

**ASSESSMENT OF WOODY PLANT DIVERSITY AND CARBON STORAGE IN
URBAN SECONDARY SCHOOLS IN ABUJA**

BY

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CERTIFICATION

This research project titled “Assessment of Woody Plant Diversity and Carbon Storage In Urban Secondary Schools In Abuja” by Abdullahi Fatima with Admission number: 2010302085 has been read and approved by the undersigned as meeting part of the requirement for the award of Bachelor of Science (B.Sc. Hons) Degree in Biology, Usmanu Danfodiyo University Sokoto and hereby approved for its contribution to knowledge.

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DEDICATION

I dedicate this project research to Almighty Allah who in his infinite mercy made it possible for me to carry out my research successfully and also to my Mother whose countless sacrifices, love, and encouragement have been my greatest motivation may Almighty Allah bless her abundantly Amin.

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ABSTRACT

This study investigates woody plant diversity and carbon storage across three secondary schools in Abuja, Nigeria: Government Secondary School (GSS) Jiwa, GJSS Jiwa, and GGSS Dutse Alhaji. Using a systematic sampling method, five plots per school were analyzed for tree diversity, with measurements of above-ground and below-ground biomass obtained through allometric equations. Tree diversity was quantified using Shannon and Simpson indices, while carbon storage and CO₂ emissions were calculated based on biomass measurements. At GSS Jiwa, Plot 2 (West) exhibited the highest species diversity with a Shannon index of 1.367 and Fisher's alpha of 3.538, while Plot 5 (Central) had the lowest diversity with a Shannon index of 0.3488 and Fisher's alpha of 0.7972. At GJSS Jiwa, Plot 2 (West) demonstrated the highest diversity with a Shannon index of 1.082 and Simpson's 1-D index of 0.6563, whereas Plot 1 (East), Plot 4 (North), and Plot 5 (Central) had the lowest diversity with Shannon indices of 0 and Simpson's 1-D indices of 0. Plot 2 (West) at GGSS Dutse Alhaji showed the highest diversity with a Shannon index of 0.6931 and an evenness value of 1, while Plots 2 (West), 4 (North), and 5 (Central) had the lowest diversity with Shannon indices of 0. Regarding carbon storage, GJSS Jiwa Plot 2 (West) with *Swietenia macrophylla* (Mahogany) had the highest carbon storage of 15,3356.44 kg and CO₂ emissions of 562.31 tons. In contrast, Plot 5 (Central) at GGSS Dutse Alhaji had the lowest carbon storage with 16,535.68 kg and CO₂ emissions of 60.63 tons. GSS Lafia's Plot 2 (West) contributed significantly with CO₂ emissions of 164.29 tons and carbon storage of 44,808 kg. The findings highlight the importance of maintaining diverse tree species to maximize carbon sequestration and minimize CO₂ emissions, with implications for urban green space management and climate action.

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CHAPTER ONE

INTRODUCTION

1.1 Background of Study

Since the inception of the Millennium Ecosystem Assessment in 2005, the concept of ecosystem services (ES) has emerged as a pivotal framework, facilitating the integration of biodiversity conservation efforts with human well-being (Shumi *et al.*, 2019). Central to this paradigm is the recognition that heightened biodiversity correlates directly with the enhanced provisioning of essential services, thereby bolstering human welfare (Diaz *et al.*, 2018). Biodiversity, in its manifold forms, assumes a critical role in engendering diverse ecosystem services, which encompass supporting functions such as nutrient cycling, provisioning services like food and timber, regulating mechanisms including climate regulation, and cultural benefits such as spiritual experiences (Kreman and Miles, 2012). Notably, biodiversity reinforces ecosystem resilience, augmenting their capacity to withstand disturbances and sustain functionality (FAO, 2014).

However, human development has exacted a considerable toll on the natural world, precipitating an alarming escalation in species extinctions, far surpassing historical averages by orders of magnitude over the past 10 million years (Ma *et al.*, 2023). This precipitous decline in global biodiversity stems from a confluence of anthropogenic alterations to the environment (Shin *et al.*, 2022).

Urban forests emerge as crucial repositories of benefits for cities and their inhabitants, serving as sources of sustenance, while concurrently ameliorating air pollution and climate change impacts (Nawarh *et al.*, 2021). Empirical investigations underscore the salubrious effects of urban trees on urbanites' well-being (Ma *et al.*, 2023; Nawarh *et al.*, 2021), with studies suggesting that

integrating trees into schoolyards can engender improvements in air quality, temperature regulation, and aesthetic appeal, potentially enhancing students' academic performance (Kweon et al., 2017). Moreover, urban forests play a pivotal role in urban food production, fostering greener, more sustainable cities, congruent with the United Nations Sustainable Development Goals (SDGs), particularly Goal 11 emphasizing sustainable cities and communities, and the Paris Agreement's advocacy for climate solutions, including green urban initiatives like tree planting programs (United Nations, 2021).

1.2 Statement of Problem

The absence of green spaces in urban secondary schools poses challenges to students' well-being and environmental education, as highlighted by Moussa *et al.*, (2022). Shepeley (2019) emphasises the role of schoolyards' trees in mitigating conflict and promoting physical activities in urban settings. Despite the manifold benefits urban forests provide, research on the specific contributions of trees within urban schoolyards remains scarce, with prior studies predominantly focusing on campus greenery. This dearth of investigation underscores the need to comprehensively explore the functions of trees in urban secondary school environments. Moreover, the scarcity of green spaces and biodiversity in these settings results in diminished ecological connectivity and limited opportunities for environmental education. Failure to adequately assess and manage woody plant diversity in urban secondary schools could deprive students of myriad benefits, including improved air quality, heightened aesthetics, and avenues for outdoor learning and recreation.

1.3 Justification of Study

Assessing woody plant diversity in urban secondary schools is crucial for multiple reasons. Firstly, it promotes environmental awareness among students, exposing them to the significance of biodiversity and ecosystems within their immediate surroundings. Secondly, it contributes to enhancing local biodiversity by identifying and preserving diverse plant species within school premises, thereby supporting ecological balance. Additionally, the presence of woody plant diversity creates healthier learning environments, positively impacting students' mental health, concentration, and overall well-being. Lastly, such initiatives align with sustainable development goals (SDGs), including those related to sustainable cities and communities, responsible consumption and production, and climate action, demonstrating a commitment to environmental sustainability (Yale Sustainability, 2024). Incorporating woody plant diversity assessments into urban secondary school environments, educators and students not only contribute to a greener, more sustainable future but also enrich educational experiences and promote ecological awareness.

1.4 Aim and Objectives

1.4.1 Aim

The aim of this study is to assess the woody plant diversity and carbon storage in some urban secondary schools, Abuja.

1.4.2 Objectives

The objectives of the research are to;

- a) assess the woody plant diversity of the school;
- b) assess the carbon content/storage in the schools; and
- c) determine the rate of carbon dioxide emission in the schools.

CHAPTER TWO

LITERATURE REVIEW

2.0

2.1 Woody Plants.

Woody plants are a diverse group of perennial plants that produce wood as their structural tissue, resulting in hard stems that persist above ground for many years. This group includes trees, shrubs, and lianas, each with unique characteristics and ecological roles. Woody plants are essential components of various ecosystems and have significant economic and environmental importance (Oliveira-Filho *et al.*, 2022). Woody plants are perennials (plants that live more than two years) that create stiff structures above ground that they use throughout their lives (GPNC, 2024).

Trees are perhaps the most notable woody plants, typically characterized by a single, tall trunk that supports branches and leaves. They can grow to considerable heights and have long lifespans, with some species living for centuries. Trees play a crucial role in carbon sequestration, helping to mitigate climate change by absorbing carbon dioxide from the atmosphere. They also provide habitat and food for numerous wildlife species and contribute to soil stabilization and water cycle regulation. Examples of trees include oak, pine, and maple (GPNC, 2024). Other examples of such trees in Nigeria include Iroko (*Chlorophora excelsa*) - Known locally as "Iroko" or "Odum.", Mahogany (*Khaya* spp.) - Referred to as "African Mahogany" or "Oganwo." and Teak (*Tectona grandis*) - Locally known as "Igi Afẹle" or "Ẹpẹ." (Areo *et al.*, 2023).

Shrubs are shorter than trees and have multiple stems arising from the base. They are often used in landscaping for their ornamental value, providing flowers, fruits, and foliage that enhance garden aesthetics. Shrubs also play a vital role in understory habitats, offering shelter and food for various animals. Common examples of shrubs include roses, lilacs, and azaleas (Britanica, 2024).

Lianas, or woody vines, are plants that climb on other structures such as trees, walls, or trellises.

They are well-adapted to environments where sunlight is limited at the forest floor level, often found in tropical and subtropical forests. Lianas contribute to the structural complexity of forests and can provide both ecological benefits and challenges. Notable examples of lianas include wisteria and ivy (Wikipedia, 2024). Woody plants can be classified into deciduous and evergreen categories. Deciduous woody plants, such as maples and oaks, shed their leaves annually in response to seasonal changes, which helps reduce water loss and protect against cold or dry conditions. Evergreen woody plants, such as pines and holly, retain their leaves year-round, which is advantageous in climates with less pronounced seasonal variations (Britanica, 2024).

Beyond their ecological roles, woody plants are of immense economic importance. They are a primary source of timber, paper, and various other wood products. In horticulture, they are cultivated for their aesthetic value and as sources of fruits, nuts, and other edibles. Many woody plants also possess medicinal properties and are used in traditional and modern medicine (Areo *et al.*, 2023).

2.1 The Role of Woody Plants in Urban Environments

2.1.1 Importance of Urban Green Spaces

Diverse tree species are crucial for the health and stability of urban forests. They offer protection against large-scale damage from pests and diseases (Morgenroth *et al.*, 2016). Additionally, a variety of trees fosters a well-functioning ecosystem with a richer diversity of organisms (Jim and Liu, 2001; McKinney, 2002). Urban forests with diverse trees provide aesthetic appeal and visual comfort for city residents (Goddard *et al.*, 2010). Increased exposure to nature in urban areas is linked to a stronger desire for conservation efforts. Recognizing the importance of tree diversity, urban forest management plans prioritize its preservation (Li *et al.*, 2020).

The passage goes beyond forests to discuss the broader role of urban green spaces. Urban green spaces act as habitats for various organisms, contributing to the overall stability of urban development (Lisotova *et al.*, 2021).

Vegetation plays a vital role in:

- a. Microclimate Improvement: It moderates temperatures, reduces noise pollution, and improves air quality.
- b. Air Quality: Leaves act as filters, capturing pollutants like dust (PM10) and nitrogen dioxide (NO₂) (however, the effectiveness depends on factors like wind circulation and plant structure).
- c. Balancing Air Quality and Design: While strategically placed trees can improve air quality, studies suggest that tall trees in narrow spaces can trap pollutants (Abhijith *et al.*, 2021). Conversely, hedges may reduce exposure to some pollutants but might concentrate them at pedestrian level (Taleghani *et al.*, 2020).

2.1.2 Functions of Woody Plants in Urban Areas

- a. Air Quality Improvement: Woody plants in urban areas, particularly trees, play a vital role in improving air quality by filtering pollutants through their leaves, branches, and bark (Lisotova *et al.*, 2021)
- b. Ecosystem Services: Urban trees provide various ecosystem services such as carbon sequestration, oxygen production, climate regulation, noise reduction, and biodiversity support (Guo *et al.*, 2018)
- c. Microclimate Regulation: Woody plants help regulate the urban microclimate by providing shade, reducing temperatures, and mitigating heat island effects (Michael, 2009).

- d. **Aesthetic Beauty:** Trees and other woody plants enhance the visual appeal of urban landscapes, providing greenery and natural elements that contribute to the overall aesthetics of the environment (Michael, 2009).

2.1.3 Benefits of Woody Plant Biodiversity

- a. **Ecosystem Resilience:** Woody plant biodiversity enhances ecosystem resilience by increasing resistance to pests, diseases, and environmental stresses (Christopher *et al.*, 2022)
- b. **Habitat Provision:** Diverse woody plant communities provide habitats for various wildlife species, contributing to overall biodiversity and ecological balance (Alexandra and Athanassios, 2019)
- c. **Genetic Diversity:** Woody plant biodiversity preserves genetic diversity within species, which is crucial for adaptation to changing environmental conditions and evolutionary processes (Ahuja and Jain, 2017).
- d. **Ecosystem Services:** Different woody plant species contribute to ecosystem services such as carbon sequestration, soil stabilization, water regulation, and air quality improvement.

2.2 Carbon Storage in Woody Plant

Woody plants, such as trees and shrubs, play a critical role in the global carbon cycle by sequestering carbon dioxide (CO₂) from the atmosphere and storing it in their biomass and soils (Deng *et al.*, 2022). This process is crucial for mitigating the impacts of climate change. Woody plants sequester carbon through the process of photosynthesis, where CO₂ is absorbed from the atmosphere and used to produce organic compounds (Shen *et al.*, 2022). These compounds are then stored in the plant's tissues, including the trunk, branches, leaves, and roots. The carbon sequestered in this biomass can remain stored for decades or even centuries, depending on the plant species and environmental conditions (Ning *et al.*, 2015). The biomass of woody plants

contains a significant amount of carbon (Long and Zhou, 2022). For instance, forests, which are composed of numerous woody plants, can store vast amounts of carbon both above and below ground (Long and Zhou, 2022). Ning *et al.* (2015) has shown that the carbon content and storage capacity of woody plants in forests and shrublands are substantial, with a considerable portion of the carbon stored in the woody tissues themselves (Ning *et al.*, 2015).

In addition to storing carbon in their biomass, woody plants contribute to soil carbon storage. The organic material from decaying leaves, wood, and roots enriches the soil, enhancing its ability to store carbon. This organic matter binds easily with soil particles, increasing soil organic carbon (SOC) levels. Recent trends show that the encroachment of woody plants into grass-dominated ecosystems can significantly boost SOC (Young *et al.*, 2017).

While herbaceous plants also sequester carbon, studies indicate that woody plants are more effective in long-term carbon storage due to their larger biomass and longer lifespan. Herbaceous plants might achieve rapid carbon fixation, but woody plants are superior in maintaining higher carbon storage levels over extended periods (Deng *et al.*, 2022).

The role of woody plants in carbon sequestration is vital for ecosystem stability and climate regulation. They help mitigate greenhouse gas emissions by capturing atmospheric CO₂ and storing it in a stable form. Additionally, forests and shrublands act as significant carbon sinks, contributing to the reduction of global atmospheric CO₂ levels (Dada *et al.*, 2024).

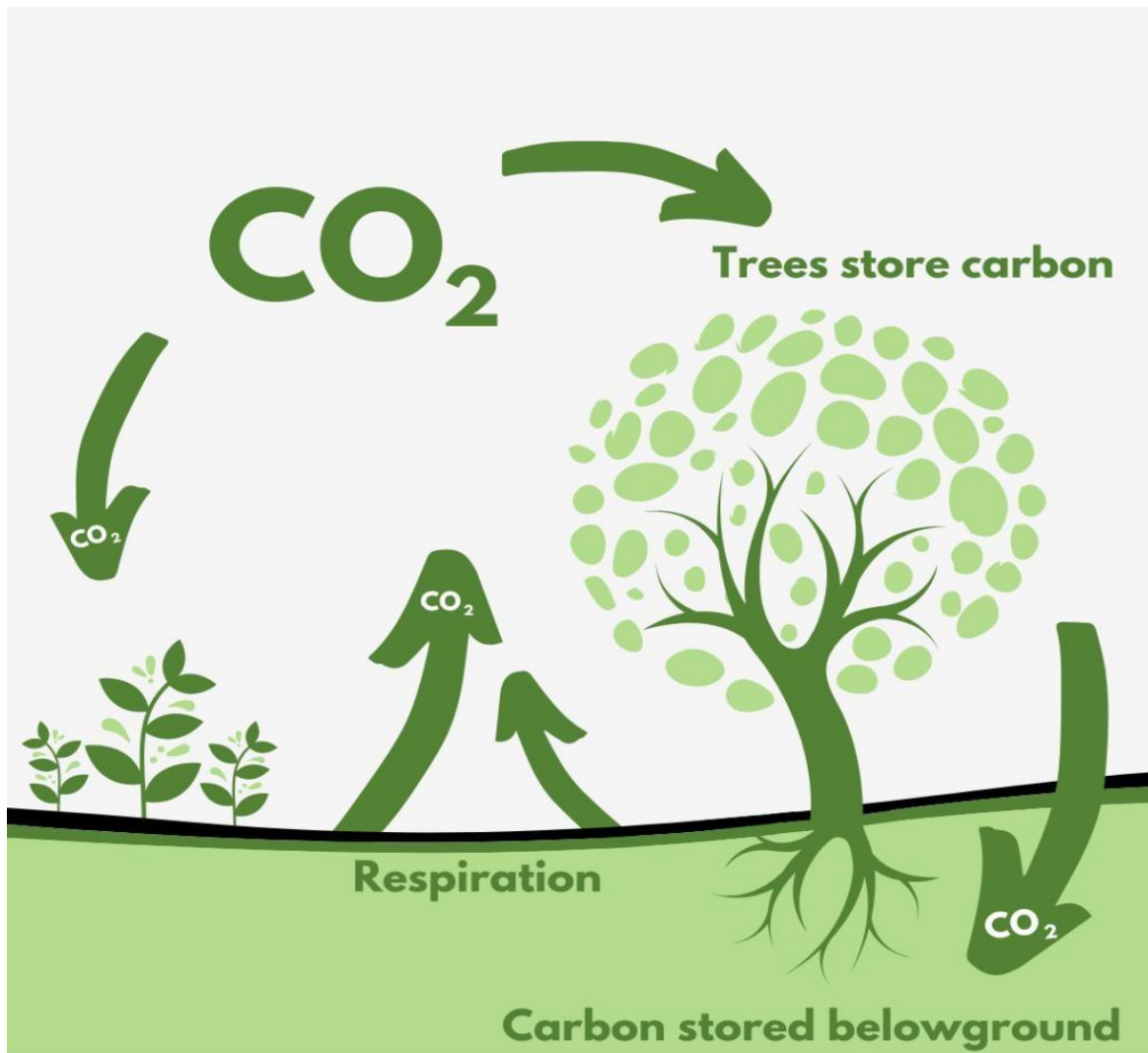


Figure 1: Carbon Sequestration in Trees (Source: Project evergreen)

2.2.1 Factors Affecting Carbon Storage in Urban Trees

Carbon storage in urban trees is influenced by a lot of natural and anthropogenic factors. These factors can be broadly categorized into (Wei *et al.*, 2024; Lopez – Cruz *et al.*, 2022; Johson and Gerhold, 2003);

1. Tree-specific factors.
2. Environmental conditions; and
3. Urban management practices

1. Tree-Specific Factors

- a) **Species:** Different tree species have varying capacities to store carbon. Species that grow larger and have denser wood typically store more carbon.
- b) **Diameter and Age:** Larger and older trees generally store more carbon due to their greater biomass. Trees accumulate carbon over time, so mature trees represent significant carbon sinks (Adedayo, 2014).
- c) **Tree Density:** Higher tree density can lead to increased overall carbon storage in an area. However, if trees are too densely packed, competition for resources can limit growth and carbon accumulation.

2. Environmental Conditions

- a) **Climate:** Temperature, precipitation, and drought conditions significantly affect tree growth and, consequently, carbon storage. Trees in favorable climates with adequate rainfall and moderate temperatures tend to grow faster and store more carbon.
- b) **Soil Quality:** Soil type, fertility, and moisture levels influence tree health and growth. Rich, well-drained soils support more vigorous tree growth, enhancing carbon storage capabilities (Jain *et al.*, 2022).
- c) **Urbanization:** Urban environments present unique challenges such as soil compaction, pollution, and heat islands, which can stress trees and affect their growth and carbon storage potential (Jain *et al.*, 2022).

3. Urban Management Practices

- a) **Planting and Maintenance:** Proper planting techniques and regular maintenance, including watering, pruning, and pest control, ensure healthy tree growth and maximize carbon storage.

- b) Species Selection: Choosing species well-suited to the urban environment and resilient to local conditions can enhance carbon sequestration.
- c) Urban Planning: Integrating green spaces, preserving existing trees, and implementing urban forestry initiatives can significantly increase carbon storage in cities.

Forest Carbon Sequestration:

Carbon Storage in Woody Biomass and Soil Organic Carbon

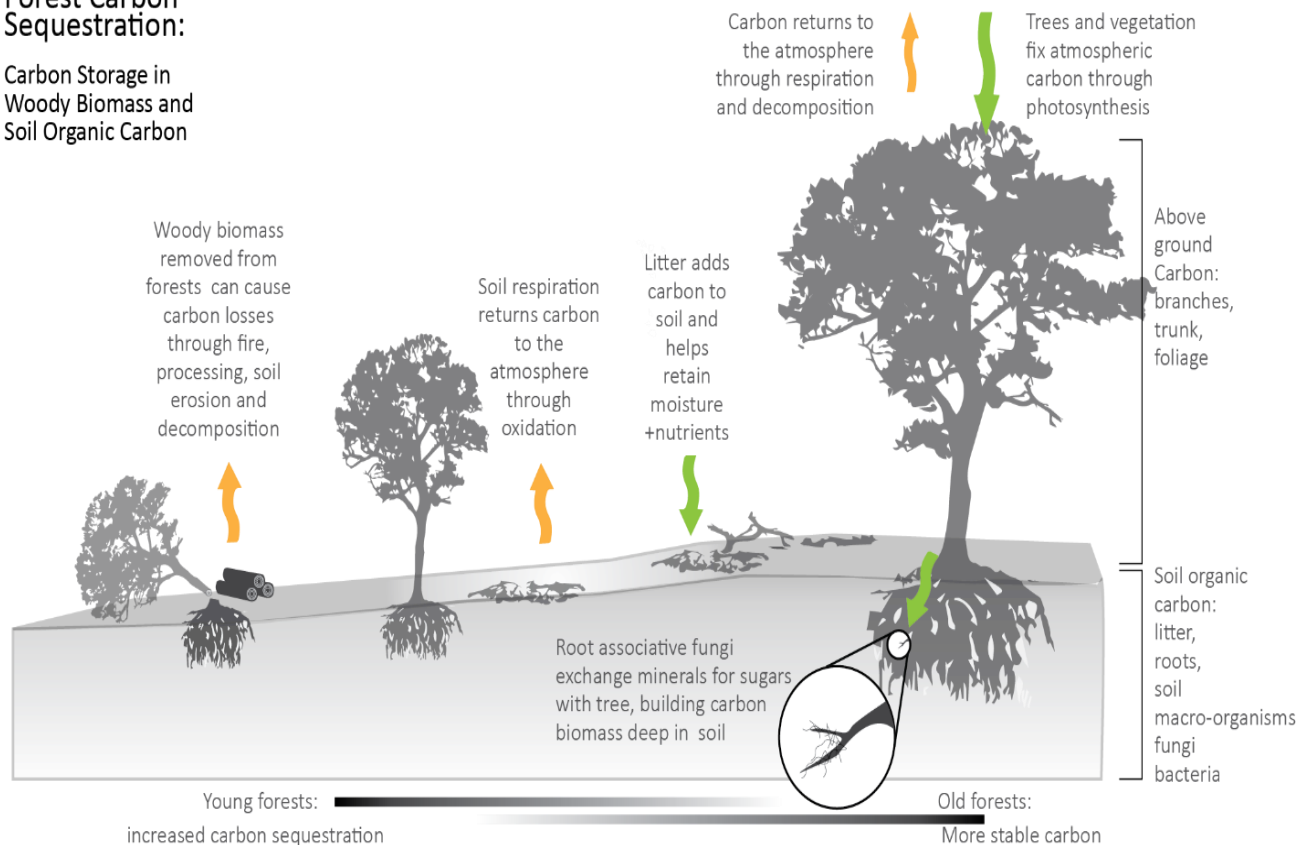


Figure 2: Forest Carbon Sequestration (Source: Lopez – Cruz et al., 2022)

2.3 Measurement Methods for Carbon Storage in Trees

2.3.1 Allometric Equations

Allometric equations are widely used in forestry to estimate the biomass and carbon content of trees without cutting them down. These equations relate easily measurable tree attributes, such as

diameter at breast height (DBH) and tree height, to biomass. They are species-specific and take into account factors like wood density and tree form (VanderSchaaf et al., 2010). There are different types of allometric equations, some formulated for specific tree species and others designed for broader applications (Kuyah *et al.*, 2012).

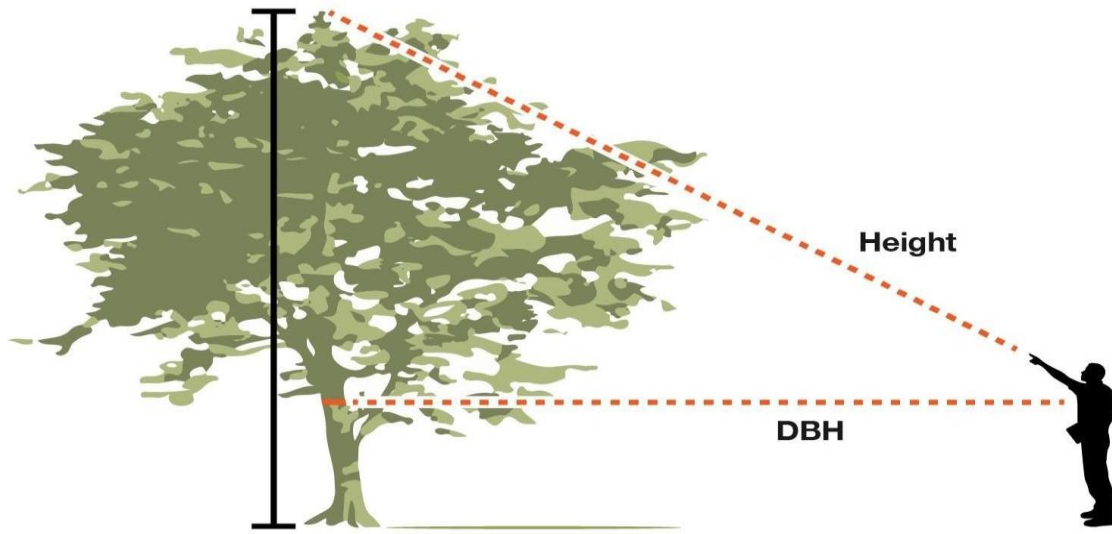


Figure 3: Demonstration of DBH and Tree Height (Source: HAMERKOP, 2024).

2.3.2 Diameter at Breast Height (DBH) and Tree Height Measurement

A common field method involves measuring the DBH (about 1.3 meters above the ground) and tree height. These measurements are then used in allometric equations to estimate biomass. Tools like a measuring tape for DBH and a hypsometer or laser rangefinder for height are typically used.

2.3.3 Biomass Harvesting

The most accurate method involves harvesting the tree, drying it, and weighing its components (roots, trunk, branches, and leaves). This direct measurement provides precise data but is destructive and impractical for large-scale assessments.

2.3.3. Remote Sensing and LIDAR

Advanced technologies like remote sensing and Light Detection and Ranging (LIDAR) are used to estimate tree biomass over large areas. These methods involve capturing detailed 3D images of forests, which can be analyzed to estimate tree volume and biomass. LIDAR is particularly effective for measuring forest structure and canopy height

2.3.4 Carbon Sequestration Calculators

Online calculators, such as those provided by environmental organizations, use standardized data and equations to estimate the carbon sequestration potential of trees based on species, age, and location. These tools provide a quick and easy way to estimate carbon storage

2.3.5 Soil Carbon Measurement

In addition to above-ground biomass, trees contribute to soil carbon through root biomass and organic matter deposition. Soil samples are collected and analyzed for carbon content, which can significantly contribute to the total carbon storage of a tree.

2.4 Previous studies

The global significance of plant species diversity and conservation is highlighted by several studies, emphasizing different contexts and regions. Panista *et al.* (2021) underscored the role of citizen science in addressing environmental and conservation issues. Their study, conducted within the Erasmus+ project CS4ESD, focused on the Olympus Mountain Biosphere Reserve in Greece during the Covid-19 pandemic. By utilizing web-based information, the research assessed young citizens' ability to evaluate environmental issues, revealing a general underestimation of plant species richness, endemism, and ecosystem services. The study highlighted the importance of education for sustainable development in enhancing environmental knowledge and awareness.

Moving to Africa, Angessa *et al.* (2019) investigated the impact of anthropogenic disturbances and topographic variables on woody plant diversity in Ethiopia. By recording woody plants of varying diameters across different plot sizes, they identified 104 species from 52 families, with significant proportions being indigenous and endemic to Ethiopia. The study found that wetlands had the highest species richness, while species richness decreased with elevation and disturbance. The findings emphasized the need for forest and shrub-cover rehabilitation to sustain the ecological functions and services of watersheds.

In the context of urban biodiversity, Moussa *et al.* (2022) assessed the structure and values of urban schoolyard forests in Niamey and Maradi, Niger Republic. Their study involved a forest inventory and participatory observations in 60 schools. They identified 97 tree species from 35 families, with neem trees and the Fabaceae family being dominant. The study revealed high similarity between the floras of the two cities and significant biomass and carbon stock values. Despite the high structural integrity of the urban schoolyard forests, students showed limited knowledge of the plants, animals, and ecosystem services. The study recommended using multipurpose woody plant species for urban greening initiatives to enhance quality education and suggested further investigation into the effects of urban forest structure on academic performance and allergenic potential.

Focusing on Nigeria, Osabiya *et al.* (2022) conducted a survey of tree species diversity in Akure Forest Reserve, Ondo State, and Okomu National Park, Edo State. They demarcated sample plots and identified tree species via their botanical names. Okomu National Park had 400 trees per hectare from 53 species and 26 families, while Akure Forest Reserve had 388 trees per hectare from 65 species and 30 families. Both reserves exhibited a J-inverse diameter distribution. The mean Diameter at Breast Height (DBH) and basal area per hectare were 32.90 cm and 48.76 m²/ha

for Akure Forest Reserve, and 20.16 cm and 16.56 m²/ha for Okomu National Park, respectively. The Shannon-Wiener diversity indices were 3.52 for Okomu and 3.83 for Akure, indicating potential biodiversity interest if better conservation management efforts are employed.

Additionally, Oyerinde *et al.* (2018) assessed and mapped the avenue tree species on the main campuses of the Federal University of Technology, Akure (FUTA), and Adekunle Ajasin University, Akungba-Akoko (AAUA), Ondo State. Using a total enumeration technique and GPS coordinates, they identified 513 tree species from 24 species and 14 families in FUTA, and 274 tree species from 22 species and 13 families in AAUA. The Caesalpiniaceae family had the highest number of species, followed by Mimosaceae and Verbenaceae. The study produced thematic maps revealing some roads devoid of avenue trees, recommending the planting of fast-growing, disease-tolerant, and shade-providing trees to enhance the aesthetic and conducive learning environment of the campuses.

CHAPTER THREE

MATERIALS AND METHOD

3.0

3.1 Study Area

The study will be carried out in three secondary schools in Abuja;

1. Government secondary school, Jiwa, FCT. (*GSS JIWA*)
2. Government girls secondary school, Dutse-Alhaji, FCT. (*GSS DUTSE ALHAJI*)
3. Government junior secondary school, Jiwa, FCT. (*GJSS JIWA*)

3.0.1 Government Secondary School, Jiwa.

Government Science School, Lafia, was established in 1985 in FCT, Nigeria. The coordinates are approximately 9.0725° N latitude and 7.3999° E longitude. The region's laterite soil hardens under sunlight. Economic trees in the area include guava and Arabian jasmine, while common plants encompass butterfly agave and American beautyberry.

3.0.2 Government girls secondary school, Dutse - Alhaji, FCT.

3.0.3 Government junior secondary school, Jiwa, FCT.

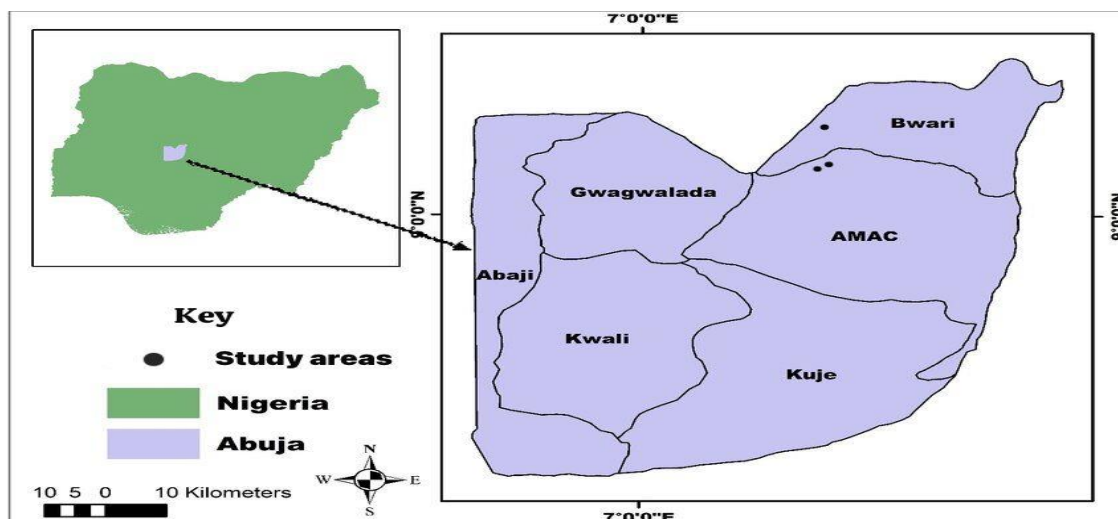


figure 4: Study Area map showing the study area in Fct

3.2 Tree Diversity Assessment

3.2.1. Sampling Design.

A random sampling method was employed to ensure representation of different areas within each school campus. The total land area of the school was divided into five areas (north, south, east, west and central). One sample plot (30 x 30 m²) was established in each of the five areas. The distance between the plots from each other was not be less than 50 m. Within each sample plot, five subplots of size 2 x 2 m² were established for easier assessment of the woody plant diversity. All tree species within the subplots were identified, counted and recorded. For each tree plant, attributes such as species name and diameter at breast height (DBH) were measured and recorded. GPS coordinates of each sample plot will be recorded to ensure accurate mapping.

3.2.2 Species Diversity Calculation

Species richness (total number of species) and species evenness (distribution of individuals among species) will be calculated for each sample plot. Shannon Diversity Index and Simpson's Diversity Index will be calculated to assess overall tree species diversity within each campus.

3.3 Estimation of Above-Ground Biomass and Below-Ground Biomass (AGB and BGB).

Above-ground and below-ground biomasses will be estimated based on field measurements of diameter at breast height (DBH) of the tree using allometric equations. The equation given below is applicable to dry climates with annual rainfall < 1500 mm (MacDicken, 1997).

$$AGB = 34.4703 - 8.0671D + 0.6589D^2 \text{-----} (1)$$

$$BGB = AGB \times (15/100) \text{-----} (2)$$

where D is the DBH (cm).

3.4 Estimation of Total Biomass (TB)

Total biomass of individual trees w_i respectively, given by the following equation:

$$Total\ Biomass = AGB + BGB \text{ -----} (3)$$

3.5 Estimation of Carbon Content

Generally, for any plant species, 50% of its biomass is its carbon content (IPCC, 2006).

$$Carbon\ Content = 0.5 \times Total\ Biomass \text{ -----} (4)$$

CO₂ equivalent will then be calculated using the equation below:

$$CO_2\ (eq.) = (Carbon\ content \times 44)/12 \text{ -----} (5)$$

CHAPTER FOUR

4.0

RESULTS AND DISCUSSION

4.1 Results

4.1.1 Woody Plant Diversity.

4.1.2 Tree Plants community characteristics of GSS Jiwa

Table 1 showed that Plot 2 (West) exhibits the highest diversity with five taxa and eleven individuals, reflecting high biodiversity with a Shannon diversity index of 1.367 and Fisher's alpha of 3.538. It also shows considerable evenness (0.7845), suggesting a relatively balanced distribution of individuals among species. Plot 5 (Central), on the other hand, shows the lowest diversity and evenness, with only two taxa and a dominance index (D) of 0.8025, indicating one species' dominance. The Simpson's index and Shannon index values for Plot 5 are the lowest among the plots, underscoring its reduced biodiversity.

Table 2 gives the eigenvalues and percentage variances from the Principal Component Analysis (PCA). The first principal component (PC1) accounts for 59.43% of the total variance, indicating it captures the majority of the variation in the data. The second and third components (PC2 and PC3) explain 20.179% and 13.388% of the variance, respectively, while the remaining components contribute minimal variation. The PCA scatter plot in Figure 5 illustrates the contributions of different tree species to the overall variation in the community characteristics.

Table 1: Tree plants community characteristics of GSS jiwa

	PLOT 1 EAST	PLOT 2 WEST	PLOT 3 SOUTH	PLOT 4 NORTH	PLOT 5 CENTRAL
Taxa_S	4	5	4	3	2
Individuals	9	11	7	8	9
Dominance_D	0.284	0.3058	0.3878	0.3438	0.8025
Simpson_1-D	0.716	0.6942	0.6122	0.6563	0.1975
Shannon_H	1.311	1.367	1.154	1.082	0.3488
Evenness_e^H/S	0.9273	0.7845	0.7925	0.9837	0.7087
Brillouin	0.9472	0.993	0.7639	0.791	0.2441
Menhinick	1.333	1.508	1.512	1.061	0.6667
Margalef	1.365	1.668	1.542	0.9618	0.4551
Equitability_J	0.9455	0.8492	0.8322	0.9851	0.5033
Fisher_alpha	2.759	3.538	3.878	1.743	0.7972
Berger-Parker	0.3333	0.4545	0.5714	0.375	0.8889
Chao-1	4	8	7	3	2

Table 2: Eigen values of the principal components showing the percentage variation

PC	Eigenvalue	% Variance
1	8.34654	59.43
2	2.83408	20.179
3	1.88034	13.388
4	0.813344	5.7912
5	0.170137	1.2114

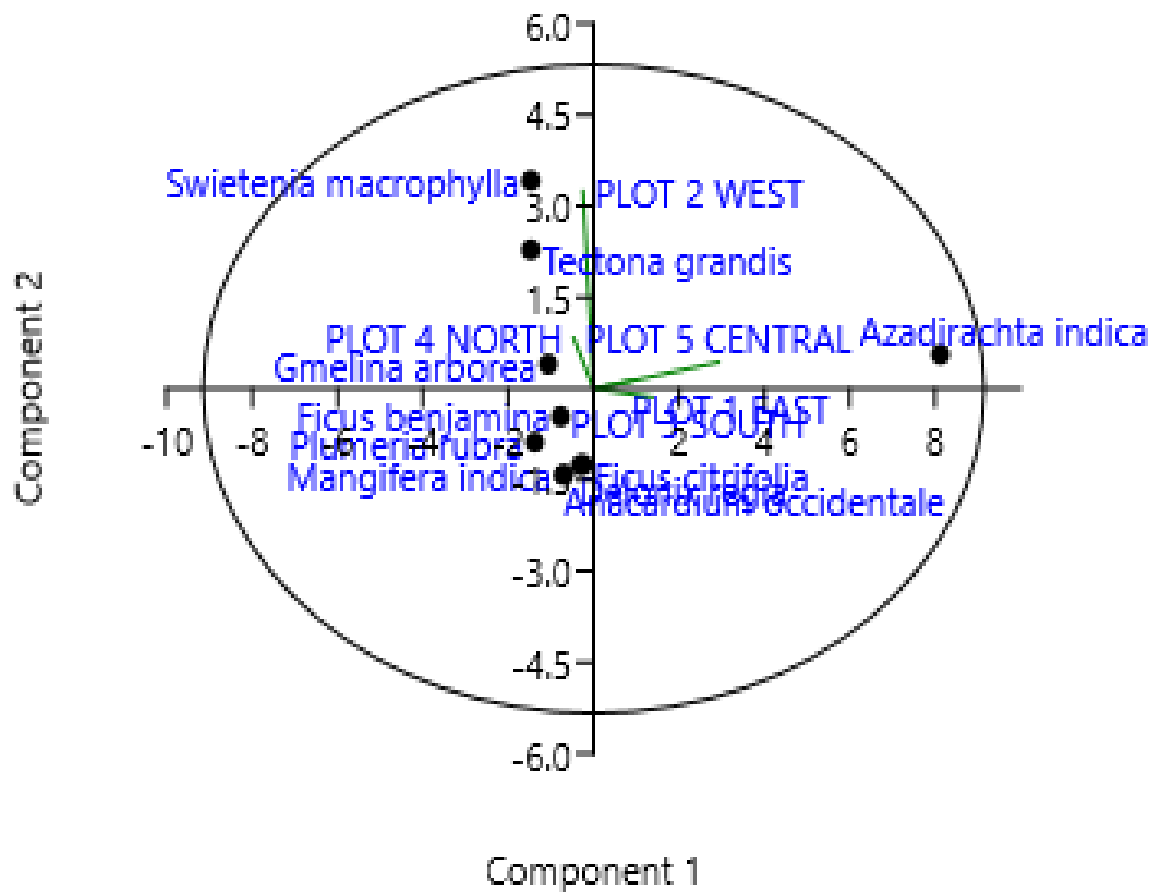


Figure 5: PCA Scatter Plot Showing the Contributions of the Individual Tree Species to the Pool of Variation in GSS jiwa.

4.1.3 Tree plants community characteristics of GJSS jiwa.

Table 3 showed that Plot 2 (West) stands out with the highest diversity, containing three taxa and eight individuals. This plot also has the lowest dominance index (D) of 0.3438 and the highest values for Simpson's diversity index (1-D) and Shannon diversity index (H), at 0.6563 and 1.082, respectively. This suggests a more even distribution of species and greater diversity compared to other plots. In contrast, Plots 1 (East), 4 (North), and 5 (Central) show very low diversity, each with only one taxon. The dominance index for these plots is 1, indicating complete dominance by a single species, which is also reflected in their Simpson's index and Shannon index values, both being zero. Plot 3 (South) has two taxa and two individuals, with moderate diversity indices, including a Shannon index of 0.6931 and a Simpson's index of 0.5. The Evenness (e^H/S) values are at maximum (1) for Plots 1, 3, 4, and 5, indicating that in these plots, where more than one species is present, individuals are evenly distributed. The Brillouin index and other richness indices such as Menhinick and Margalef also reflect similar trends, with Plot 2 showing the highest richness and diversity values.

Table 4 presents the eigenvalues and percentage variance from the Principal Component Analysis (PCA) for GJSS jiwa. The first principal component (PC1) accounts for 61.442% of the total variance, capturing the majority of the variation in the dataset. The second component (PC2) explains 25.271% of the variance, while the third component (PC3) accounts for 13.287%. The fourth component contributes insignificantly to the variance. The PCA scatter plot in Figure 3 illustrates the contributions of different tree species to the overall variation within the community.

Table 3: Tree plants community characteristics of GJSS jiwa

	PLOT 1 EAST	PLOT 2 WEST	PLOT 3 SOUTH	PLOT 4 NORTH	PLOT 5 CENTRAL
Taxa_S	1	3	2	1	1
Individuals	2	8	2	3	2
Dominance_D	1	0.3438	0.5	1	1
Simpson_1-D	0	0.6563	0.5	0	0
Shannon_H	0	1.082	0.6931	0	0
Evenness_e^H/S	1	0.9837	1	1	1
Brillouin	0	0.791	0.3466	0	0
Menhinick	0.7071	1.061	1.414	0.5774	0.7071
Margalef	0	0.9618	1.443	0	0
Equitability_J		0.9851	1		
Fisher_alpha	0.7959	1.743	0	0.5252	0.7959
Berger-Parker	1	0.375	0.5	1	1
Chao-1	1	3	3	1	1

Table 4: Eigen values of the principal components showing the percentage variation in GJSS Jiwa

PC	Eigenvalue	% variance
1	3.68651	61.442
2	1.51627	25.271
3	0.797219	13.287
4	7.75574E-33	1.2926E-31

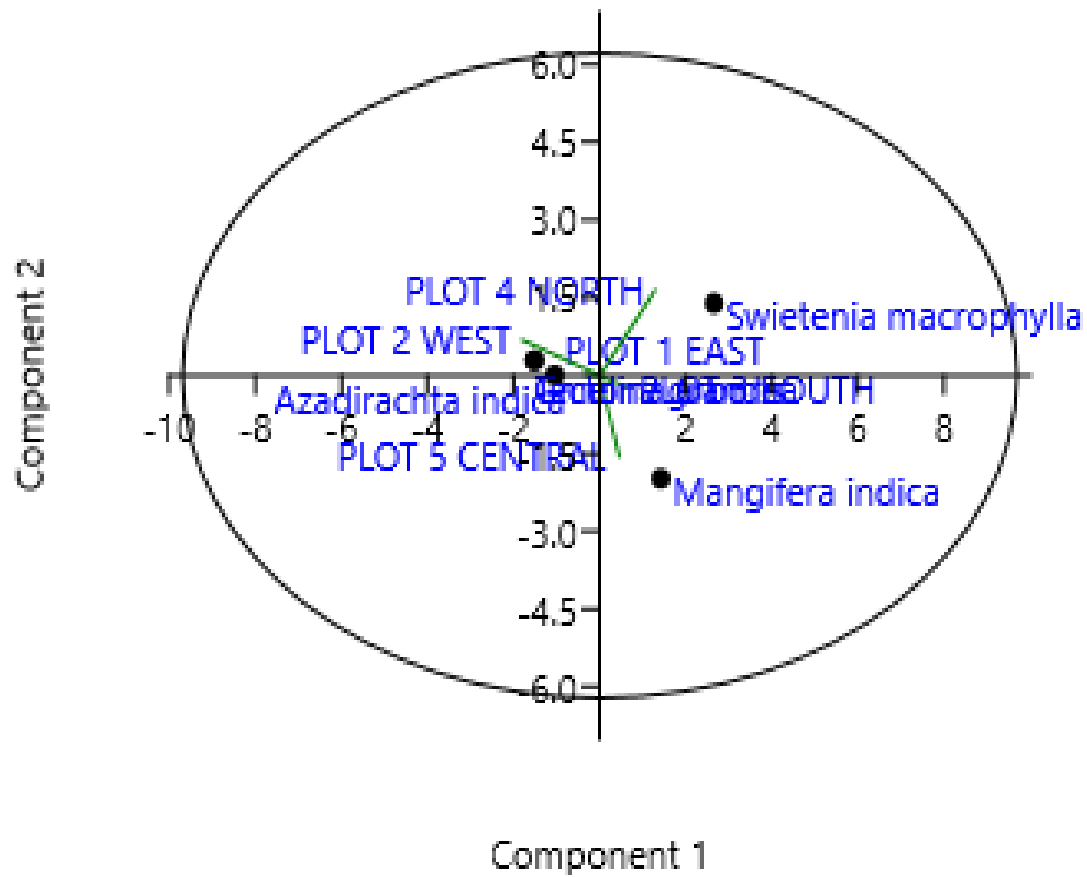


Figure 6: PCA Scatter Plot Showing the Contributions of the Individual Tree Species to the Pool of Variation in GJSS jiwa.

4.1.4 Tree plants community characteristics of GGSS Dutse Alhaji.

Table 5 revealed that Plot 1 (East) and Plot 3 (South) display moderate diversity compared to the other plots. Plot 1 has two taxa and six individuals, with a dominance index (D) of 0.5. The Simpson's diversity index (1-D) and Shannon diversity index (H) for Plot 1 are 0.5 and 0.6931, respectively. The evenness ($e^{H/S}$) is at maximum (1). Plot 3 also has two taxa but only four individuals, with a slightly higher dominance index (0.625) and lower diversity indices (Simpson's 1-D of 0.375 and Shannon's H of 0.5623). The evenness value is 0.8774, indicating a relatively balanced distribution, though not as evenly distributed as Plot 1.

In contrast, Plots 2 (West), 4 (North), and 5 (Central) exhibit very low diversity, each with only one taxon and one individual. The dominance index for these plots is 1, indicating complete dominance by a single species. Consequently, the Simpson's index and Shannon index values are zero, reflecting the absence of diversity. These plots also show maximum evenness values (1), but this is trivial as there is only one species present. The Brillouin index and other richness indices such as Menhinick and Margalef are higher for Plot 1 and Plot 3, reflecting their greater richness and diversity compared to the other plots. Fisher's alpha follows a similar trend, being highest for Plot 3 (1.592), indicating higher species richness.

Table 5: Tree plants community characteristics of GGSS Dutse Alhaji

	PLOT 1 EAST	PLOT 2 WEST	PLOT 3 SOUTH	PLOT 4 NORTH	PLOT 5 CENTRAL
Taxa_S	2	1	2	1	1
Individuals	6	1	4	1	1
Dominance_D	0.5	1	0.625	1	1
Simpson_1-D	0.5	0	0.375	0	0
Shannon_H	0.6931	0	0.5623	0	0
Evenness_e^H/S	1	1	0.8774	1	1
Brillouin	0.4993	0	0.3466	0	0
Menhinick	0.8165	1	1	1	1
Margalef	0.5581	0	0.7213	0	0
Equitability_J	1		0.8113		
Fisher_alpha	1.051	0	1.592	0	0
Berger-Parker	0.5	1	0.75	1	1
Chao-1	2	1	2	1	1

4.2 Carbon Storage and Rate of CO₂ emission rates at GSS jiwa, GJSS jiwa and GGSS Dutse Alhaji.

4.2.1 GSS juwa

The carbon storage and CO₂ emissions at GSS jiwa vary significantly across different plots, as seen in Table 6. The central plot has species such as *Azadirachta indica* (Neem tree) and *Ficus citrifolia* (Wimba Tree), contributing the highest carbon storage with CO₂ emissions of 19.98 tons and 164.29 tons, respectively. The Neem tree, particularly in the west and south plots, also shows substantial carbon storage and CO₂ emissions, indicating its effectiveness in sequestering carbon. *Gmelina arborea* (White teak tree) in the north plot and *Mangifera indica* (Mango) in the south plot also show significant contributions to carbon storage and emissions.

4.2.2 GJSS jiwa

At GJSS jiwa, Table 7 shows that the north plot contains a *Swietenia macrophylla* (Mahogany) tree with a mean DBH of 642.33 cm, which stores the highest amount of carbon (15,3356.44 kg) and has the highest CO₂ emissions (562.31 tons). This indicates that large trees, particularly mahogany, are vital for carbon sequestration. Other significant contributors include the central plot with a *Mangifera indica* (Mango tree) storing 52,400.54 kg of carbon and emitting 192.14 tons of CO₂, and the south plot with another mahogany tree contributing 69,693.24 kg of carbon and 255.54 tons of CO₂ emissions.

4.2.3 GGSS Dutse Alhaji

In GGSS Dutse Alhaji, as depicted in Table 8, the east plot with *Mangifera indica* (Mango tree) has the highest carbon storage (27,805.06 kg) and CO₂ emissions (101.95 tons). *Anacardium occidentale* (Cashew tree) is prevalent in multiple plots, showing moderate carbon storage and

emissions. The central plot with another Mango tree also contributes significantly with 16,535.68 kg of carbon storage and 60.63 tons of CO₂ emissions.

4.2.4 Carbon Storage by Tree Species at GSS jiwa, GJSS Jiwa and GGSS Dutse Alhaji.

Figure 7 showcases the amount of carbon (in kg) sequestered by various tree species at the three locations: GSS jiwa, GJSS jiwa, and GGSS Dutse Alhaji. *Mangifera indica* demonstrates substantial carbon storage across all sites, with the highest recorded at GJSS jiwa (38,610 kg). *Ficus citrifolia* shows the highest carbon storage value at GSS Lafia (44,808 kg). *Anacardium occidentale* exhibits notable carbon storage at GSS jiwa (19,680 kg) and moderate levels at GGSS Dutse Alhaji (6,331 kg), *Gmelina aborea* and *Swietenia macrophylla* are particularly effective at GJSS jiwa, with carbon storage values of 19,136 kg and 129,388 kg.

4.2.5 CO₂ Emission Rates by Tree Species at GSS jiwa, GJSS Jiwa and GGSS Dutse Alhaji.

The CO₂ emission rates bar chart (Figure 8) provides insights into the carbon dioxide emissions (in kg) associated with the same tree species at the three locations. *Ficus citrifolia* exhibits the highest CO₂ emission rate at GSS jiwa (164,294 kg). *Mangifera indica* continues to show significant values across all locations, with the highest at GJSS jiwa (141,570 kg). *Plumeria rubra* demonstrates a high CO₂ emission rate at GSS jiwa (104,222 kg). *Swietenia macrophylla* at GJSS jiwa presents an exceptionally high emission rate (474,423 kg). *Gmelina aborea* and *Azadirachta indica* also show substantial CO₂ emissions at GSS Shabu.

Carbon Storage at GSS jiwa, GJSS Jiwa and GGSS Dutse Alhaji.

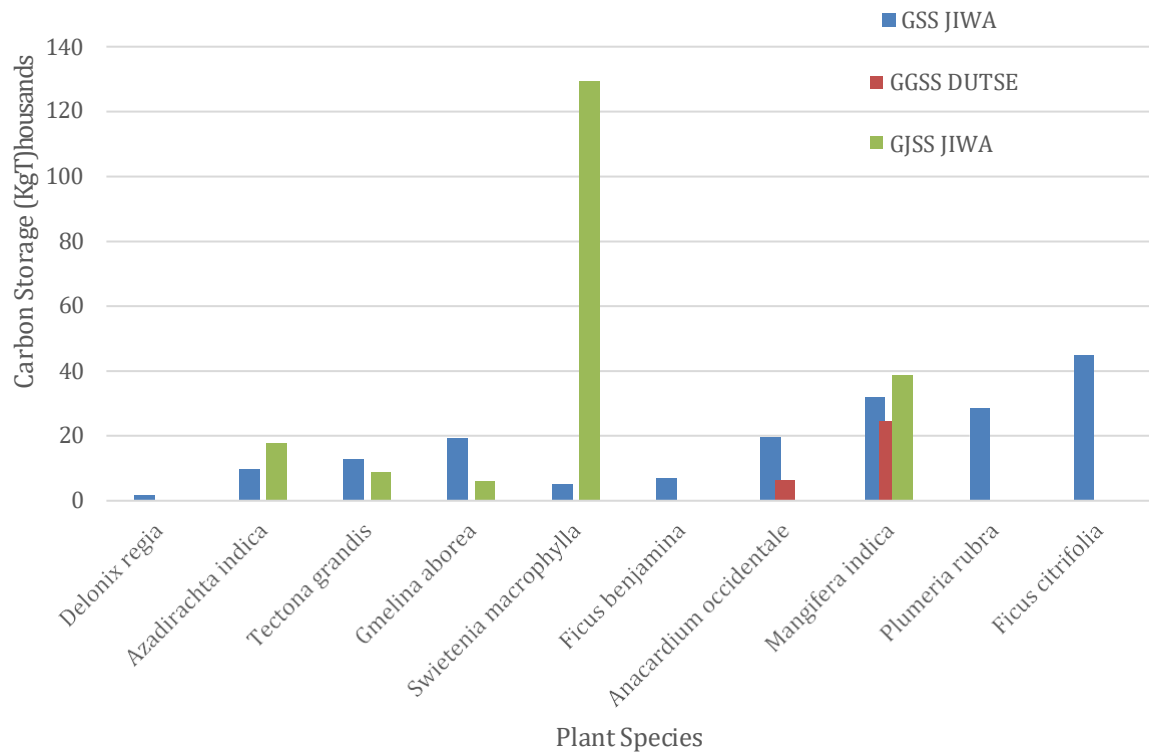


Figure 7: Carbon Storage by Tree Species at GSS jiwa, GJSS Jiwa and GGSS Dutse Alhaji

**CO₂ Emission Rates by Tree Species at GSS Jiwa, GJSS Jiwa and GGSS
Dutse Alhaji.**

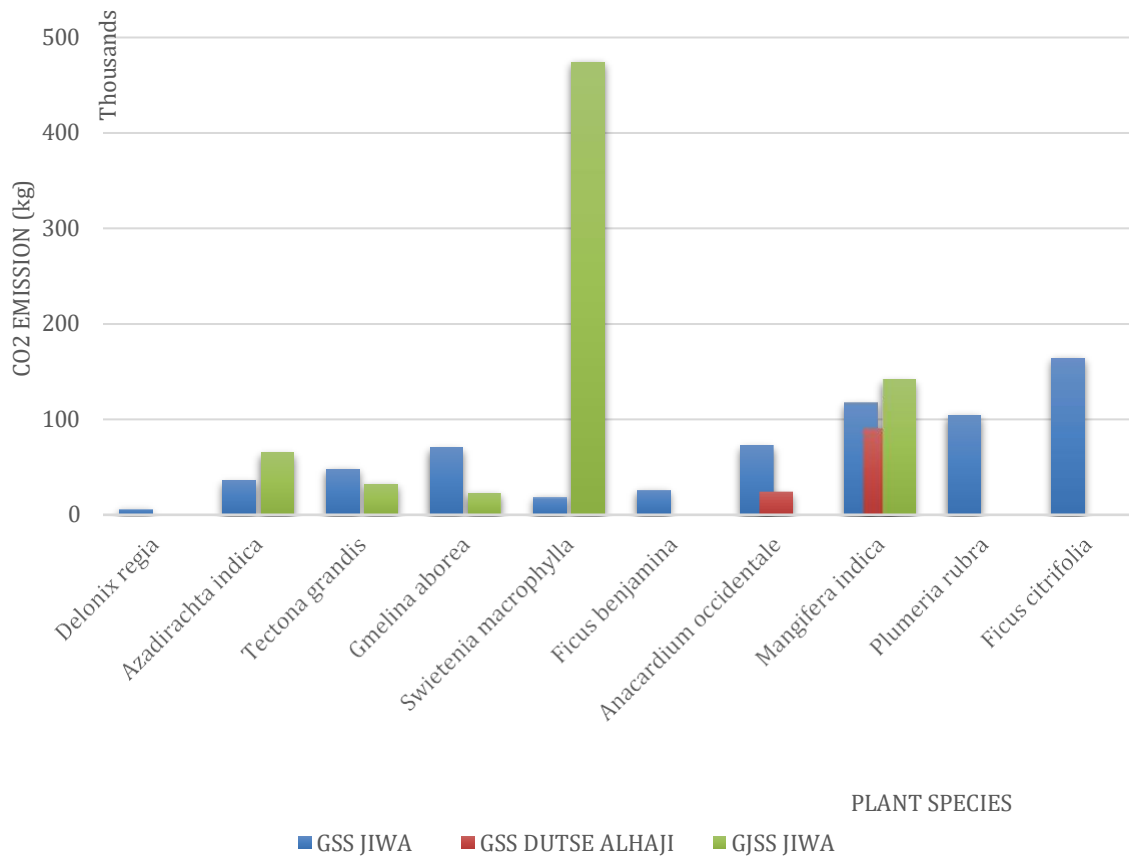


Figure 8: CO₂ Emission Rates by Tree Species at GSS Jiwa, GJSS Jiwa and GGSS Dutse Alhaji.

Table 6: Carbon Storage and Rate of CO₂ emission at GSS Jiwa

GSS JIWA										
S/N	SCIENTIFIC NAME	FAMILY NAME	COMMON NAME	EAST (8.503929/8.5516138)						
				M. DBH(cm)	AGB(kg)	BGB (kg)	TB(kg)	Carbon (kg)	CO2 eqn (kg)	CO2 (tons)
1	<i>Delonix regia</i>	Fabaceae	Flame forest Tree	23.00	197.49	29.62	227.11	113.55	416.36	0.42
2	<i>Azadirachta indica</i>	Meliaceae	Neem tree	154.33	14482.99	2172.45	16655.44	8327.72	30534.97	30.53
3	<i>Tectona grandis</i>	Lamiaceae	Teak tree	71.00	2783.22	417.48	3200.70	1600.35	5867.96	5.87
4	<i>Gmelina aborea</i>	Lamiaceae	White teak tree	293.50	54425.90	8163.89	62589.79	31294.90	114747.95	114.75
WEST (8.50334/8.515131)										
1	<i>Tectona grandis</i>	Lamiaceae	Teak tree	211.33	27756.37	4163.46	31919.82	15959.91	58519.67	58.52
2	<i>Swietenia macrophylla</i>	Meliaceae	Mahogany	122.00	8857.35	1328.60	10185.95	5092.98	18674.25	18.67
3	<i>Gmelina arborea</i>	Lamiaceae	White teak tree	42.00	857.95	128.69	986.64	493.32	1808.85	1.81
4	<i>Ficus benjamina</i>	Moraceae	Weeping fig tree	34.00	521.88	78.28	600.16	300.08	1100.29	1.10
5	<i>Azadirachta indica</i>	Meliaceae	Neem tree	318.00	64099.74	9614.96	73714.70	36857.35	135143.61	135.14
SOUTH (8.502889/8.513364)										
1	<i>Azadirachta indica</i>	Meliaceae	Neem tree	219.25	29939.45	4490.92	34430.37	17215.19	63122.35	63.12
2	<i>Ficus benjamina</i>	Moraceae	Weeping fig tree	250.00	39198.95	5879.84	45078.79	22539.39	82644.44	82.64
3	<i>Anacardium occidentale</i>	Anacardiaceae	Cashew tree	234.00	34225.50	5133.82	39359.32	19679.66	72158.76	72.16

4	<i>Mangifera indica</i>	Anacardiaceae	Mango	296.00	55376.79	8306.52	63683.31	31841.65	116752.73	116.75
NORTH (8.502347/8.515235)										
1	<i>Gmelina arborea</i>	Lamiaceae	White teak tree	252.00	39844.35	5976.65	45821.00	22910.50	84005.16	84.01
2	<i>Tectona grandis</i>	Lamiaceae	Teak tree	210.33	27486.60	4122.99	31609.59	15804.80	57950.92	57.95
3	<i>Plumeria rubra</i>	Apocynaceae	Frangipani	280.00	49433.44	7415.02	56848.46	28424.23	104222.17	104.22
CENTRAL (8.507929/8.520439)										
1	<i>Azadirachta indica</i>	Meliaceae	Neem tree	126.00	9478.71	1421.81	10900.52	5450.26	19984.28	19.98
2	<i>Ficus citrifolia</i>	Moraceae	Wimba Tree	350.00	77926.24	11688.94	89615.17	44807.59	164294.48	164.29

Table 7: Carbon Storage and Rate of CO₂ emission at GJSS JIWA

GJSS JIWA										
EAST (8.574151/8.557385)										
S/N	SCIENTIFIC NAME	FAMILY NAME	COMMON NAME	MEAN DBH(cm)	AGB(kg)	BGB (kg)	TB(kg)	Carbon (kg)	CO2 eqn (kg)	CO2 (tons)
1	<i>Azadirachta indica</i>	Meliaceae	Neem tree	266.00	44509.75	6676.46	51186.21	25593.11	93841.39	93.84
WEST (8.574706/8.557835)										
1	<i>Azadirachta indica</i>	Meliaceae	Neem tree	179.50	19816.35	2972.45	22788.80	11394.40	41779.47	41.78
2	<i>Tectona grandis</i>	Lamiaceae	Teak tree	157.66	15140.67	2271.10	17411.78	8705.89	31921.59	31.92
3	<i>Gmelina arborea</i>	Lamiaceae	White teak tree	133.66	10727.47	1609.12	12336.59	6168.29	22617.08	22.62
SOUTH (8.573142/8.557484)										
1	<i>Mangifera indica</i>	Anacardiaceae	Mango tree	220.00	30150.47	4522.57	34673.04	17336.52	63567.24	63.57
2	<i>Swietenia macrophylla</i>	Meliaceae	Mahogany	435.00	121205.63	18180.85	139386.48	69693.24	255541.88	255.54

NORTH (8.574725/8.557708)										
1	<i>Swietenia macrophylla</i>	Meliaceae	Mahogany	642.33	266706.85	40006.03	306712.88	153356.44	562306.94	562.31
CENTRAL (8.574276/8.557855)										
1	<i>Mangifera indica</i>	Anacardiaceae	Mango tree	378.00	91131.37	13669.71	104801.08	52400.54	192135.31	192.14

Table 8: Carbon Storage and Rate of CO₂ emission at GGSS DUTSE ALHAJI

GGSS DUTSE ALHAJI										
S/ N	SCIENTIFIC NAME	FAMILY NAME	COMMON NAME	EAST (8.490108/8.544489) MEAN DBH(cm)	AGB(kg)	BGB (kg)	TB(kg)	Carbon (kg)	CO2 eqn (kg)	CO2 (tons)
1	<i>Mangifera indica</i>	Anacardiaceae	Mango tree	277.00	48356.6	7253.4	55610.1	27805.06	101951.88	101.95
					2	9	1			
2	<i>Anacardium occidentale</i>	Anacardiaceae	Cashew tree	84.00	4006.03	600.90	4606.94	2303.47	8446.05	8.45
WEST (8.490310/8.544741)										
1	<i>Anacardium occidentale</i>	Anacardiaceae	Cashew tree	208.00	26863.1	4029.4	30892.6	15446.32	56636.50	56.64
					6	7	4			
SOUTH (8.491007/8.544537)										
1	<i>Anacardium occidentale</i>	Anacardiaceae	Cashew tree	144.00	12535.7	1880.3	14416.1	7208.06	26429.56	26.43
					6	6	2			
2	<i>Mangifera indica</i>	Anacardiaceae	Mango tree	259.00	42144.7	6321.7	48466.4	24233.24	88855.21	88.86
					6	1	8			
NORTH (8.490548/8.544510)										
1	<i>Anacardium occidentale</i>	Anacardiaceae	Cashew tree	208.00	26863.1	4029.4	30892.6	15446.32	56636.50	56.64
					6	7	4			
CENTRAL (8.490540/8.544114)										
1	<i>Mangifera indica</i>	Anacardiaceae	Mango tree	215.00	28757.7	4313.6	33071.3	16535.68	60630.81	60.63
					0	5	5			

4.1.1 Assessing Woody Plant Diversity and Its Influencing Factors in Urban Secondary Schools: Insights from GSS Jiwa, GJSS jiwa, and GGSS Dutse Alhaji.

The study of woody plant diversity encompasses species richness, composition, and structure, and is influenced by various environmental factors and land-use types. In GSS jiwa and GJSS jiwa, differences in species richness and diversity indices reflect the influence of these factors. For instance, Plot 2 (West) in GSS Jiwa shows high diversity with a Shannon index of 1.367 and a Fisher's alpha of 3.538, indicating a balanced species distribution. Similar patterns are observed in studies conducted in different regions. In Beijing's urban area, spatial patterns of woody plant diversity demonstrate significant differences influenced by geographic coordinates and urbanization (Li *et al.*, 2020).

In GSS Jiwa, Plot 2 (West) exhibits the highest diversity with a Shannon diversity index of 1.367 and Fisher's alpha of 3.538, indicating a well-balanced and diverse tree community. This aligns with findings from studies such as Mensah *et al.* (2021), which also reported high biodiversity in urban areas with significant green space management. In contrast, Plot 5 (Central) shows the lowest diversity with a dominance index of 0.8025 and a Shannon index of 0.3488, reflecting a scenario where one species dominates. This mirrors results from studies like Adesina *et al.* (2019), where urban central plots often suffer from reduced biodiversity due to human activities and infrastructure development.

GJSS Jiwa's Plot 2 (West) stands out with the highest diversity indices, including a Shannon index of 1.082 and a Simpson's index of 0.6563, suggesting a more even species distribution. Similar results were observed in urban forest studies by Oluwole and Adeola (2020), where areas with proactive tree planting and maintenance showed higher diversity. Conversely, Plots 1 (East), 4

(North), and 5 (Central) exhibit very low diversity, each with only one taxon and dominance indices of 1, indicating complete dominance by a single species. This pattern is comparable to the findings of Ojo *et al.* (2018), which highlighted the impact of limited green space and neglect in certain urban zones.

In GGSS Dutse Alhaji, Plot 1 (East) and Plot 3 (South) display moderate diversity, with Shannon indices of 0.6931 and 0.5623, respectively. The evenness values for these plots also suggest a relatively balanced distribution of individuals among species. Studies by Bello *et al.* (2021) on suburban school environments noted similar moderate diversity levels, often influenced by the local microclimate and school gardening initiatives. However, Plots 2 (West), 4 (North), and 5 (Central) show very low diversity with dominance indices of 1, indicative of complete species dominance, consistent with findings from urban studies by Chukwuma *et al.* (2017), where certain plots are neglected or less prioritized in urban planning.

The PCA results for GSS Jiwa, GJSS Jiwa, and GGSS Dutse Alhaji reveal significant variance captured by the first principal component (PC1), accounting for 59.43%, 61.442%, and 61.442% of the total variance, respectively. This indicates that the majority of variation in tree community characteristics is explained by a single factor, which could be related to species richness or evenness. The subsequent components (PC2 and PC3) account for lesser variance, underscoring the dominance of the primary factor. Similar patterns were observed in studies by Ajayi and Adegboye (2020), where PCA was used to identify key factors influencing urban tree diversity, often linked to environmental and anthropogenic factors.

4.1.2 Comparative Analysis of Carbon Storage and CO₂ Emission Rates Among Tree Species in Urban Secondary Schools of Abuja, Jiwa, and Dutse Alhaji

Our study reveals notable differences in the carbon sequestration capabilities and CO₂ emission rates among different species. *Mangifera indica* demonstrates substantial carbon storage across all three locations, with the highest recorded at GJSS jiwa (38,610 kg). This aligns with findings from Jagadamma *et al.* (2017), who reported that *Mangifera indica* has a high carbon sequestration potential due to its extensive canopy and biomass. Similarly, the high CO₂ emission rates observed for *Mangifera indica* at GJSS Jiwa (141,570 kg) suggest a dynamic carbon cycle, consistent with studies by Abraham *et al.* (2018), which emphasize the species' significant respiratory activity and biomass turnover.

Ficus citrifolia shows the highest carbon storage value at GSS Jiwa (44,808 kg), indicating its potential as an effective carbon sink in urban environments. This observation is supported by research from Nowak *et al.* (2023), which found that *Ficus species* are efficient in capturing atmospheric CO₂ due to their rapid growth and dense foliage. The high CO₂ emission rate for *Ficus citrifolia* at GSS Jiwa (164,294 kg) further corroborates its active metabolic processes, as highlighted by Nowak and Crane (2020).

Anacardium occidentale exhibits notable carbon storage at GSS Jiwa (19,680 kg) and moderate levels at GGSS Dutse Alhaji (6,331 kg), suggesting its adaptability to different environmental conditions. This is consistent with findings by Kalaba *et al.* (2019), who reported that *Anacardium occidentale* can thrive in various climatic conditions and contribute significantly to carbon sequestration.

Swietenia macrophylla shows an exceptionally high carbon storage value at GJSS Jiwa (129,388 kg) and a corresponding high CO₂ emission rate (474,423 kg). This is in line with studies by de

Carvalho *et al.* (2018), which highlight *Swietenia macrophylla*'s rapid growth and substantial biomass accumulation, leading to high carbon sequestration and emission rates. The species' ability to store large amounts of carbon makes it a valuable asset for urban forestry projects aimed at enhancing carbon sinks (Carvalho *et al.* 2018).

The significant carbon storage observed for *Plumeria rubra* at GSS Jiwa (28,424 kg) and its high CO₂ emission rate (104,222 kg) reflect its robust carbon cycle. This finding is supported by research from Saha *et al.* (2019), which indicates that *Plumeria* species are effective in sequestering carbon due to their dense biomass and high photosynthetic activity.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The study reveals substantial variability in woody plant diversity and carbon storage across the assessed secondary schools. The analysis of tree community characteristics indicated significant variation in species diversity among the different plots within each school. At GSS Jiwa, Plot 2 (West) exhibited the highest diversity with a Shannon Index of 1.367 and a Fisher's alpha of 3.538, suggesting a well-balanced distribution of tree species and individuals. In contrast, Plot 5 (Central) demonstrated the lowest diversity and evenness, indicating a dominance by a few species. Similarly, GJSS Jiwa's West Plot had the highest diversity, characterized by a Shannon Index of 1.082 and a low dominance index, while other plots showed lower diversity and higher dominance. GGSS Dutse Alhaji presented moderate diversity in Plots 1 (East) and 3 (South), with diversity indices showing balanced species distribution in Plot 1 but a higher dominance index in Plot 3. The overall lower diversity in other plots suggests a need for increased species variety to enhance ecological balance.

Carbon storage and CO₂ emissions varied significantly across the study sites. GJSS Jiwa, in particular, showed high carbon storage with *Mangifera indica* and *Swietenia macrophylla* contributing substantially. The North Plot's *Swietenia macrophylla* recorded the highest carbon storage (15,3356.44 kg) and CO₂ emissions (562.31 tons), highlighting the importance of large tree species in carbon sequestration. GSS Jiwa also showed significant carbon storage, with species such as *Ficus citrifolia* and *Azadirachta indica* contributing notably to CO₂ emissions.

GGSS Dutse Alhaji's data indicated that *Mangifera indica* in the East Plot had the highest carbon storage (27,805.06 kg) and CO₂ emissions (101.95 tons), while other plots with single-species dominance showed minimal carbon benefits. These findings underscore the role of diverse and larger trees in enhancing carbon sequestration and reducing CO₂ emissions.

5.2 Recommendation

It is recommended that schools adopt strategies to increase tree species diversity, manage existing green spaces effectively, and integrate environmental education into the curriculum. Regular monitoring of tree health and carbon dynamics will ensure that urban school environments continue to provide valuable ecosystem services and contribute to climate change mitigation efforts.

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