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Assessment of Biomass and Carbon Stock across Different Agroforestry Systems in Niger State, Nigeria

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Abstract: This study assesses the biomass and carbon stock in agroforestry land use types in Niger State, Nigeria. Direct biomass collection, laboratory analysis techniques, and biometric forest inventory methodologies were used to collect the data. To summarize the data, descriptive statistics were employed. Carbon stock equivalent was then calculated from biomass data. Vegetation cover and carbon stock change during a 20-year period were estimated using NIGERIASAT-1 satellite imagery from 2003 and 2023, respectively. The results show that the research area's four primary agroforestry land use categories are savanna woodland (53.22%), grassland (15.03%), scrubland (16.5%), and cropland (15.45%). The findings show that the principal tree species within the studies place are Vitalleria paradoxa, Irvingia gabonensis, Parkia biglobosa, and Anogeissus leiocarpus. collectively, these account for about 65.2% of all species. The common carbon stock for savanna woodland (469.62±18.21), scrubland (278.37±27.55), grassland (153.15±12.42), and cropland (139.35±24.31) turned into the lowest (Mg C/ha-1). inside the take a look at place, the average carbon stock for distinct agroforestry land use sorts so as are Savanna woodland (347.45 Mg C ha-1), scrubland (212.13 Mg C ha-1), grassland (124.78 Mg C ha-1), and cropland (123.ninety-four Mg C ha-1). To help with carbon offset, this observe recommends holding tree species like Anogeissus leiocarpus and Parkia biglobosa due to the fact they may be local, ecologically crucial, and may keep loads of carbon due to their biomass inside the place.

Keywords: Biomass, Carbon, Stock, Savanna woodland, Agroforestry and Vegetation.

I. INTRODUCTION

Biomass is the total weight of aboveground biomass (AGB) and belowground biomass (BGB), which includes parts of living plants like wood, bark, branches, trunks, logs, and roots, along with waste in the soil (Raihan et al., 2021). Trees take in carbon dioxide from the air in a process called carbon sequestration, which is a key function of forests (Mauya and Madundo, 2021). Moreover, forests are critical to the global carbon cycle considering that they hold tremendous carbon in each soil and flowers. in addition to soaking up carbon dioxide from the air via photosynthesis and respiration, timber can also grow to be emitters of carbon monoxide at the same time as subjected to herbal or anthropogenic events together with forest fires, deforestation because of insufficient logging, limit and burn, and conversion of forests to different uses (Ghasem et al., 2021). Surroundings severa modern studies has validated that land use-associated practices at the side of deforestation, enteric fermentation, and fertilization substantially affect the overall amount of anthropogenic greenhouse gas emissions (Tubiello et al., 2015; Zhu et al., 2016). Further, there had been opinions of developing emissions of nitrous oxide and methane from agricultural fields (Czubaszek et al., 2018; Hao-tian et al., 2019). Li (2021) emphasizes how critical landmasses are to surface dynamics, aerosols, water flows, and the better environment. However, a range of things render those precious assets vulnerable to intense weather occasions and weather exchange (Li, 2021; Zaninovich et al., 2016). The lack of biodiversity and other atmosphere services is one of the number one reasons of land degradation, consistent with Brassoulis (2019) and Zaninovich et al. (2016). pollution, compaction, closure, erosion, nutrient shortages, acidification, lack of soil organic carbon (SOC), waterlogging, salinization, and biodiversity loss are only a few of the eleven problems that Panagos et al. (2020) identified as having an effect on soil performance. Weather models predict that destiny precipitation and common temperatures will significantly alter, growing the frequency of excessive precipitation and temperatures (IPCC, 2018; Kopittke et al., 2019). Average July temperatures by way of the quilt of the twenty-first century will surpass those discovered among 1900 and 2006.

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Carbon stock

The main contributor to climate alternate is the growth of greenhouse gases (GHG) inside the environment. The stability of solar radiation from the solar and the earth, in addition to sun power assets, is suffering from the boom in concentrations of gases along with carbon dioxide (CO2), methane (CH4), nitrogen oxide (N_2O), and so on. (Lal, 2010; Ciais et al., 2013). Consistent with the worldwide power company (2015), carbon dioxide tiers are presently 397 elements consistent with million, up from 280 elements in keeping with million in the pre-enterprise technology. but Dlugokecky and Tans (2018) determined that atmospheric CO_2 degrees prolonged with the useful resource of 128 factors in step with million among 1750 (the start of the pre-business duration) and 2017. Fossil gas combustion and land use exchange are the two fundamental causes of carbon dioxide deterioration. As said with the aid of Ciais and co-workers (2013). In truth, burning fossil fuels for transportation, heating, and cooling, as well as for the production of cement and different commercial products, accounts for more than seventy-five% of worldwide carbon dioxide emissions. Among 1990 and 2013, Ethiopia's emissions of CO2 from fossil fuels accelerated from 2. Three million heaps to 8.5 million tons (IEA, 2015).

Carbon sequestration in agriculture

The process of removing carbon (C) from the environment and storing it in landfills like soil, flowers, or the ocean is known as carbon sequestration (Smith, 2019). Carbon sequestration in terrestrial ecosystems, inclusive of agroforestry structures and practices, is usually connected to the switch of carbon dioxide to soil, biomass, and waste for garage as well as the absorption of carbon dioxide from the atmosphere through photosynthesis (Nair, 2016). About 24% of worldwide carbon emissions come from agriculture, making it a primary contributor to these emissions (Zomer et al., 2017). In line with Lal (2010), the global soil carbon (C) pool is kind of four instances large than the biological pool and 3.2 instances larger than the atmospheric pool. Agricultural soils are a huge storage of CO_2 because of their ability to lure carbon (Zomer et al., 2017). Around 10% of the worldwide SOC pool is product of the 140 × 109 tons of carbon that flowers store inside the pinnacle 30 cm of soil (Paustian et al., 2016). Agricultural lands are a amazing choice for enhancing soil carbon sequestration due to the fact that they will have more ability if they'll be managed better. Preceding estimates indicate that among 50% and 70% of soil carbon shares are misplaced because of agriculture (Lal, 2010). Consequently, there may be a terrific-sized risk that agricultural regions will maintain carbon till they achieve saturation (Sommer and Bossio, 2014).

Biomass

Through the carbon contained in their biomass, tree-based land-use systems, including plantations, agroforestry systems, and traditional forests, sequester CO_2 (Nair, 2016). Turning low-biomass soils—like grasslands, agricultural wetlands, and permanent vegetation—into tree trunks is the most effective way to sequester carbon. Forest ecosystems retain more than 70% of all soil organic carbon and more than 80% of all aboveground carbon (Paustian et al. 2016). Because they can store up to 350 degrees Celsius, plants are a major global source of carbon (Dlugokenky and Tans, 2018). Events such as harvesting, regrowth, and conversion to different land uses can alter how much carbon is stored by plants, which can result in fluxes of carbon emissions into the atmosphere.

Agroforestry

Perennial woody flora is designed to be used in spatial arrangement or temporary intercropping with crops and/or livestock inside the identical land management unit. Those land use styles and processes additionally consist of agriculture (Kopittke et al., 2019). Exclusive factors of agroforestry structures are both economically and ecologically effective. In addition, agroforestry structures are important for biodiversity conservation. They can also increase model to weather exchange and precipitation differences by increasing soil fertility, as a consequence growing productivity and generating greater income. Agriculture (Haile et al., 2017). After primary forests and degraded lands, agroforestry is Africa's third largest carbon sink. According to Nair et al. (2011), bushes in agroforestry save three to four times as much carbon as treeless farmland and pastures, with carbon shares ranging from 29 to 228 Mg ha–1. Over the next 50 years, it is anticipated that 1.6 billion hectares of land will be covered by various agroforestry systems that have the capacity to sequester carbon.

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Effects of Agroforestry on Biomass and Carbon Stock

since the operation, the amount of carbon dioxide launched into the surroundings has increased considerably, making it the maximum effective greenhouse gas and a giant contributor to global warming (>70%). around 3. five parts in line with millions of CO_2 are launched into the surroundings each year, endangering the surroundings global. Twenty to thirty percentage of the world's ecosystems might be harmed if international temperatures rise via 20°C over the next numerous years (Haile et al., 2017). Consistent with Kopittke et al. (2019), human actions consisting of burning fossil fuels, deforestation, and drastic modifications in land use styles have resulted in on-going carbon dioxide emissions that gas weather exchange. One control method for boosting the ecosystem offerings supplied through agricultural land is agroforestry. Agroforestry systems are notion to have the ability to mitigate worldwide climate trade due to the fact timber planted at the landscape growth the capability of those structures to seize and save carbon.

II. METHODOLOGY

The exploratory survey technique changed into used to gather the research records inside the examine region. Each forest changed into cut up into 4 sections, one from south to north and one from east to west. Four connection strains were prolonged up to 2 km to identify the agroforestry-based quadrants, and one square became located on every east-west and north-south line. a complete of forty-eight quadrats have been installation, with 12 quadrats in keeping with rotation to degree biomass and forty-eight quadrats (16 in step with herbal wooded area) to quantify carbon shares and vegetation cowl in every quadrat. The AGB of the tree species layer turned into computed from the measured DBH and tree top using the tree biomass regression equation for rainfall region (Makinde et al., 2017): BGB = 20% AGB (three) is calculated through converting ãy = eã^((- three.1141+ 0.9719 In (DBHÃH)), (1) in which y is the biomass (AGB), in kg;) to tonha1. The plants is composed of numerous agroforestry land use types, which encompass savanna forests (SW), shrublands (SL), grasslands (GL), and farmlands (CL). Signs and symptoms of plant groups consist of biomass, carbon inventory (CS), style of species (SP), tree crown (TCC), shrub cowl (SC), grass cover (GC), treetop (TH), diameter at breast height (DBH), basal region (BA), and tree crown. Samples have been taken from each 1 m2 subplot at wonderful depths (0–15 cm and 15–30 cm). the quantity of soil organic carbon changed into measured with the aid of combining the 4 samples from every plot into composite samples based totally on depth classes; collecting intact soil samples from depths (zero–15 cm and 16–30 cm) using tremendous earrings (functionality ninety eight.2 cm3, cylinder radius 2.5 cm, and period 5 cm); gathering soil, muddle, and savanna forest and shrub land samples the usage of four 1 m2 quadrats; accumulating carbon storage records from 5 essential carbon sinks: aboveground trees, shrubs, root carbon, clutter, and deadwood; measuring carbon dioxide emissions the usage of the proper strategies (e.g., biomass sampling/allometric equations for aboveground tree stocks. Samples of deadwood, logs, grass, and litter are then accrued from the field and brought to a check facility for isothermal moisture content material measurements. The study made extensive use of an analysis of variance (ANOVA) to observe the variations in mean values of various agroforestry land use patterns within the study area, as well as a student t-test to assess differences in flower variety and carbon shares among plant communities, specifically savanna and shrubland. Assessments are also conducted to determine the density and natural content of soil samples, and the full carbon in each plot is calculated by adding the carbon in each pool. Statistical analyses had been carried out at 0.05, zero.01 and 0.001 importance degrees.

III. RESULT AND DISCUSSION

Agroforest land use types and plant communities

This section describes the agroforestry land types commonly used by farmers in the research area, which include cropland, grassland, scrubland, and savanna woodland, which accounts for 53.02% of the agroforestry land use in the research region (Table 4.1). The amount of vegetation cover is gradually decreasing due to the negligent use of forest resources for human purposes. On the other side, 16.5% of the study area's agroforestry land is covered by scrublands. However, the amount of usable grassland (15.03%) and farmland (15.45%) increases as savanna woodland and scrubland diminish. Interestingly, there was an increase in Grassland coverage from 2012 to 2020.

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Table 1: Agroforestry land types of area coverage over the study area

Agroforestry land use types	Area of land (ha)	Frequency	percentage
Savanna woodland	7930.30	9	53.02
Scrub land	2467.40	15	16.50
Grassland	2247.81	8	15.03
Crop land	2311.78	29	15.45
Total	**14957.29**	**60**	**100**

Source: Authors field work, 2023.

Composition of Woody Species over the study area

1,505 wonderful woody stands comprising 36 species, 18 genera, and 18 households had been located and tallied for the duration of the research region's agroforestry plant groups. the following tree species account for about sixty five.2% of the species dominance inside the research place: Vitalleria paradoxa (thirteen.eight%), Irvingia gabonensis (9.2%), Parkia biglobosa (8.0%), Annona senegalensis (7.7%), Pterocarpus erinaceous (7.four%), Detarium microcarpum (five.7%), Prosopis africana (five.7%), Danellia oliveri (four.2%), and Afzelia Africana (three.five%).

The Combrataceae, Moraceae, Malvaceae, and Fabaceae are also the most prevalent families. Since plant communities are essentially the result of strict habitat choice that denies possibility to all but a particularly small quantity of the exceptional variety of species, the observed dominance of specific species and species families over the study area can be attributed to the impact of species ecological amplitude (environmental tolerance) (Jibrin et al., 2018). Because of this, specific plant species mixtures often create somewhat unique ecosystems. Each community is described through specific species which might be invisible or underrepresented in other groups.

Table 2: Composition of woody species over the study area

S/N	Tree species	Genus	Family	Percentage composition
1	*Vitellaria paradoxa*	*Vitellaria*	*Sapotaceae*	13.8
2	*Irvingia gabonensis*	*Irvingia*	*Irvingiacea*	9.2
3	*Parkia biglobosa*	*Parkia*	*Mimosaceae*	8.0
4	*Annona senegalensis*	*Annona*	*Annonaceae*	7.7
5	*Pterocarpus erinaceous*	*Pterocarpus*	*Fabaceae*	7.4
6	*Detarium microcarpum*	*Detarium*	*Caesalpiniaceae*	5.7
7	*Prosopis africana*	*Prosopsis*	*Fabaceae*	5.7
8	*Danellia oliveri*	*Danellia*	*Caesalpiniaceae*	4.2
9	*Afzelia africana*	*Afzelia*	*Fabaceae*	3.5
10	*Khaya senegalensis*	*Khaya*	*Meliaceae*	3.4
11	*Adansonia digitata*	*Adansonia*	*Malvaceae*	1
12	*Ceiba pentandra*	*Ceiba*	*Malvaceae*	0.9
13	*Tamarindus indica*	*Tamarindus*	*Fabaceae*	0.9
14	*Elaeis guineensis*	*Elaeis*	*Fabaceae*	0.8
15	*Mangifera indica*	*Mangifera*	*Anacardiaceae*	0.6
16	*Acacia senegal*	*Acacia*	*Fabaceae*	0.2
17	*Cocos nucifera*	*Cocos*	*Malvaceae*	0.1
18	*Anacardium occidentale*	*Anacardium*	*Anarcardiaceae*	0.1

Source: Field survey, 2023.

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The carbon stock of land use types

Aboveground carbon stock

Since there are no trees in agricultural and pasture areas, only savanna trees and agroforestry areas were used in biomass assessment. The study found that savanna forests store more carbon than agroforestry areas used for vegetation. 83.3% of the biomass carbon pool is made up of the aboveground biomass found in savanna forests (Table 3). Trees with DBH ≤ 30 cm were shown to sequester the most carbon (Table 2). A few uncommon tree species were found and measured in agroforestry plants. The results showed that 93.59% of biomass carbon stocks were higher than biomass in agroforestry land use, including forests and forested savannas. However, only savanna trees and agroforestry soils were used to measure carbon content. The productivity mentioned above was not measured because the aboveground biomass of grasses and plants was not measured. Since savanna forests have more large trees and other plants than agroforestry, the soil biomass carbon content is the highest in agroforestry. This shows that there are trees in any area that can capture and store biomass carbon through photosynthesis. This will help mitigate climate change. Compared to forest savannas, taller trees with a bigger diameter at breast height (dbh) might be linked to higher CO2 levels (Dumitras et al., 2020).

Belowground biomass

The savanna woodland had the highest mean belowground biomass (22.23 t ha-1) regardless of altitudinal gradients, whereas the scrubland agroforestry land use had the lowest (3.45 t ha-1). The savanna woodland and scrubland agroforestry land use categories were the only ones used to quantify aboveground carbon; the belowground carbon stock was not measured because there was no detectable belowground biomass in the grasslands or croplands. The savanna woodland had a higher belowground biomass carbon storage than the scrubland agroforestry because it contained more tree roots, litter composition, and other vegetation cover.

Root carbon stock

The base carbon stocks based totally on aboveground biomass (20%) for savanna forest and shrubland agroforestry are predicted to be 23.29 ± 3.56 and 3. forty-three ± zero.34 ha-1, respectively. Roots are crucial for balance as they switch a big amount of carbon to the soil. in this experience, savannas play a crucial role in storing carbon beneath greater strong tillage layers. Roots are the main supply of organic carbon within the soil in flora (Raihan et al., 2021). Since aboveground biomass was used to compute the carbon source, it is possible that the low biomass content of the soil is the reason for the reduced CO2 level in this observation. However, savanna forests have a higher capacity to store carbon than agroforestry land use, indicating that forests may be better at storing carbon in their roots. According to Ivá (2019), trees with deep roots will store more carbon in their root biomass; however, when soil moisture levels rise, this amount should fall. According to Abdullahi et al., roots are a fantastic way to store carbon because the majority of the aboveground biomass is destroyed. Consequently, so as to better estimate the carbon footprint, indirect strategies ought to be used instead of direct methods to determine the carbon footprint. The carbon shares of the intercropped flora have been determined to be zero.69 ± 0.08 t/ha and zero.36 ± zero.04 t/ha, respectively. on the grounds that agricultural wastes are used for production, fuel and animal feed functions within the take a look at vicinity, there's no waste within the fields. further, because the plants is dense inside the take a look at place and the mowing and transportation system is nicely developed, there was nearly no clutter on the grass. due to the fact there may be no grass a number of the bushes. Some other important supply of natural carbon is rubbish, especially in environments with herbal plants. According to Tessema and Kibebew (2019), the charge of decomposition of waste determines how a good deal carbon will input the soil. This charge is tormented by garbage pleasant and plant variety.

Litter carbon stock

Carbon storage was higher in savanna woodland and agroforestry land use groups compared to grassland and agricultural land. Reducing trees in agroforestry lands using pasture and agricultural lands in the study area will help reduce waste in the region. Ivan et al. Litter is believed to be important for the biogeological cycle as it acts as a carbon sink for soil and vegetation. (2019). Therefore, proper waste management is necessary to stabilize the organic matter in the body. The primary sources of organic carbon in soil are found in plant roots (Raihan et al., 2021). The drop in CO_2 in this study could be the result of less land usage because the carbon base

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was computed using the biomass mentioned above.

However, savanna forests may be good at storing carbon in their deep roots since their root carbon stores are higher than those of agroforestry land use plants. Deep-rooted trees may store large amounts of carbon in their root biomass, according to Ivan et al. (2019); however, this capacity is expected to decrease as soil cover increases. According to Abdullahi et al. (2014), other specific locations and specific land uses may affect this source. In addition, differences in carbon storage among forests may be due to animal composition and forest conditions such as weather and soil. While roots are considered the best place for carbon removal, aboveground biomass has also undergone various removal processes. Therefore, to better estimate the carbon footprint of a product, an indirect method should be used instead of a direct method of determining the carbon footprint.

Dead wood carbon stock

The carbon stock was not evaluated because dead wood was not found during the reconnaissance survey in the savanna forest zone or in the sample plots. Similarly, the carbon stock of debris was eliminated since the croplands under study did not have debris as a carbon pool and because savanna forest garbage is routinely exploited for fuel and construction lumber. Dead wood from the savanna woodland is regularly collected by the locals and used as their main energy source. Despite the fact that dead wood contributes significantly to the carbon pool of a forest ecosystem, ongoing forest disturbance has led to the full exploitation of any dead trees.

Table 3: Carbon stock of different agroforestry land use (t ha^{-1})

Agroforestry land use types	Carbon stock in different carbon pools				
	AGC	BGC	LC	SOC	Total carbon
Savanna woodland	116.56±18.71	22.23±3.56	0.69±0.08	319.39±21.02	469.62±18.21c
Scrubland	16.25±1.9	3.45±0.36	0.37±0.04	269.49 ±25.54	278.37±27.55b
Grassland				153.15±12.42	153.15±12.42a
Cropland				139.85±24.01	139.35±24.31a

Source: Field survey, 2023.

For each parameter, different letters in a column indicate significant differences ($p<0.5$) with respect to land uses.
AGC= Aboveground carbon, BGC= Belowground carbon, LC = Litter carbon, SOC= Soil organic carbon.

Simulate the biomass carbon stock per Agroforest land use type by year 2050

The predicted carbon emissions for several agroforestry land use types are displayed in Table 4. Each plant community has the following common carbon stocks: grassland (124.seventy-eight Mg C ha-1), cropland (123.94 Mg (C) ha-1), shrubland (212.thirteen Mg C ha-1), and savanna woodland area (347.forty-five Mg C ha-1). We projected to 2050 and decided to increase agroforestry for each type of land use. However, savanna woodland agroforestry land use had altered by 26% by the end of the evaluation period, which was the highest proportion of carbon emissions across the entire agroforestry land use organization. Cropland and pastures are the best agroforestry land use types a good way to bring about the bottom yield losses. Until 2050, the boom in the lack of aboveground and belowground biomass carbon stocks in savanna forests is because of the forest improvement sports of rural humans. The contribution of scrub agroforestry land use (212.13 Mg C ha-1) is huge, whilst the lower in carbon stocks is sizable. The reforestation analysis's results demonstrate that reforestation has a high capacity to sequester carbon and store biomass and timber products, particularly in savanna woodlands (347.45 Mg C ha-1) and scrublands (212.thirteen Mg C ha-1), which may help lower greenhouse gas emissions. Deforestation continues at 11.05 percent, with carbon stocks mostly lost through agricultural land usage, as a result of ongoing agricultural expansion and the lack of agricultural land launch over the past 20 years. Furthermore, although cleared land may be used (usually until 2035), the land from regeneration has the lowest carbon footprint since vegetation, such as

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forests, have low carbon footprints in a given area.

Table 4: Mean of carbon stock estimates by the year 2050

Agroforestry land use types	Carbon stock Mg C ha^{-1}						
	2023	2030	2035	2040	2045	2050	%ΔC
Savanna woodland	469.62	363.83	348.22	343.27	334.34	347.45	26.01
Scrubland	278.37	256.38	227.85	219.35	215.36	212.13	23.79
Grassland	153.15	146.04	138.34	137.16	125.47	124.78	18.52
Cropland	139.35	135.29	137.98	133.71	125.70	123.94	11.05
Total	1040.49	901.54	852.39	833.49	800.98	808.3	22.31

Source: Authors Field work, 2023.

IV. CONCLUSIONS

This takes a look at gives correct estimates of agroforestry biomass and carbon shares in a widely used landscape in Niger country, Nigeria. These estimates offer a foundation for estimating modifications in carbon shares over the years and can form a vital basis for assessing destiny projections. To accurately degree and show carbon emissions in savanna communities, it is vital to set up baseline facts on species composition, variety and distribution of plants within the look at place. The idea of habitat heterogeneity (fragmentation) complements the range of plants in savanna forests and shrublands and is supported with the aid of motives of flora composition, shape and range in humans. Ecologically vital bushes inside the study region include Vitaleria paradoxa, Irvingia gabonensis, Parkia biglobosa, Anogeissus leiocarpus, Pterocarpus erinaceous, Detarium microcarpum, Prosopis africana, Danellia oliveri and Afzelia africana. Collectively, the ones animals account for about 65.2% of all controlled animals. The dominance of tremendous species similarly allows the ecological amplitude principle. This finding is steady with previous studies and together gives an ecological model. The composition and form of the fauna observe the sample of the Guinea Savanna ecoregion, in which tree species dominate. The tree species that contributed the maximum to the panorama were Anogeissus leiocarpus (401.98 kg), Parkia biglobosa (352.nine kg), Pterocarpus roxburghii (290.sixty-three kg), Irvingia gabonensis (258.80-three kg) and Viariatellpp. The results of this study show that red very well are the maximum carbon-wealthy tree species within the have a look at region. among all plant's sorts, savanna wooded area (469.62 Mg ha-1), shrubland (278.37 Mg ha-1), grassland (153.13 Mg ha-1) and cropland (139.35 Mg ha-1) had the lowest average carbon shares. however, in line with the estimates of carbon emissions from special agricultural and forestry sports activities, the common carbon stocks of plant groups had been as follows: grassland (123.94 Mg C ha-1), grassland (124.seventy-8 Mg C ha-1), shrubland (212.thirteen Mg C. ha-1).

Recommendations

i. Because of their ecological significance, nativeness, and high capacity to sequester carbon through their biomass stocks, this study suggests that tree species like Anogeissus leiocarpus, Parkia biglobosa, Pterocarpus erinaceous, Irvingia gabonensis, and Vitellaria paradoxa be preserved for carbon offset purposes.
ii. Finding, assessing, and implementing solutions that enhance and safeguard the carbon stock under the various land use/cover types in a way that is both environmentally and economically sound is crucial.
iii. The carbon stock predictor models developed here offer a perfect chance to continue working on the validation of woody biomass/carbon stock computations, resulting in more significant estimates.
iv. In order to guarantee the survival of this ecosystem, this study suggests that forestry rules be strengthened and enforced. This will significantly contribute to the research area's full potential for carbon sequestration.
v. Fire control and human land-use practices, such as prohibiting logging and bush burning and providing a sufficient supply of gas, electricity, and kerosene as substitute fuels for domestic cooking, should be the main objectives of forest management activities and practices in the study area. This would improve the plant communities' carbon sink and lower their carbon emissions in the research area.

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vi. More research is needed to demonstrate that broad area measurement systems are practical in the study area in order to have a thorough understanding of the current carbon dynamics in the region. Furthermore, to understand the dynamics of carbon trapped in the studied area, temporal periodic investigations are necessary.

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