean polythene bag with the appropriate labels for laboratory analysis.

2.4 Physiochemical analysis

A 1:2.5 soil to water solution was used to measure the pH of the soil. Soil organic percentage was calculated by Walkley and Black (1934) [41]. According to Black *et al.* (1965) [44],

the soil bulk density was estimated using a core sampler after pebbles were removed.

2.5 Soil carbon stock calculation

The soil organic carbon (t ha⁻¹) was assessed by using the methods of Nelson and Sommers (1996) [28].

Soil Carbon stock (t ha⁻¹) = [soil bulk density (g cm⁻³)] x soil depth (cm) x soil carbon (%)

2.6 Tree component DBH and volume

The height of the trees recorded with the help of Indian made Ravi's Altimeter and the diameter of tree trunk at BH can be determined by tree calliper at 1.37 meter from the ground level. The volume of chosen trees was calculated by Pressler's (1865) [30] and Bitlerlich's (1984) [2] methods.

2.7 Biomass estimation of trees and crops

In each sample trees total number of branches was counted and divided into three group viz, 6 cm, 6-10 cm, and 10 cm. Leaves from the branches which were ever removed, were weighed and oven dried separately to a constant weight at 80+5 °C (Chidumaya, 1990) [10]. The leaf biomass of each fruit tree on the other was calculated during the leaf fall (December-January). The tree biomass was converted into carbon fraction by a factor of 0.5 (IPCC, 2006) [14]. Belowground biomass of tree roots was calculated by multiplying the above ground biomass by a factor of 0.26 (Cairns *et al.* 1997; IPCC, 2007) [6, 15]. The above-ground and below-ground biomass of wheat was calculated for the current year of study.

2.8 Total carbon stock

Total carbon stock (Plant + Soil) was calculated by following formula:

Total carbon stock = plant carbon stock + soil carbon stock

2.9 Total carbon in trees and carbon credit

Total tree biomass multiplied by a factor of 0.45 because approximately 45% carbon is found in the total biomass of trees (Woomer, 1999) [42]. For the estimation of agriculture crop biomass five plots of 1x1 m² were formed. All crop found inside the quadrates borders was cut at ground level, and the collected samples were weighed, subsampled, and oven dried at constant weight. Crop biomass was multiplied by a factor of 0.5 to create carbon (IPCC, 2006) [14]. The one carbon credit is equal to the one tonne of CO₂ sequester/ absorbed from the atmosphere and locked in the form of biomass (IPCC, 2007) [15]. The carbon credit was calculated as per the following formula:

Rate (t ha⁻¹ yr⁻¹) x 30 US \$ x 79.85 Indian rupees

2.10 Statistical analysis:

For statistical analysis "Analysis of variance" technique was applied to the data recorded for each character. Overall differences were tested by "F" test of significance at 5% level of significance as suggested by (Cochran and Cox, 1957). Critical differences at 5% level of probability were worked out for comparing treatments.

C.D. at 5% $\sqrt{\frac{2 \text{ Error mean Square}}{N}} \times T' \text{ value at } 5\%$

3. Results

3.1 Physiochemical properties

The bulk density of various land use system at 0-10 cm soil depth was lowest and highest value was 1.31, and 1.39 g cm⁻³ in SPS and AHS respectively but at the depth of 10-20 cm the highest value was recorded in the ASS and lowest value was recorded in HPS system. The mean value of soil bulk density was recorded that the highest bulk density 1.45 g cm⁻³ in ASS and lowest 1.34 g cm⁻³ was recorded in natural grassland. The variation in bulk density of soils in different and land use system presented in Fig. 1. Which indicated that the bulk density values for four non arable different land use system types viz. HS, SPS, HPS, and NGS compared to arable land use system types i.e., AHS, ASS and AS were lower.

3.2 Soil organic carbon and Stock

The soil organic carbon plays a significant role in regulation of soil ecosystem by improving soil microbes, structure, and availability of organic bound nutrients. The maximum and minimum soil organic concentration was 0.52 in SPS system and 0.27% in NGS system at 0-10 cm depth while at the depth of 0-20 cm was highest in SPS system (0.38%) and lowest in AS (0.21%). An examination of the mean values has shown that surface soils had the maximum (0.40) SOC value. It decreased with the increase in soil depth gradually resulting into the lowest value of 0.14 at 30-40 cm soil depth. The average of 0-40 cm depth, the maximum SOC was found in the SP system (0.35%) and minimum was recorded in the AS (0.18%).

The different land use systems influenced SOC stocks significantly. A critical assessment of data in (Fig. 2) indicated that babool + grasses (T₄) SPS showed significantly higher (4.95 t ha⁻¹) SOC stock. HPS and AHS showing their relevant SOC stock of (4.60 t ha⁻¹) and (4.27 t ha⁻¹) followed the ASS. The lowest soil organic carbon stock (2.63 t ha⁻¹) agriculture crop (T₂) among all seven land use systems. Analysis of mean values have shown that surface soils had the maximum (5.40 t ha⁻¹) depth 0-10 cm and significantly higher SOC stock values over the remaining. The lowest value of soil organic carbon stock was found that (2.01 t ha⁻¹) at the depth 30-40 cm (D₄).

3.3 Biomass and biomass-based carbon stock

Carbon is transferred from the atmosphere to the environment on land by vegetation. Photosynthesis and respiration play a vital role in the terrestrial C-cycle in the ecosystem. The above, below, and total biomass was significantly varied in different land use systems. The results reveal that SPS was having significantly higher AGB (18.46 t ha⁻¹), BGB (4.80 t ha⁻¹) and total biomass (23.26 t ha⁻¹) as compared to other land use system. Moreover, the above ground, below ground and total biomass production was found in higher to lower HPS, AHS, ASS, HS, AS and NGS land use system respectively.

The data of biomass-based C stock presented in (table 2) shows that SPS system was having significantly higher AGB carbon stock (8.30 t ha⁻¹), BGB carbon stock (2.16 t ha⁻¹) and total biomass carbon stock (10.46 t ha⁻¹) as compared to other treatments whereas, NGS recorded the lowest above ground biomass carbon stock (0.51 t ha⁻¹), lowest BGB carbon stock (0.13 t ha⁻¹) and Total biomass carbon stock (0.65 t ha⁻¹) among all the treatments. The remaining systems the biomass-based carbon stock recorded

in descending order HPS, AHS, ASS, HS, AS and NGS land use system respectively.

3.4 Total carbon stock (t ha⁻¹)

The total carbon stocks among the different systems considering belowground profile depth upto 40 cm were higher in babool + grasses (T₄) SPS (29.35 t ha⁻¹) and minimum under NGS (T₁) (11.87 t ha⁻¹) now, different land use system type viz. SPS and HPS in non-arable lands have higher amounts of carbon than AS, ASS and AHS systems planted in arable lands. Although SPS in non-arable lands had more carbon stocks than the all-in arable lands (Fig. 5)

3.5 CO₂ sequestration and carbon credit

In all land use system, the capacity for CO₂ sequestration and C credits were strongly correlated (Fig. 4). The highest amount of CO₂ mitigation level potential observed under SPS (38.41 t ha⁻¹) followed by HPS (31.99 t ha⁻¹), AHS (31.88 t ha⁻¹), ASS (30.88 t ha⁻¹), HS (24.70 t ha⁻¹), AS (18.27 t ha⁻¹) and lowest amount of CO₂ sequestration level potential was estimated in NGS (2.40 t ha⁻¹). Similarly, critical evaluation data showed that carbon credit (Rs ha⁻¹ yr⁻¹) varied appreciably under different land use systems (Fig. 6). Maximum carbon credit (Rs 92,018.90 ha⁻¹ yr⁻¹) was evaluated SPS among all the treatments. This was followed by HPS (Rs 76,632.56 ha⁻¹ yr⁻¹), AHS (Rs 76,366.71 ha⁻¹ yr⁻¹), ASS (Rs 73,990.63 ha⁻¹ yr⁻¹). Whereas significantly lowest carbon credit (t ha⁻¹yr⁻¹), potential was estimated in NGS (Rs 5,765.72 ha⁻¹ yr⁻¹).

4. Discussion

4.1 Physiochemical properties of soil

The data presented in (Fig. 1) shows that the highest bulk density was recorded in (1.45 g cm⁻³) was obtained from AS followed by minimum bulk density (1.36 g cm⁻³) was recorded in SPS. Also reported that soil bulk density in wheat ranged from 1.33 g cm⁻³ at 0-15 cm to 1.41 g cm⁻³ at 15-30 cm soil depth, while in a study on some physico-chemical properties of soil in wheat and reported that the bulk density ranged from 1.20 to 1.52 mg cm⁻³. The difference in the bulk density may be due to the variation in land use system. Similarly, Mishra *et al.* (2014) [25] reported that in the surface soil layer (0-15 cm), the bulk density (BD) decreased under agroforestry, horticultural plantations, and rice-wheat systems over the uncultivated barren sodic soil. Under the *Casuarina equisetifolia* L. The lowest BD (1.36 mg m⁻³) was observed, whereas the highest BD of 1.52 mg m³ was recorded under the uncultivated barren sodic soil.

4.2 Soil organic carbon and stock

The significant changes in SOC were presented in (Table.2). The maximum soil organic carbon was recorded in SPS (0.35%) was followed by (0.33%) HPS whereas, minimum soil organic carbon (0.18%) was found in AS. The increased in soil organic carbon on tree-based land-use system may be attributed to more leaf litter and root turnover from trees while in order of soil layers the soil organic carbon decreases with increase in depth of soil in all the land-use system due to less accumulation of leaf litter. Similarly, The SOC stock was higher in (4.95 t ha⁻¹) under SPS, followed by HPS (4.60 t ha⁻¹) and AHS (4.27 t ha⁻¹), while the lowest SOC stock recorded in (2.34 t ha⁻¹) AS land use system. The changes in SOC stock concentration are depends upon

above ground biomass, below ground biomass, and total biomass carbon (Table 2). The four land uses (forest, grassland, horticulture, agriculture) on SOC stock as well as concentration was found to be the highest at soil depth (0-100 cm) in temperate and the lowest in subtropical climate in the same soil (Singh *et al.* 2011) [36]. Also reported that soil (0-50 cm depth) under no-tillage retained higher carbon than conventional tillage treatment.

4.3 Biomass accumulation and biomass-based carbon stock

The experiment findings showed that the pace of biomass buildup is significantly influenced by each of the land use system. The maximum above ground biomass production (18.46 t ha⁻¹) SPS, followed by HPS (15.37 t ha⁻¹). Minimum above ground biomass production was found in NGS (1.15 t ha⁻¹). The below ground biomass and total biomass followed the same trend as the maximum below ground biomass production SPS (4.80 t ha⁻¹), (23.626 t ha⁻¹) respectively, and minimum was recorded in NGS (0.30 t ha⁻¹) and (1.46 t ha⁻¹) respectively. The variation is might be due to the tree (woody component grown under different systems) and crop combination in SPS have greater potential for biomass accumulation. All the arable land use with agroforestry systems showed higher biomass accumulation than non-arable land use systems (Goswami *et al.* 2014) [13]. The similar findings were reported by (Bohre *et al.* 2014) [3], Chavan and Rasal (2012) [9] and Yadava (2015) [43] for biomass production. Likewise, biomass above below and total biomass was significantly influenced due to the different land-use system. The maximum AGB carbon stock (8.30 t ha⁻¹), BGB (2.16 t ha⁻¹) carbon stock, and total biomass carbon stock (10.46 t ha⁻¹) were found in SPS than all other system. Some trend in the rate of C sequestration and total carbon sequestration in agroforestry systems was also reported by Chavan and Rasal (2012) [9], Bohre *et al.*

(2014) [3], Koul and Panwar (2008) [18], Rathore and Jasrai (2013) [31].

4.4 Total carbon stock

Different agroforestry systems on the basis of total carbon stock (0-20 cm soil depth) observed the following decreasing order: SPS>HPS>AHS>ASS>HS>AS>NGS (Fig. 5). Results were almost similar if soil depth was 0-40 cm. In this case of different land-use systems observed the following descending order: SPS>HPS>ASS>AHS>HS>AS>NGS. The highest value in both cases same but lowest values in both cases were not shown by same in this system types. The findings also indicated that total carbon stocks increased when profile depth was 0-40 cm in place of 0-20 cm. The results are evident remaining to increased soil volume in concern.

4.5 CO₂ sequestration (t ha⁻¹ yr⁻¹) and carbon credit (Rs t ha⁻¹ yr⁻¹)

Among the various land sue systems the rate of carbon sequestration varied significantly. The highest carbon sequestration rate recorded in SPS (38.41 tha⁻¹) among all the land use system (Fig. 4). It might be due the highest rate of c stock in above and below ground biomass under the SPS (Table 2). Critical appraisal of data showed that carbon credit (Rs t ha⁻¹ yr⁻¹) varied appreciably under different land use systems. This was consistent with the findings of Kanime *et al.* (2013) [16]. The one carbon credit is equal to one ton of C fixed in biomass and is worth in Rs (Fig. 5). Maximum carbon credit (Rs 92,018.90t ha⁻¹ yr⁻¹) was evaluated by SPS, and this followed by ASS (Rs 73,990.63 ha⁻¹ yr⁻¹) HPS (Rs76,632.56 ha⁻¹ yr⁻¹), AHS (Rs 76,366.71 ha⁻¹ yr⁻¹), SPS (Rs 73,990.63 ha⁻¹ yr⁻¹). Whereas significantly lowest carbon credit (t ha⁻¹ yr⁻¹), potential was estimated in NGS (T₁) (Rs 5,765.72 ha⁻¹ yr⁻¹) respectively. The similar trends of results were found by Kanime *et al.*, (2011) [16].

Table 1: Investigational details of different land use systems tree-crop combination.

System type	Tree crop combination	Main sample plot size m ²	Planting distance (ha ⁻¹)	Intercrop Spacing	No. of trees (ha ⁻¹)	Age of trees (Years)
Agriculture (A)	<i>Triticum aestivum</i>	50 × 20	-	22.5×5 cm	-	-
Horticulture (H)	<i>Emblia officinalis</i>	50 × 20	7×7 m	-	205	8
Natural Grassland (NG)	<i>Grasses</i>	50 × 20	-	-	-	-
Silvi-pastoral (HP)	<i>Acacia nilotica</i> + <i>Grasses</i>	50 × 20	Scattered trees	-	63	15
Horti-pastoral (SP)	<i>Emblia officinalis</i> + <i>grasses</i>	50 × 20	7×7 m	-	205	8
Agri-silviculture (AS)	<i>Tectona grandis</i> + <i>Triticum aestivum</i>	50 × 20	2.5×2.5 m	22.5×5 cm	80	8
Agri- horticulture (AH)	<i>Psidium guajava</i> + <i>Triticum aestivum</i>	50 × 20	7×7 m	22.5×5 cm	205	8

Table 2: Variation in soil organic carbon (%) in the different land use system.

LUS	Soil Organic Carbon (%)				
	(0-10 cm)	(10-20 cm)	(20-30 cm)	(30-40 cm)	Mean (0-40 cm)
NGS	0.27	0.22	0.21	0.11	0.20
AS	0.34	0.21	0.1	0.09	0.18
HS	0.37	0.26	0.21	0.11	0.24
SPS	0.52	0.38	0.27	0.23	0.35
HPS	0.42	0.38	0.36	0.23	0.33
ASS	0.39	0.34	0.26	0.09	0.27
AHS	0.5	0.36	0.27	0.12	0.31
Mean	0.4±0.02	0.31±0.01	0.24±0.02	0.14±0.01	0.14±0.01
CD (p<0.05)	0.08	0.06	0.06	0.05	0.05

LUS: Land use systems, NGS: Natural grassland, AS: Agriculture, HS: Horticulture, SPS: Silvi-pastoral system, HPS: Horti-pastoral system, ASS: Agri-silviculture system, AHS: Agri-horticulture system; CD: Critical difference.

Table 3: Variation in biomass and carbon stock (t ha^{-1}) in different land use systems.

LUS	Biomass (t ha^{-1})			Carbon stock (t ha^{-1})		
	AGB	BGB	Total	AGB	BGB	Total
NGS	1.15	0.3	1.46	0.51	0.13	0.65
AS	8.78	2.28	11.06	3.95	1.02	4.98
HS	11.87	3.08	14.96	5.34	1.39	6.73
SPS	18.46	4.8	23.26	8.3	2.16	10.46
HPS	15.37	3.99	19.37	6.91	1.79	8.71
ASS	14.84	3.86	18.7	6.68	1.73	8.41
AHS	15.32	3.98	19.3	6.89	1.79	8.68
Mean	12.26 $\pm$ 0.53	3.18 $\pm$ 0.13	15.44 $\pm$ 0.67	5.51 $\pm$ 0.24	1.43 $\pm$ 0.06	6.95 $\pm$ 0.94
CD ($p < 0.05$)	1.66	0.43	2.09	0.74	0.19	0.302

LUS: Land use systems, NGS: Natural grassland, AS: Agriculture, HS: Horticulture, SPS: Silvi-pastural system, HPS: Horti-pastural system, ASS: Agri-silviculture system, AHS: Agri-horticulture system; AGB: Above ground biomass, BGB: Below ground biomass; CD: Critical difference.

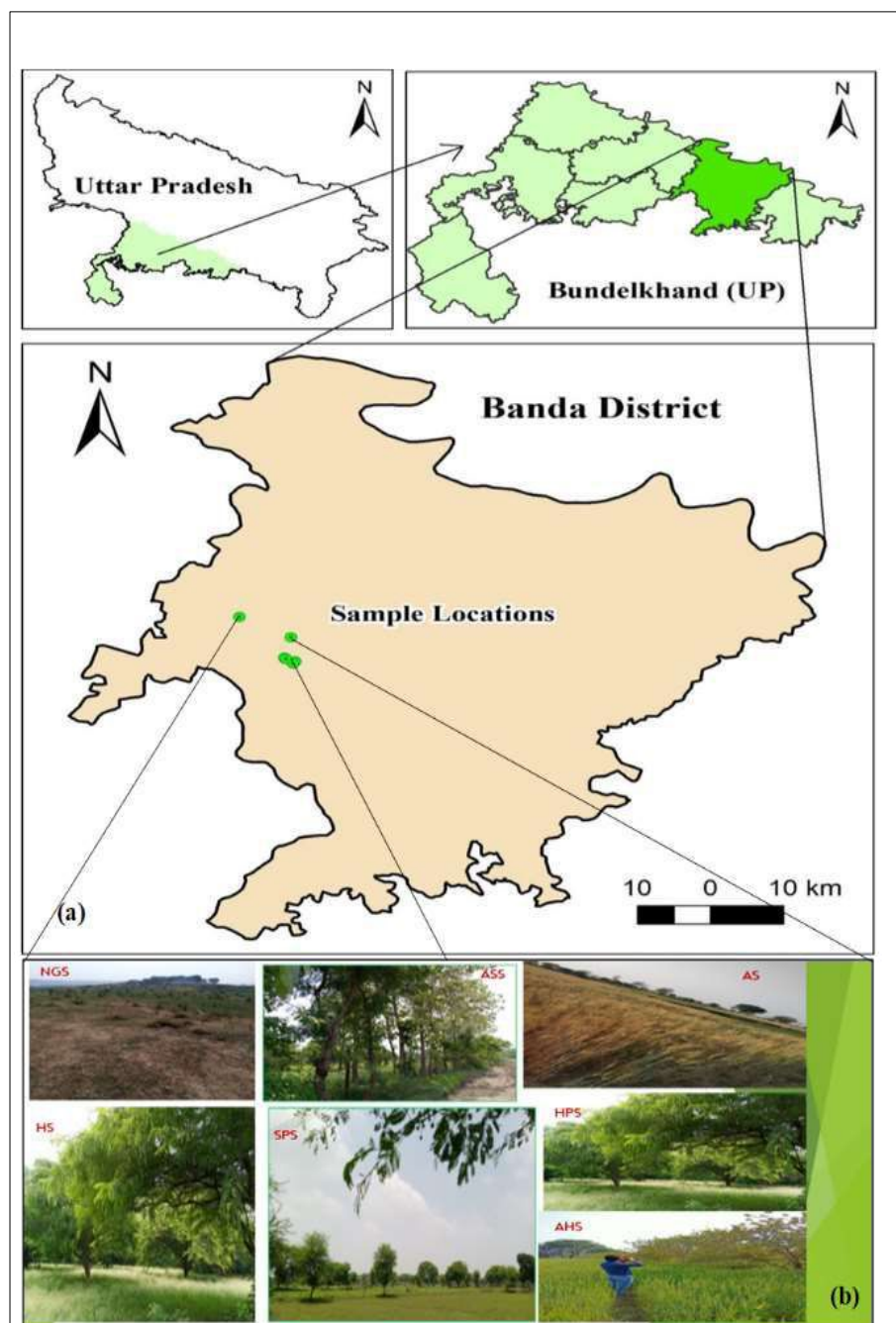


Fig 1. a) Location map of Experimental site in Banda district of Bundelkhand region. **b)** Selected Land use system (LUS): NGS- Open grassland, ASS- Agri silviculture system, AS- Agriculture system (sole), HS- Horticulture system, SPS- Silvopastoral system, HPS- Hortipastoral system, AHS- Agri horticulture system.

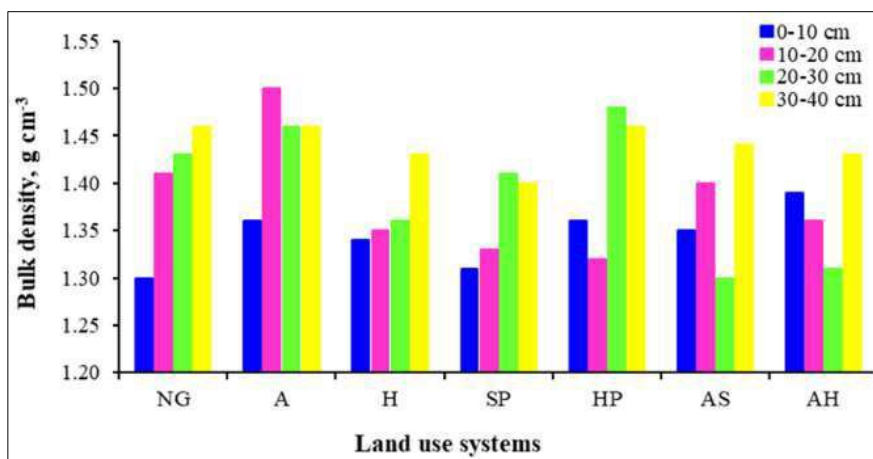


Fig 2: Depth wise soil bulk density in different Land use systems

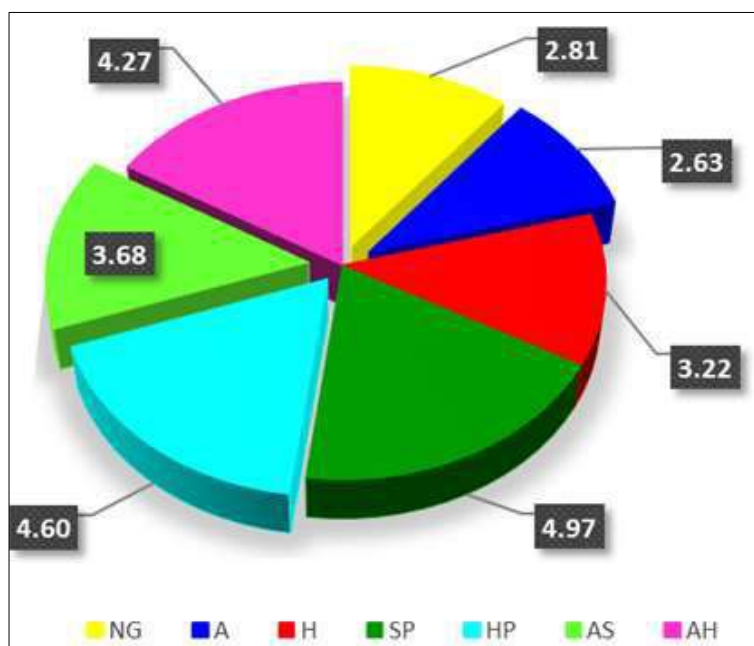


Fig 3: Variation in soil carbon stock (t ha⁻¹) in different land use systems.

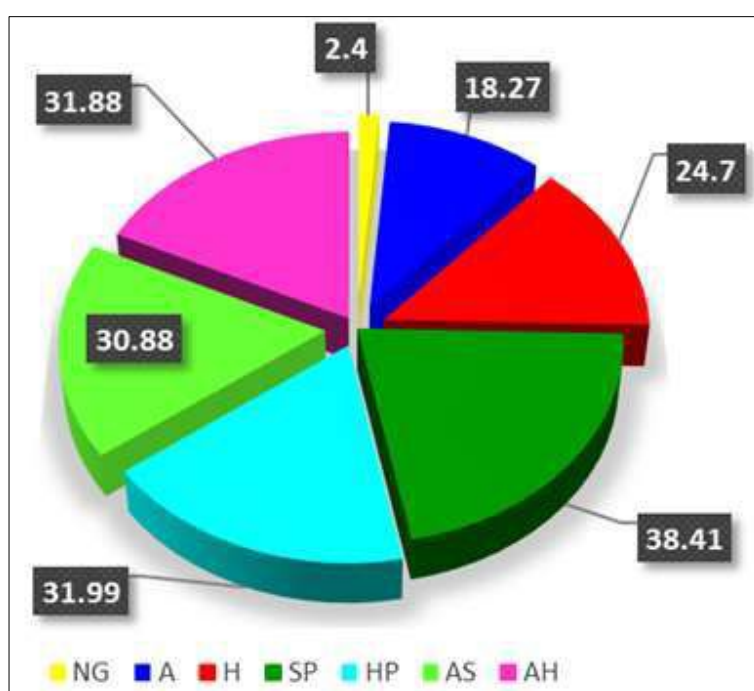


Fig 4: Variation in total CO₂ sequestration (t ha⁻¹) of the different land use systems.

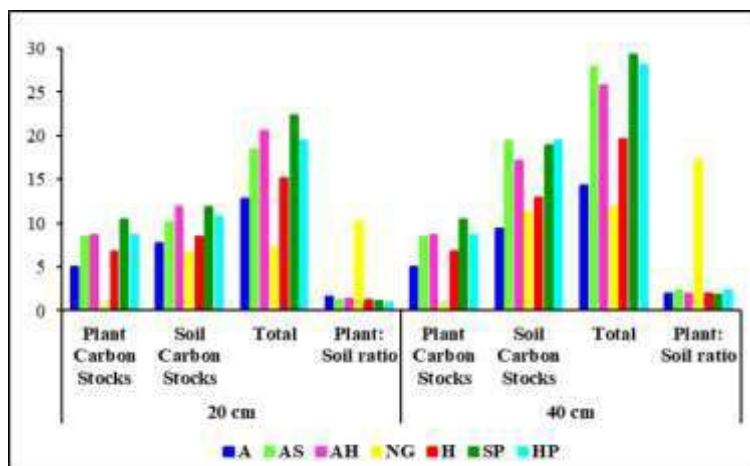


Fig 5: Carbon stock (t ha^{-1}) of different land-use systems considering belowground carbon up to 20 cm and 40 cm profile depth

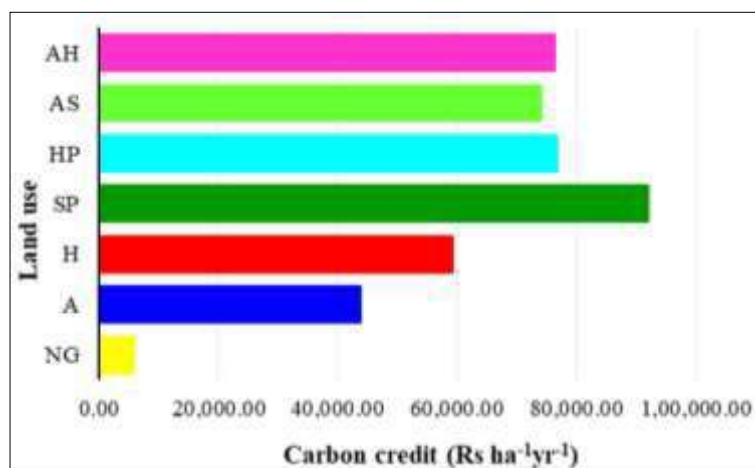


Fig 6: Variation in total carbon credit ($\text{Rs ha}^{-1} \text{yr}^{-1}$) in different land use systems

5. Conclusion

The results of this study demonstrate that trees in various land use systems serve as carbon sinks by storing carbon in their tissues as biomass and lowering atmospheric CO_2 levels. This study concluded that best land-use system for biomass and carbon stock in different land-use systems. The biomass production potential was highest in different land-use systems followed by SPS, HPS, AHS, ASS, HS, AS, and NGS land-use systems. Further, in terms of soil properties, better physical and chemical properties were found in different land-use systems. on the basis of total carbon stock (0-20 cm soil depth) observed the following decreasing order: $\text{SPS} > \text{HPS} > \text{AHS} > \text{ASS} > \text{HS} > \text{AS} > \text{NGS}$. Results were almost similar for soil depth upto 40 cm. The following descending order $\text{SPS} > \text{HPS} > \text{ASS} > \text{AHS} > \text{HS} > \text{AS} > \text{NGS}$ was observed for 0-40 cm soil profile depth.

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