TREE CENSUS AND ASSESSMENT OF CARBON SEQUESTRATION UNDER DIFFERENT TREE SPECIES AT AGRO ECOLOGY AND ENVIRONMENT CENTRE DR. PDKV AKOLA

THESIS

Submitted to
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola
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(ECOTOURISM)

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DECLARATION OF STUDENT

I hereby declare that the experimental work and its interpretation in the thesis entitled **"TREE CENSUS AND ASSESSMENT OF CARBON SEQUESTRATION UNDER DIFFERENT TREE SPECIES AT AGRO ECOLOGY AND ENVIRONMENT CENTRE DR. PDKV AKOLA"** or part thereof has neither been submitted for any other degree or diploma of any University, nor the data have been derived from any thesis / publication of any University or scientific organization. The source of materials used and all assistance received during the course of investigation have been duly acknowledged.

Place: Akola **(SARADE TUSHAR DADASAHEB)**

Date: / /2023 Enrolment No.TT/3122

CERTIFICATE

This is to certify that thesis entitled **"TREE CENSUS AND ASSESSMENT OF CARBON SEQUESTRATION UNDER DIFFERENT TREE SPECIES AT AGRO ECOLOGY AND ENVIRONMENT CENTRE DR. PDKV AKOLA "**submitted in partial fulfilment of the requirement for the degree of **"Master of Science in Forestry (Natural Resource Management)"** of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola is a record of bonafide research work carried out by **SARADE TUSHAR DADASAHEB** under my guidance and supervision.

The subject of the thesis has been approved by the student's Advisory Committee.

Place: Akola
Date: / /2023

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Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola**.**

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE INCLUDING EXTERNAL EXAMINER (AFTER VIVA-VOCE)

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(D) Abbreviations

%	:	Percent
C	:	Carbon
^0C	:	Degree Celsius
$^{-1}$or /	:	Per
CO_2	:	Carbondioxide
cm	:	Centimeter
CCS		Carbon Capture and Storage
dSm^{-1}	:	Decisiemenspermeter
EC	:	Electricalconductivity
etal.	:	Etalia(andothers)
etc.	:	Etcetera
E-W	:	East-West
ha	:	Hectare
Hr.	:	Hour
i.e.,	:	that is
m	:	Meter
mm	:	Millimeter
MSL	:	Meansealevel
No.	:	Number
N-S	:	North-south
OC	:	Organic carbon
PDKV	:	Panjabrao Deshmukh Krishi Vidyapeeth
pH	:	Power of Hydrogen
SOC	:	Soil organic carbon
spp.	:	Species
t/ha	:	Tonnes per hectare

(E) **THESIS ABSTRACT**

a)	**Title of the thesis**	**:**	**"TREE CENSUS AND ASSESSMENT OF CARBON SEQUESTRATION UNDER DIFFERENT TREE SPECIES AT AGRO ECOLOGY AND ENVIRONMENT CENTER DR. PDKV AKOLA"**
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ABSTRACT

The present investigation entitled "Tree census and assessment of carbon sequestration under different tree species at Agro Ecology and Environment Center Dr. PDKV Akola," was carried out at the Dr. Panjabrao Deshmukh Krishi Vidyapeeth Akola in 2022–2023. The aim of the investigation was to estimate carbon sequestration as well as examine the impact of various tree species on the physical and chemical properties of soil.

A simple survey approach was used to conduct the experiment. Ten distinct species of trees have been chosen for investigation namely Anjan, Neem, Karanj, Wood Apple, Teak, Lemon, Karonda, Tamarind, Aonla and Custard Apple.The result showed that the Anjan plantation had the maximum number of individual trees (553), through tree census survey. The maximum height recorded by Teak was (11.59 meters), while their lowest height was recorded for Karonda (1.52 meters). Anjan Plantation achieved the largest basal area (51.25 $m^{2/}$ ha), while Teak was highest above-ground biomass (116.75 t/ha). Teak sequestered the highest amount of carbon (73.5 t/ha). The Anjan plantation was found to be composed of the highest SOC (0.91%). In Anjan Plantation, the soil's organic carbon content increased while the pH and EC values decreased.The highest pH value (8.0) was observed under Tamarind and highest EC value (0.21 ds m^{-1}) was recorded under the Anjan species The phytosociological analysis of the agro ecological and environment centre Dr.PDKV Akola in the survey the highest density was observed in the Teak plantation with (310 %) the highest relative basal area was recorded in Anjan Plantation (0.224) additionally the important value index (IVI) of the site was recorded with the highest IVI found in the Teak Plot (10.44).This data shows how important it is to maintain different tree species in order to improve soil fertility and carbon sequestration, which will eventually support the ecosystem's long-term resilience and health.

CHAPTER I

INTRODUCTION

1.1 Background Information

Trees hold immense ecological, social, and economic importance, playing a critical role in maintaining a balanced and sustainable environment. trees absorb carbon dioxide during photosynthesis and help mitigate climate change by acting as carbon sinks (Pan *et al.,* 2011). Trees also produce oxygen through photosynthesis, trees release oxygen, essential for human and animal survival (Larcher, 2003). Tree roots help prevent soil erosion and improve soil structure by binding the soil particles (Levia & Frost, 2003). Trees also provide habitats for numerous species, supporting biodiversity and fostering a balanced ecosystem (Gibson *et al*., 2011). They serve as sources of food and shelter for various wildlife, promoting ecological diversity (Lindenmayer *et al*., 2014). Trees play a crucial role in water regulation by absorbing excess water during heavy rains and reducing surface runoff, thus preventing floods (Krecek, 2011).Their roots help recharge groundwater and maintain water tables (Brown and Lant, 2017).

Trees in urban areas enhance the aesthetic value, reduce stress, and improve mental health and overall well-being (Wolf, 2003). They provide shade, cooling effects, and contribute to energy savings by reducing air conditioning needs (Akbari *et al.*, 2009). Trees contribute to tourism and recreation, attracting visitors to forests and parks (Kaltenborn *et al*., 2016).

A tree census, also known as arboricultural inventory survey, is an organized and comprehensive endeavor to document various aspects of trees within a defined geographic area. This methodical assessment involves collecting detailed data about tree species, including their botanical and common names, height, girth, canopy size, health conditions, age, and geographic coordinates. The information is often gathered through field surveys and can also utilize advanced technologies such as Geographic Information Systems (GIS) and remote sensing. The primary objectives of a tree census are manifold firstly, it provides crucial insights into the diversity and composition of tree species within a specific region, aiding in understanding the ecological dynamics and promoting biodiversity conservation. Secondly, it allows for the assessment of the health and condition of trees, which is vital for identifying potential risks, disease outbreaks, or environmental stress factors affecting the tree population. Urban planners and city officials often leverage tree census data to make informed decisions regarding urban forest management and development strategies. Understanding the distribution and types of trees in urban areas helps in planning green spaces, managing tree health, optimizing resource allocation for maintenance, and making decisions that enhance the overall quality of life in a city. Moreover, it provides a basis for formulating policies related to urban greening, sustainable development, and climate resilience. (Smith *et al.,*2020).

Maharashtra State Government has enacted an act "The Maharashtra (Urban Areas) Preservation of Trees Act", No. XLIV of 1975 (last amended as modified up to 9thJune 2004). It was formed for preservation, protection and plantation of trees in the urban areas. As per the section of 7 (b) of the said Act, it is duty on the Tree Authority of the Municipal Corporation to carry out a census of trees in all lands within the jurisdiction once in every five years

Biodiversity refers to the variety of life on Earth at all levels, including genes, species, and ecosystems. Biodiversity is a complex and dynamic system that encompasses the vast array of life forms, from microorganisms to plants, animals, and the intricate ecosystems they form Biodiversity plays a fundamental role in providing ecosystem services such as pollination, nutrient cycling, climate regulation, and clean water as well as for the well-being and survival of all life forms, including humans. Which are crucial for sustaining life on Earth. Biodiversity also holds intrinsic value, offering aesthetic, cultural, and recreational benefits to humanity. Understanding, conserving, and promoting biodiversity is a global priority due to the accelerating loss of species and habitats, primarily caused by human activities like habitat destruction, pollution, climate change, overexploitation of resources, and invasive species. Preserving biodiversity is not only an ethical responsibility but also essential for our own well-being and the health of the planet (Sala *et al*. 2000).

Biodiversity in India is incredibly rich and diverse, given the country's varied geography, climates, and ecosystems. Here's a brief overview of biodiversity in India. India is one of the world's biodiversity hotspots, harboring approximately 7-8% of the known global species. The country boasts a wide range of ecosystems, including tropical rainforests, mangroves, grasslands, deserts, alpine meadows, and coral reefs, each hosting a diverse array of flora and fauna. India is recognized for its diverse flora, with over 47,000 plant species, including numerous endemic and medicinal plants. The fauna of India is equally diverse, with around 91,000 animal species. This includes iconic species like Bengal tiger, Asian elephant, Indian rhinoceros, and various species of deer, primates, reptiles, and birds. India is also known for its high amphibian diversity, with a significant number of endemic species. Efforts to document and conserve India's biodiversity are ongoing, including various initiatives by the Ministry of Environment, Forest and Climate Change, Government of India. These initiatives include the National Biodiversity Authority (NBA) and the Biodiversity Information System (BIS) aimed at cataloging and managing biodiversity data. (Khati, D., & Khati, P.S.2004)

Natural carbon sequestration occurs in forests, oceans, wetlands, and soils, where plants and ecosystems absorb CO_2 during photosynthesis. Additionally, geological sequestration involves injecting CO_2 into geological formations like depleted oil and gas reservoirs, preventing its release into the atmosphere. Human interventions, such as afforestation, reforestation, and enhanced weathering, enhance carbon sequestration. Additionally, technologies like carbon capture and storage (CCS) in industrial processes and power plants trap CO_2 emissions before they are released into the air. (Lal, 2008).

Trees are carbon reservoir on earth. In nature, forest ecosystem act as a reservoir of carbon. They store huge quantities of carbon and regulate the carbon cycle by exchange of from the atmosphere. Forest ecosystem is one of the most important carbon sinks of CO_2 the terrestrial ecosystem. Plant uptakes the carbon dioxide by the process of photosynthesis and stores the carbon in the plant tissues. Forest ecosystem plays important role in the global carbon cycle by sequestering a substantial amount of carbon dioxide from the atmosphere (Vashum and Kumar, 2012).

Soil organic carbon (SOC) has very labile, labile, less labile and non- labile pools based on decomposition rate. Labile carbon pool is main source of energy for the soil food web which maintains the soil fertility (Chan *et al*., 2001). It is most sensitive pool available relatively in small proportion as it is easily affected by fluctuation in environmental conditions. It also rapidly decomposes and gets oxidized easily with any changes in land use practice. Another SOC pool is the non-labile pool (passive pool) which is more stable and recalcitrant fraction of SOC forming organic-mineral complexes with soil mineral and gets decomposed slowly by microbial activity. It is modified very slowly by action of the microorganisms (Sherrod *et al.*, 2005). Soil fertility is mainly associated with labile pool and the sequestration of atmospheric carbon dioxide is related to the recalcitrant pool. Soil organic carbon (SOC) is one of the most widely use soil quality indicator. In terrestrial ecosystems, it determines the fertility and productivity by improving the physical, chemical and biological properties and also useful in predicting climate change and its effects.

1.2 Need and Importance of Study

A tree census holds significant importance for a multitude of reasons, encompassing environmental, ecological, social, and economic aspects. Tree censuses play a pivotal role in assessing and documenting biodiversity by identifying different tree species within a specific region. Understanding the diversity and distribution of tree species is fundamental for conservation efforts. In urban areas, tree censuses support urban planning and green infrastructure development. Understanding the composition and distribution of trees in cities helps in optimizing green spaces, which is vital for urban sustainability and enhancing the quality of life (Nowak *et al*., 2001).

Tree censuses provide essential data for sustainable forest management by helping to monitor tree growth, regeneration, and forest dynamics. This information guides forest management practices, ensuring long-term sustainability and productivity. (Mello *et al*., 2017). Additionally, a tree census facilitates the assessment of forest biodiversity, identifying threatened species and ecosystems that require conservation efforts.

CO_2 sequestration is crucial due to its potential to mitigate climate change by reducing the amount of carbon dioxide (CO_2) in the atmosphere. CO_2 is a major greenhouse gas responsible for climate change. Sequestering CO_2 from the atmosphere helps in mitigating global warming and its adverse effects on ecosystems, weather patterns, sea levels, and human societies (IPCC, 2018). Carbon sequestration practices like afforestation and reforestation improve soil health and structure, enhancing agricultural productivity. Agroforestry and sustainable land use play a vital role in sequestering CO_2 (Smith *et al*., 2007). CO_2 sequestration supports carbon trading initiatives and carbon offset programs. Companies and nations can offset their emissions by investing in projects that sequester an equivalent amount of carbon, contributing to a carbon-neutral approach (Michaelowa and Dransfeld, 2008). Anthropogenic activities have significantly increased atmospheric CO_2 levels, which need to be stabilized to prevent further climate disruptions. Carbon sequestration is essential in achieving this stability by capturing CO_2 and storing it long-term, thereby mitigating its impact on the climate. (Kirschbaum, 2003)

The study of biodiversity is essential for several critical reasons, encompassing ecological, economic, social, and ethical aspects. Biodiversity is fundamental for ecosystem stability and resilience. Diverse ecosystems can withstand and recover from environmental changes, ensuring they continue to function and provide essential ecosystem services (Tilman *et al*., 1996). Biodiversity contributes significantly to economic sectors like agriculture, pharmaceuticals, fisheries, and tourism. Understanding biodiversity helps in sustainable resource management, ensuring long-term economic benefits (TEEB, 2010). Biodiversity provides genetic resources critical for adapting to changing environmental conditions and developing resilient crops, livestock, and other organisms (FAO, 1996). Biodiversity plays a role in climate change mitigation by sequestering carbon and influencing climate patterns. Additionally, diverse ecosystems enhance climate change adaptation by providing natural buffers against extreme weather events (CBD, 2009). Biodiversity is deeply intertwined with cultural identity and spiritual values of many communities. Studying biodiversity helps in recognizing and respecting these values, fostering cultural diversity and harmony (Posey, 1999).

1.3 Objectives:

Looking to significantly of the problem under the present investigations entitled Tree census and assessment of carbon sequestration under different tree species at Agro Ecology and Environment Centre Dr. PDKV Akola was conducted with following objectives:

1. To identify tree species at Agro Ecology and Environment Centre
2. To study the floristic diversity and soil fertility under different tree species
3. To estimate the carbon storage under different tree species

1.4 Scope and limitations

A tree census involves systematically documenting and quantifying the trees within a defined area. The scope includes identifying species, measuring their dimensions, assessing health, and mapping locations. However, limitations may arise from funding, resource constraints, accuracy of data, and potential underrepresentation of certain tree populations.

The scope of a floristic biodiversity study involves the comprehensive assessment and documentation of plant species within a particular region or habitat identifying and classifying plant species based on morphological, genetic, and ecological characteristics. Mapping the distribution and abundance of plant species within the study area to understand their spatial arrangement and density. Analyzing the role of different plant species within ecosystems, their interactions, and contributions to ecological processes and functions. Identifying and studying endemic or rare plant species to assess their conservation status and ecological significance. Studying the genetic diversity within and between plant populations to comprehend their adaptability and potential for evolution.

Limitations of a floristic biodiversity Limited funding, expertise, and time can restrict the extent and depth of the study. Difficulty in accurately identifying and classifying species due to taxonomic complexities and variations. Biases in sampling methodologies can result in an incomplete or skewed representation of the plant species present in the area. Biodiversity is dynamic, and the study might not capture changes over time, especially in rapidly changing environments. Reliance on existing data or databases, which may have limitations in accuracy, coverage, or completeness. Factors like weather conditions, accessibility, and safety concerns can limit fieldwork and data collection.

The negligence in site management practices reduced the biomass production and carbon sequestration potential of multipurpose tree species. This negligence also affects the soil fertility and this declination is recognized as a form of degradation. It is widespread on smallholder farms that are continuously cultivated for subsistence in the country. In farmers' fields, fertility decline occurs if crop uptake is not compensated for with adequate nutrient amendments through the application of fertilizers or return of much needed organic matter from plant debris or most importantly the use of agroforestry technology that could contribute substantial amounts of nutrients to the soil. Combinations of processes occur in the soil, which lowers soil organic matter and subsequently the loss of nutrients. Several practices in farmer's fields including bush burning degrade the soil and deplete the soil of organic matter that may serve as nutrient base for farmers' crop. Evidence of fertility decline include soil organic matter depletion, negative soil nutrient balance, imbalance in fertilizer application, secondary and micronutrient deficiencies and failure to increase fertilizer use to match the increase in crop yield, longer responses to fertilizers and loss of hydraulic properties of soil. The belief in the use of trees to restore fertility loss in crop fields is based on the hypothesis, supported by scientific data that different tree species improve the soil beneath them, which have been recognized in many traditional farming systems especially in age long shifting cultivation (Nair, 1993).

CHAPTER II

REVIEW OF LITERATURE

The proposed research work is an attempt to study the "Tree census and assessment of carbon sequestration under different tree species at Agro Ecology and Environment Centre Dr. PDKV Akola."

The literature relevant to identification of trees, species richness, evenness and similarity between the ecosystem, tree carbon stock, oxygen release to atmosphere, canopy cover, to the trap pollutant have been reviewed and presented in this chapter. The chapter has been presented under the following headings.

1. Tree census and identification of tree species
2. Floristic diversity and soil fertility under different tree species
3. Carbon sequestration under different tree species

2.1 Tree census and identification of tree species

Balslev *et al*. (1998) showed results of an attempt to count all species of vascular plants in a 1-ha plot of tropical lowland rain forest in Amazonian Ecuador. Species count of vascular plants in one hectare of humid lowland forest in Amazonian Ecuador. Although trees made up the bulk of biomass and species in tropical rain forests, knowledge of the contribution of other life forms to species richness if also of interest from a biological viewpoint. Nevertheless, most plot- and transect-based species counts in neotropical rain forests have dealt only with trees, most commonly with those of dbh (diameter at breast height) ≥10 cm. Some counts of herbaceous species have been carried out, but total species counts in plots of neotropical rain forests have been attempted only a few times.

Condit *et al. (*1998) revealed that fastest-growing tree in the 50 ha plot was the balsa, *Ochroma pyramidale*, which reached 10 cm in 5 years and 30 cm in 10. *Cavanillesia platanifolia, Trema micrantha, Zanthoxylum belizense*, and *Vochysia ferruginea* were the other top-ranking species. At mean growth, the top 15 ranking species required 5–25 years to reach 10 cm, 10–67 years to reach 30 cm, and 32–111 years to reach 60 cm, starting at 1 cm. At growth one standard deviation above the mean, the same species requried 4–18 years to reach 10 cm, 8–35 years to reach 30 cm, and 19–69 years to reach 60 cm dbh, and recommend that the little-known species from this list be further tested in reforestation trials.

Kohyama *et al.*(2005) studied simulation models which use growth rates estimated from resident distributions and assume a Markov process are valid only to reconstruct the dynamics of the overall size structure of a stand. When examining the influence of life history strategy on forest dynamics, models must incorporate the effect of temporal autocorrelation on growth rates and suggest that temporal autocorrelation causes the positive skew in growth rate distributions.

Mayer *et al*. (2006) studied statistical climate-adjustment model was developed using growers' historical yields, taken from the AMS database. This model accounted for the effects of tree age, variety, year, region and tree spacing, and explained 65% of the total variation in the yield per tree data. The second level of crop prediction is an annual climate adjustment of these overall long-term estimates, taking into account the expected effects on production of the previous year's climate. For 2001–2003, the overall forecasts were in the right direction (when compared with the long-term expected values), but were over-estimates. In 2004 the forecast was well under the observed production, and in 2005 the revised models produced a forecast within 5.1% of the actual production. Over the first five years of forecasting.

Potapov *et al*. (2008) presented a new approach for assessment of ecological integrity and intactness at the regional to-global scale. At the core of this approach is a rapid and straightforward method for mapping and monitoring of Intact Forest Landscapes that relies on publicly available high spatial resolution satellite imagery and fine scale maps. Application of this method yielded the first global Intact Forest Landscape map. This map makes it possible, for the first time, to quantify and compare the extent of remaining large natural forest areas worldwide. It also provides a suitable baseline for operational, cost-effective, satellite-based monitoring of forest loss and degradation, where its global scope and consistency is particularly useful for capturing issues of leakage.

Wagner *et al.* (2010) Study provides an easy method to assess dataset limitations in efforts to estimate descriptors of forest structure and dynamic, which is of primary importance to decipher any clear consequences of global change in tropical forests. more than 90 per cent of the inherent variability of these coefficients was predicted using a simple model including plot size and census interval in a Bayesian modeling framework. All descriptors of forest structure varied by <10 per cent for plot sizes >2 ha. Among the descriptors of forest dynamics, AGB loss was the most variable.

Pervaiz *et al*. (2018) study showed that the significant fluctuation in green cover has the negative impacts on urban environment which ultimately creates hurdles in coping with global warming and curbing the climate change rising threat. So, the role of the government towards maintenance of green spaces in the graveyards for urban sustainability is very important. Hence, the present research would be helpful to provide baseline information for urban planners and foresters to plan appropriate composition of green space trees in the graveyards. In addition, the inventoried data would be valuable for city authorities for decision making about green cemeteries and also helpful for further research on urban ecosystem.

Nyelele *et al*. (2019) analyzed at the census block group level to determine the magnitude and direction of change for each service and benefit over time. Results revealed that the monetary value of trees in the Bronx in 2010 is estimated to be $37.6 million, and this value is estimated to range from $40.7 million to $43.9 million in 2030 if the current canopy is maintained and newly planted trees grow to maturity. Tree cover scenarios (assuming no tree mortality, 4% and 8% annual mortality). Land cover and tree canopy estimates for 2010 are derived from a high-resolution land cover dataset. A grow-out scenario based on urban tree database information and allometric equations is used to predict future canopy cover.

Kane *et al.* (2020) studied the scope and opportunities available in Pune to understand the temporal and spatial status of the green cover across the municipal limits that help improve the scenario in view of maintaining and optimizing the biodiversity and review the conversion of land usage due to urbanization over last three decades as well as evaluate the collected census data to provide deeper insights into how the data can be used to create a decision support system by Pune Municipal Corporation to address the expectation of improvements of green cover across the city.

Khadanga *et al.* (2020) revealed application of remote sensing techniques as a potentially low-cost alternative to field-based assessments like tree census, tree crown and tree type detected by means of a simple threshold, using the Green Red Vegetation Index (GRVI).

Lechner *et al*. (2020) Introduced that remote sensing provides valuable insights into pressing environmental challenges and is a critical tool for driving solutions. The important role of remote sensing in forest ecology and management, includes applications as diverse as mapping the distribution of forest ecosystems and characterizing the three-dimensional structure of forests.

Smith *et al*. (2020) reported that inventory of urban trees in California called the California Urban Forest (CUF) Inventory. These data are offered to the public (aggregated to ZIP code) via an online data portal, which at the time of publication contained over 6.6 million urban tree records. Urban street trees provide many benefits to surrounding communities, but our ability to assess such benefits relies on the availability of high-quality urban tree data.

Geraldi (2021) found that there is a high diversity of tree species. Results showed that of the total number of spaces with species, 7424 are in good health. Pique’s urban trees have a high per centage of trees that obstruct or interfere with the wiring of public services.

Abigail *et al*. (2022) reported that Climate change has affected Cuenca Ecuador. One effect is increased air pollution. Having an appropriate number of trees is essential to sustain life everywhere. The goal of this project, sponsored by Gustavo Morejón of Save.bio, was to determine the most feasible method to conduct a tree census.

Devid *et al*.(2022) studies shown that heat island effects are greater, imperviousness is higher, and tree cover lower in areas that were formerly redlined (class D). further the author analyzed all redlined areas in U.S. cities and confirms that redlined areas (class D) have lower tree cover, greater impervious cover and lower forest ecosystem service values than other classes, with tree cover declining and impervious cover increasing as security risk class increased.

2.2 Floristic diversity and soil fertility under different tree species

Kornas (1968) collected floristic materials (both native and alien plant species) were analyzed in terms of life form, botanical family, geographical-historical groups and phytosociological affiliation of species. Classification of species with regard to their affiliation to geographical-historical groups and names of flowering plants and pteridophyte species.

Narain *et al.* (1970) reported that, irrespective of forest covers in Doon valley, bulk density of soil was found to increase and pore space decreased with increase in soil depth. In surface soil (0-30 cm) bulk density was lowest and pore space was highest under brushwood followed by Eucalyptus and the Sal Forest, which may be due to the organic carbon content of the soil.

Haigh (1980) reported that tree species diversity and richness is enhanced in urban areas compared with surrounding landscapes and/or typical forest stands as native species richness is supplemented with species introduced by urban inhabitants or processes. People often plant trees in urban areas to improve aesthetics and/or the physical or social environment. Some nonnative species can invade via transportation corridors or escape from cultivation.

Vadiraj and Rudrappa (1990) studied the nutrient status of soil under different plantation like *Tamarindus indica, Casuarina equisetifolia, Eucalyptus camaldulemis* and *Mangifera indica* in Bangalore district, Karnataka and the study revealed that electrical conductivity did not differ soils under different plantations.

Balagopalan *et al.* (1992) compared physical properties of soils viz., bulk density and particle size composition (Per centage gravel, sand, silt and clay) under monoculture *Tectona grandis, Eucalyptus tereticornis* and mixed stands of *Tectona grandis* & *Bombax ceiba*. They found very negligible differences in physical properties.

Ilorkar and Totey (2001) conducted a study on soil and floristic diversity in Navegaon national park (Maharashtra) and revealed that highest floristic diversity (1.210) and density (914.75) was observed at an elevation range of 500- 600 m and soils at elevation range of 300-400 m presented maximum productivity index (51.98 and 62.32) followed by at 500-600 m (61.56 and 49.24) and 400-500 m (44.32 and 53.40).

Ilorkar *et al*. (2002) conducted a study on medicinal plant potential of Navegaon national park (Maharashtra) and observed that the area is an important habitat for many migratory birds, it accommodates more than 130 plant species belonging to 117 genera and 42 families.

Augusto *et al.* (2002) worked on European temperate forest tree species to know its effect on the soil fertility. Result of the study indicated that impact of tree species was maximum in the top soil. Coniferous tree Picea abies showed negative impact on some nutrients (Ca and Mg) and it promoted soil acidification and reduces soil pH. Hence, it is not suitable for very poor soils (areas of acidic atmospheric depositions).

Nowak *et al*. (2002) Concluded that Urban forests can play a significant role in helping to reduce atmospheric carbon dioxide levels. Urban forests likely will have a greater impact per area of tree canopy cover than nonurban forests due to faster growth rates, increased proportions of large trees, and possible secondary effects of reduced building energy use and consequent carbon emissions from power plants. However, urban tree maintenance emissions can offset some of the carbon gains by urban forest systems.

Supriya Devi and Yadava (2006) conducted study of floristic diversity of *Dipterocarpus tuberculatus* dominated forest of Manipur situated along the Indo-Myanmar Border, north-eastern India. A total of 123 species belonging to 48 families were recorded. The quantitative features such as density and importance value index of species varied greatly. In the present study the diversity index of shrubs and herbs were found to be higher than the tree species. The concentration of dominance was recorded highest in the tree species. The presence of low number of higher girth class of tree species and higher number of the saplings and seedlings indicates that the present forest is young exhibiting frequent regeneration.

Singh *et al.* (2010) conducted the experiment to evaluate the effect of pure stands of tree species and poplar-based agroforestry system on soil organic carbon (OC) and available N, P and K contents. Depth wise soil samples were taken from 13-year-old *Eucalyptus tereticornis, Azadirachta indica, Melia azedarach, Dalbergia sissoo, Albizia lebbeck, Leucaena leucocephala* and *Acacia nilotica* spaced at 6 m x 3 m and adjoining open area (control) from PAU Regional Station at Bathinda. Outcome shows that there was significantly higher amount of soil OC and available nutrients in the surface soil depths (0-15 cm) than below.

Ogunkunle *et al.* (2011) assessed the effects of teak single cropping and cocoa-kola intercropping on the soil fertility. Analysis of results showed that the decomposition of cocoa and kola leaves improved the soil organic matter content in cocoa/cola site and same in teak site. Thus, there was high soil organic matter content in forest site (9.12%) fallowed by cocoa/kola site (7.34) and was least in the teak site (3.04%).

Breuste *et al.* (2013) in their study estimated that parks are an important element of green areas of cities and serve various purposes such as recreation, health and social functions and improving the condition of the urban environment.

Konijnendijk *et al.* (2013) estimated that the advantages of urban green areas are notable primarily in city parks, where valuable urban biotopes generate a varied set of substantial ecosystem services for people.

Nielsen *et al.* (2013) in the era of climate change, there is growing recognition of urban areas as hosts for modern or innovative ways to conserve and promote biodiversity parks, as one specific type of urban green space, constitute particularly important biodiversity hotspots in the cityscape.

Lindenmayer *et al*. (2014) reported that forest biodiversity conservation that reflects the multi-scaled nature of conservation approaches on forested land. At the regional scale, management should ensure the establishment of large ecological reserves. At the landscape scale, off-reserve conservation measures should include: (1) protected areas within production forests; (2) buffers for aquatic ecosystems; (3) appropriately designed and located road networks; (4) the careful spatial and temporal arrangement of harvest units; and (5) appropriate fire management practices.

Oumarou (2016) investigated the influence of four different tree species (*Acacia albida, Combretum aculeatum, Acacia senegalensis* and *Piliostigma reticulatum*) on soil fertility in semi-arid climate Niger. Soil sample were collected at various depths (0-10, 10-20, 20-30, 30-40 and 40-50 cm) and two age classes (young and mature). Results showed that the OC was more under leguminous trees (*A. albida* and *P. reticulatum*) compared to nonleguminous trees (*A. senegalensis* and *C. aculeatum*). N, P and K were less under *C. aculeatum* than other tree species. However, Na, Mg and Ca concentrations were lower under *A. senegalensisth* and other tree species.

Izakovicova and Swiader (2017) reported that urban green space refers to public spaces in city areas, mostly covered by different types of vegetation, which include urban parks, woodlands, street trees, square plantings and other social infrastructure. City parks are often designed along the river in many cities which also influences species composition and biodiversity. They are also elements of ecological network.

Kumar *et al.* (2017) investigated the effect of multipurpose tree species namely Prosopis cineraria, Acacia senegal and Tecomella undulate on the physical and chemical properties of soils representing Typic Haplocambids. This study shows result that the soil had an overall low status of SOC (<0.50%), low to medium P (8.2-15.7 kg ha-1) and medium to high K (276-498 kg ha-1). Slight decrease in pH of the soils under these tree species were noticed, whereas changes in EC were not appreciable. Significant improvement in soil organic carbon (0.12 to 0.27 %), available P (9.70 to

13.36 kg ha-1) and K (336 to 393 kg ha-1) was observed under these tree species compare to field without plantation. This study also indicated that these available nutrients had significant and positive correlation with organic carbon content across the land uses.

Chauhan *et al*. (2018) assessed the soil health under four multipurpose tree (MPTs) plantation (*Acacia catechu, Dalbergia sissoo, Melia azadirachta* and *Terminalia arjuna*) after ten years of growth on riverine soils. The result shows that soil health in terms of physical and chemical parameters showed improvement under all the tree species than the control (tree-less area). An enhanced enzymatic activity besides microbial biomass carbon was observed underneath soil of different species than tree-less area, which shows ameliorative potential of soil through plantations on degraded soils.

Thakre *et al.* (2018) carried out study in urban forest of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. A total of 89 species belonging to 74 genera and 35 families have been collected and documented from the university. Out of these, 82 species with 68 genera of 33 families belong to dicots, 7 species and 6 genera of 2 families belong to monocot. Data reveals that dicots dominate over monocots in the vegetation of the area.

Thakur *et al*. (2020) assessed the soil organic carbon stock under different forest types and different depths. The seven forest types selected for study were northern dry mixed deciduous forests, Himalayan Chir pine forest, ban oak forest, moist deodar forest, mohru oak forest, low level blue pine 23 forest and Kharsu forest. The Highest SOC content (32.3 g kg-1) was recorded under Kharsu forest and the lowest SOC content (11.6 g kg^{-1}) was noticed under northern dry mixed deciduous forests. The Bulk density of all the forests was ranged from 0.95 to 1.12 Mg m^{-3}. Also, the soils of different forests were contained 26.8 to 37.4 per cent coarse fragments. The kharsu forests stored the highest carbon stock (41.4 Mg C ha^{-1}), whereas Northern dry mixed deciduous forests contained lowest SOC stock (16.6 Mg C ha^{-1})

Ramesh *et al.* (2023) conducted a study to evaluate the economics and changes in the soil qualities were evaluated by growing agricultural and horticultural crops, namely pearl millet, sorghum, maize, sesame, small onions, green gram, and red gram, as intercrops under eight-month-old eucalyptus clone trees using a same randomised block design in three replications at a spacing of 3 m × 1.5 m. and revealed that the volume of the trees was generally increased more favorably by red gram than by green gram. The intercrops had some effects on the nutrients in the soil and supports a complementary relationship, the lack of awareness among farmers of Eucalyptus allelopathy formed the major limitation.

2.3 Carbon sequestration under different tree species

Rowntree and Nowak (1991) studied the total carbon storage and annual carbon sequestration by trees can also be estimated using tree cover and tree diameter distribution data. Current international researchers on carbon stock estimation in urban green space mainly focus on carbon stock of trees. Few consider the carbon stock of shrubs and herbs. Shrubs and herbs are also important contributors to urban green space

Ravindranath *et al*. (1997) estimated that the Tree, shrub, soil and sea water play crucial role in absorbing atmospheric carbon dioxide. The trees act as major CO_2, sink which captures carbon from the atmosphere and acts as sink, stores the same in the form of fixed biomass during the growth process. Therefore, growing trees in urban areas can be a potential contributor in reducing the concentration of CO_2 in atmosphere by its accumulation in the form of biomass

Guan *et al*. (1998) estimated green space carbon stock in the dense urban areas of Guangzhou city, and indicated that the roles of urban vegetation in the balance of carbon and oxygen would be increased greatly if it could be conserved and improved in some way.

McPherson (1998) quantified the benefits of the urban forests in Sacramento, USA in offsetting carbon emissions from human energy consumption and presented guidelines of urban forest management to improve these benefits.

Nowak *et al*. (2002) Concluded that Urban forests can play a significant role in helping to reduce atmospheric carbon dioxide levels. Urban forests likely will have a greater impact per area of tree canopy cover than nonurban forests due to faster growth rates, increased proportions of large trees, and possible secondary effects of reduced building energy use and consequent carbon emissions from power plants. However, urban tree maintenance emissions can offset some of the carbon gains by urban forest systems.

Nowak and Crane (2002) Vegetation in urban green space can absorb CO_2 in the atmosphere through photosynthesis and store excessive carbon as biomass. Therefore, the quantification of carbon stock in urban green space can help better understand its function in reducing CO_2 emission in the global carbon cycle and provide a theoretical basis for the planning and management of urban green space.

Lal (2004) estimated that the potential of soil organic carbon sequestration is finite in magnitude and duration. It is only a short-term strategy to mitigating anthropogenic enrichment of atmospheric CO_2.

Oelbermann *et al*. (2004) reported that above ground biomass is capable of sequestering 2.1109 Mg/C yr $^{-1}$ in tropical and 1.9 both 109 Mg/C yr $^{-1}$ in temperate regions.

Pearson *et al*. (2005) generally, for any plant species 45% of its biomass is considered as carbon i.e., Carbon Storage = Biomass x 45%. It is believed that AFS has a higher sequester C potential than pastures or field crops growing under similar ecological conditions.

Kadiro and Zeide (2007) studied using practical process models, it is found that the long-term optimal density index for teak plantations in Kerala, southern India, is 475. Analysis of data from the Inventory of Teak Plantations in Kerala-1997, consisting of 1170 sample plots representing teak plantations in Kerala, showed that only 4.8% of the stands have optimal density and found that by controlling understory species in teak plantations, the mean annual increment in volume of teak can be increased by 30 per cent. Removal of understory growth would also lead to social benefits by providing firewood to the local inhabitants other than its effects on the growth enhancement of teak trees. Although these results pertain to only one region in southern India, the developed methodology may be useful for other places and Species.

Huang (2008) compared with other methods of mitigating CO_2 emission under the background of global climate change, urban forests have their own specific advantages, such as lower cost and higher efficiency.

Chatterjee *et al.* (2009) Determining soil carbon (C) with high precision is an essential requisite for the success of the terrestrial C sequestration program. The informed choice of management practices for different terrestrial ecosystems rests upon accurately measuring the potential for Carbon sequestration. Numerous methods are available for assessing soil C.

Chavan and Rasal (2010) studied that total carbon sequestered in trees in the campus Dr. B.A.M. University, Aurangabad is conducted. The biomass and total organic carbon of standing trees is estimated by non destructive method. The tree height and girth is to be taken into consideration for the measurement of biomass and carbon content.

Nair *et al*. (2010) From the point of view of agroforestry, C sequestration primarily involves the absorption of atmospheric CO_2 during photosynthesis and the transfer of fixed C into vegetation, detritus and soil pools for "safe" (i.e. long-term) storage.

Pan *et al.* (2011) reported that the terrestrial carbon sink has been large in recent decades, but its size and location remain uncertain. Using forest inventory data and long-term ecosystem carbon studies, we estimate a total forest sink of 2.4 ± 0.4 petagrams of carbon per year (Pg C $year^{-1}$) globally for 1990 to 2007 and also estimate total forest sink estimate is equivalent in magnitude to the terrestrial sink deduced from fossil fuel emissions and land-use change sources minus ocean and atmospheric sinks.

Suryawanshi *et al*. (2014) investigated that total biomass and carbon sequestrated in the tree species have been estimated using non-destructive method. The aboveground and belowground organic carbon (tones/tree) and total organic carbon of each species were calculated. The calculated total organic carbon has been compared with allometric model.

Satheesan *et al.* (2016) assessed the distribution patterns, growth conditions and aboveground biomass in Mullaitivu district during the period of February to May, 2015. Plant height, diameter (dbh), crown height and canopy diameter were measured from selected teak plants in four locations such as Mulliyawalai, Mankulam, Karripatammuripu and Theravil. The measurements were taken with square plot of the size 15 m × 15 m and findings from the Mulliyawalai and Theravil sites had same aged plantation of 22 years, highest average height and dbh value had observed in Theravil site as 19.80 ± 0.28 m and 20.10 ± 0.24 cm, respectively. The highest aboveground biomass of 410.37 tonne ha^{-1} and tree volume of 579.58 m^3 ha^{-1} was found in Mulliyawalai. Among the four locations, the highest average aboveground biomass (1,301.49 tonne ha^{-1}) and tree volume (2,043.77 m^3 ha1) were observed in Karripatammuripu plantation. From this study Theravil site was selected as the best site for the plantation of teak.

Saini (2017) Signified that terrestrial carbon storage is one of many different ways to tackle the problem of greenhouse gases (GHG) emissions resulting from non-point sources. However, the development of large-scale urban forest acreage is not an easy undertaking, and could continue to store (sequester) atmospheric carbon in significant quantities over an extended period (>100 years). In the study, seven urban tree species were identified as the top candidates for terrestrial carbon storage in water-stressed Californian regions, which are also the regions with the worst air quality in the nation.

Nirala *et al.* (2018) assess the total biomass, carbon stock and carbon dioxide (CO_2) content of different age group plantations of teak at five different compartments of Bhabar and Shivalik regions of Kotdwar Forest Division, Uttarakhand. They found that above ground biomass (AGB), below ground biomass (BGB) and total biomass (TB) significantly influenced by different sites and age group of teak plantations. The extent of increase in AGB (687.07 tonne ha^{-1}), BGB (171.77 tonne ha^{-1}) and TB (858.84 tonne ha^{-1}) in S26 (Sigaddi-18A) plantation site at the age of 48 was 70.10 % over S8 (Sigaddi-18B) in AGB (205.40 tonne ha^{-1}), BGB (51.35 tonne ha^{-1}) and TB (256.75 tonne ha^{-1}) at the age of 33 years. Further, the total carbon (TC)

(429.42 tonne ha^{-1}) and CO^2 (1575.97 tonne ha^{-1}) was highest in Sigaddi-18A (S26) plantation site at the age of 48 years. Whereas, the lowest TC (128.37 tonne ha^{-1}) and CO^2 (471.13 tonne ha^{-1}) at the age of 33 years was observed in S8 (Sigaddi-18).

CHAPTER III

MATERIAL AND METHODS

The present study entitled **"Tree census and assessment of carbon sequestration under different tree species at Agro Ecology and Environment Centre Dr. PDKV Akola"** was carried out at Agro Ecology and Environment Centre in the premises of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra to identification of tree species, influence of multipurpose tree species on tree productivity, accumulation of biomass, carbon sequestration, soil fertility and also study the floristic diversity. The details of the study, techniques used and methodology adopted during the course of investigation were given in this chapter under the following main headings.

3.1 Study site

The experiment was conducted at Agro Ecology and Environment Centre Dr. PDKV Akola. Akola is located about 580 kilometers east of the state capital, Mumbai, and 250 kilometers west of the second capital, Nagpur. Akola is the administrative headquarters of the Akola district. Indian cork tree located in the Amravati Division, and is governed by the Akola Municipal Corporation. This study was experimental in different Sites of AEEC Dr. PDKV Akola are described in Table 1 (Plate 1).

3.2 Material used

The equipment's to be used in the research are Ravi altimeter, measuring tape, marking spray, weighing balance and Green India Service Provider Ltd. Tree Census App.

3.2.1 Ravi altimeter

Ravi altimeter is used to measure the height of tree, as forests crops. It helps researchers and environmentalists monitor changes in vegetation height over time, which is crucial for understanding ecosystem health, growth patterns, and the effects of environmental changes.

3.2.2 Measuring Tape

Measuring the diameter of trees at breast height (usually 1.3 meters above the ground) to assess tree growth and health.

3.2.3 Marking Spray

Spray was used to mark the tree to avoiding repetition of counting trees.

3.3 Climate and Weather

Akola has a national weather station that serves as local weather center. Annual temperature ranges from a high of 47.6°C to a low of 22°C. Akola lies near the Tropic of Cancer and becomes very hot during the summer, especially in May.

3.4 Rainfall (mm)

The annual rainfall averages 800 mm. Most of the rainfall occurs in the monsoon season between June and September, but there is some rainfall in January and February.

3.5 Temperature (°C)

The maximum temperature 36.75 °C was recorded in the month of June, whereas the minimum temperature 10.51 °C was observed in the month of December.

Table 1. Land use and other agricultural characteristics of the study area in Akola district (2020-2021)

Description	Area (ha)
District Name	Akola
District Area	540
Cultivable Area	455
Forest Area	35
Land under Non-agricultural use	5.00
Permanent Pasture	12.00
Cultivable waste land	6.00
Land under Misc. Trees and groves	6.00
Barren and un cultivable land	18.00
Current Fallow	7.00
Other Fallow	5.00

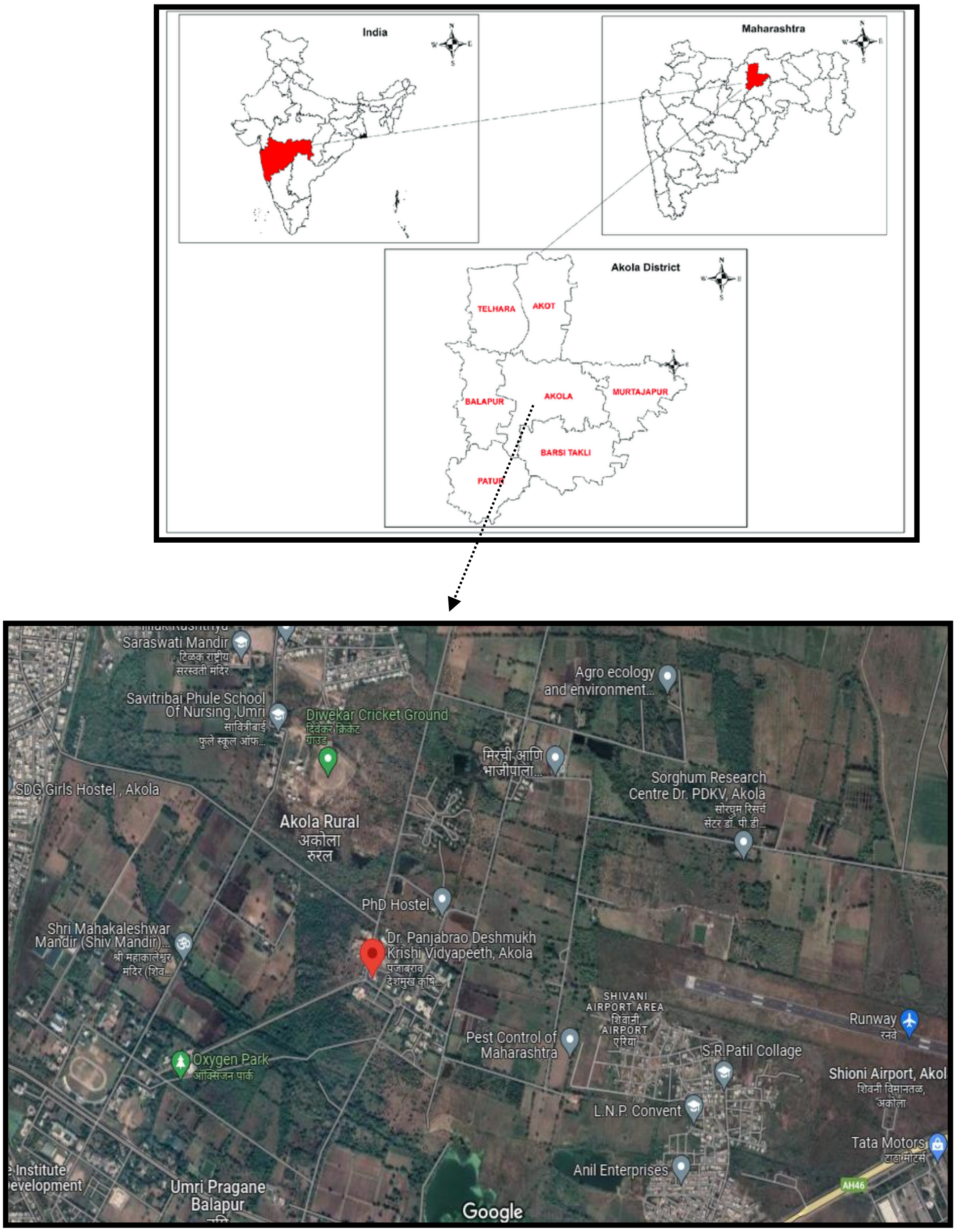

Plate 1. Map of Akola

(Courtesy: Google Earth)

3.6 Selection of quadrant

Study was conducted in ten different plantations at AEEC, Dr. PDKV, Akola. viz Anjan, Neem, Karanj, Wood Apple, Teak, Lemon, Karonda, Tamarind, Aonla, Custard Apple in the premises of Dr.PDKV Akola Further, the study was conducted for comparing Biomass, carbon storage and soil properties with selected plantations described below Table 2 (Plate 2).

Table 2. Name and location of site

Name of Plot	Area	Area of Sampling	Area of size	Total No. of Quadrant (20×20m^2)
Anjan	2.66 acre	3.7% of total area	400 m^2	2
Neem	2.97 acre	3.3% of total area	400 m^2	2
Karanj	1.85 acre	5.3% of total area	400 m^2	2
Wood Apple	1.21 acre	8.1% of total area	400 m^2	2
Teak	0.44 acre	22% of total area	400 m^2	2
Lemon	0.52 acre	18% of total area	400 m^2	2
Karonda	0.47 acre	21% of total area	400 m^2	2
Tamarind	1.55 acre	6.3% of total area	400 m^2	2
Aonla	2.22 acre	4.4% of total area	400 m^2	2
Custard Apple	1.42 acre	6.9% of total area	400 m^2	2

3.7 Experimental Design and Layout

Experimental design : Vegetation survey and simple soil method

Number of sample plot : 10

Quadrat size : 20X20 m^2

Quadrat sampling

per centage range : 3 to 22 %

Year of Study : 2022-23

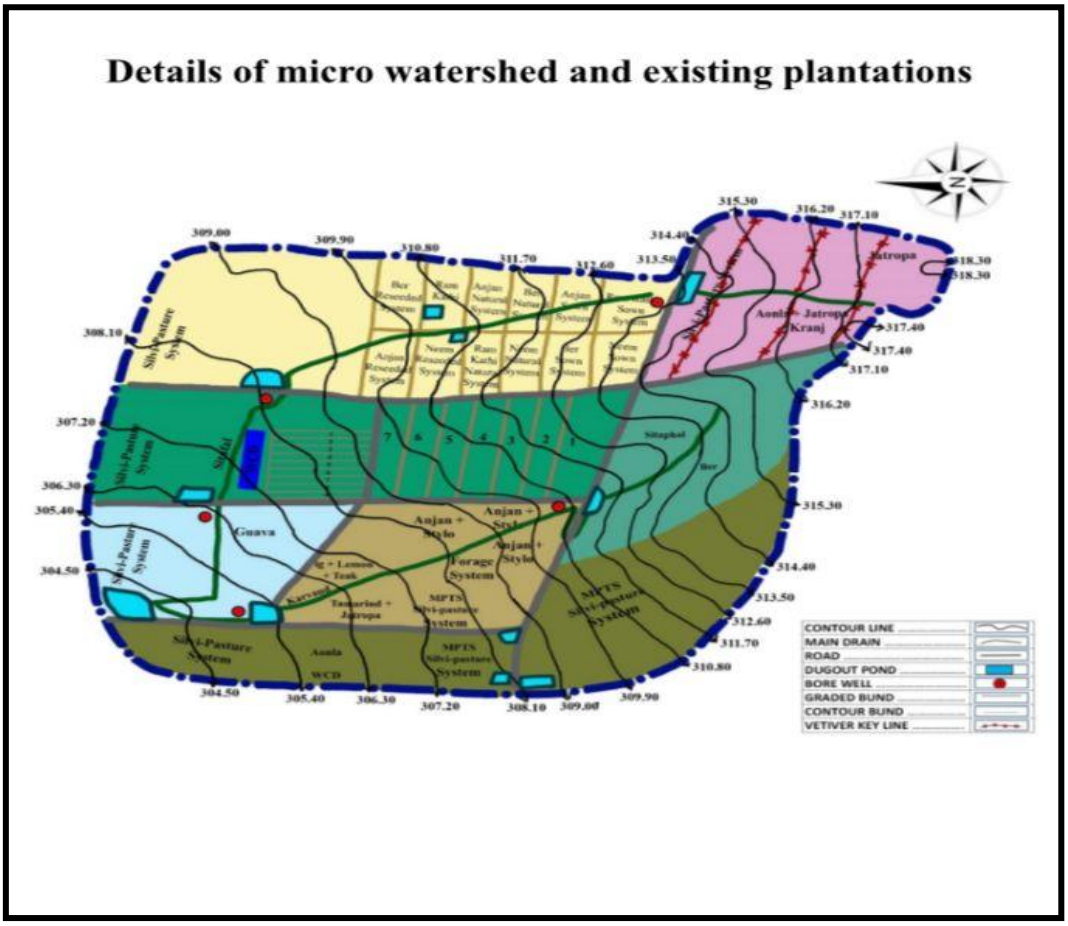

Plate 2. Map of Agro Ecology and Environment Centre, Dr. PDKV Akola

3.8 Observations recorded:

A. Biophysical parameters for determination of productivity and Biomass

i. Tree census
ii. Girth at breast height (cm)
iii. Height of the tree (m)
iv. Basal Area (m^2)
v. Volume (m^3)
vi. Above Ground Biomass (t/ha)
vii. Below Ground Biomass (t/ha)
viii. Total Biomass (t/ha)

3.8.1 Tree Census

Tree census is defined as individual counted of the species and documentation of girth, height, canopy diameter. In addition of the species**.** The number of trees at Agro Ecology and Environment center Dr. PDKV Akola was counted and geo location tagging was done by using, "Green India Service Provider Pvt. Ltd. Tree Census App" developed by Maha Agroforestry and Climate Care Services Pvt. Ltd was used for the study. The information of tree like, height, girth, canopy cover, age of tree, tree condition, geo location and photograph of each tree was collected by using the mentioned Tree Census App. The tree's height was measured with a Ravi altimeter, its girth with a measuring tape, and its canopy cover and condition were recorded using an ocular method. The age of the tree was determined from plantation records provided by AEEC, Dr. PDKV Akola, and its geolocation was recorded using a mobile device's GPS (Plate 3).

3.8.2 Girth at breast height (cm)

Girth is the circumference of the tree, perpendicular to tree axis which was measured with the help of measuring tape at 1.37 m height above the ground.

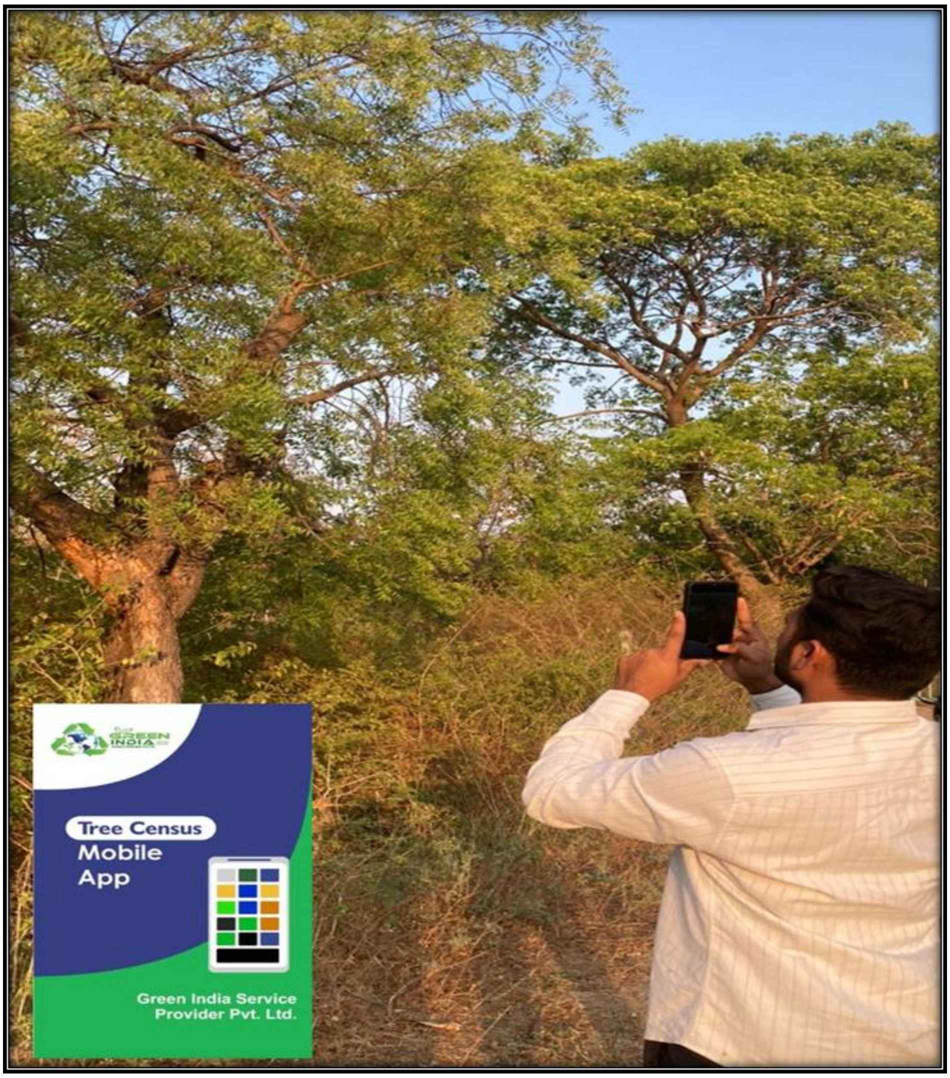

Plate 3. Tree census and geo-tagging of trees by Tree census using mobile App

Plate 4. Measurement of height of tree by using Ravi Altimeter

Plate 5. Measurement of girth of trees by using Measuring Tape

3.8.3 Total Tree Height (m)

Total tree height: - total tree height is the distance from the ground's high point at the tree's base to the very top of the tree. The tree height was measured by Ravi altimeter. (Chaturvedi and Khanna, 1981)

3.8.4 Basal area (m^2)

Basal Area: The basal area of a stand of trees is the sum of the cross-sectional surface areas of each live tree, measured at DBH, and reported on a per unit area basis.

The Basal area was calculated by following equation

$$\text{Basal area} = g^2/4\pi$$

Where 'g' is the girth at breast height (m) and 'π' is 3.14

3.8.5 Volume Estimation

The volume of standing tree was calculated by following equation;

$$\text{Volume } (m^3) = \text{Basal area } (m^2/ha) \times \text{Height } (m) \times \text{Form Factor}$$

Form Factor;

$$F = 2h^1/3h$$

Where,

F=Form factor

h^1 = Height at which diameter is half of DBH

h = Total height

3.9 Phytosociological analysis

For study of tree productivity and biomass ten Quadrat size 20 m x 20m were laid down under selected different tree species. The vegetation analysis was carried out where quantitative analysis was done. The frequency, density, basal area was calculated (Curtis and Mcintosh 1950) frequency, density and basal area calculated by as given below:

$$\text{Frequency (per cent)} = \frac{\text{No. of quadrats in which species occurred}}{\text{Total no. of quadrat studied}} \times 100$$

$$\text{Density (tree } ha^{-1}) = \frac{\text{Total no. of individuals of species}}{\text{Total no. of quadrat studied}} \times 100$$

$$\text{Relative frequency (RF)} = \frac{\text{Frequency of the individuals species}}{\text{Total frequency of all species}} \times 100$$

$$\text{Relative density (RD)} = \frac{\text{Density of the individuals of species}}{\text{Total density of all species}} \times 100$$

$$\text{Relative Basal Area (RBA)} = \frac{\text{Basal area of the individuals of Species}}{\text{Total Basal area of all species}} \times 100$$

The importance value index (IVI) was calculated as the sum of total relative frequency, relative density and relative basal area.

Importance Value Index (IVI) = RD + RF + RB

3.10 Estimation of Above Ground Biomass (t/ha)

Above Ground Biomass: Above Ground Biomass (AGB) is defined as "the aboveground standing dry mass of live or dead matter from tree or shrub (woody) life forms, expressed as a mass per unit area, typically Mg ha^{-1}. Urban trees can account for up to 97% of urban AGB.

The Above Ground Biomass (AGB) in the trees was quantified by non-destructive method using following equation against Girth at Breast Height

$$y = 0.007\,x^2 + 1.898\,x - 32.69$$

Where,

y = AGB (kg)

x = GBH (cm)

This equation has been developed at TFRI by destructive method (Jain *et al.,* 2015)**.**

3.11 Estimation of Below Ground Biomass

Below Ground Biomass: Below ground biomass is defined as the entire biomass of all live roots, although fine roots less than 2 mm in diameter are often excluded because these cannot easily be distinguished empirically from soil organic matter.

The belowground biomass (BGB) was calculated by multiplying above-ground biomass taking 0.26 as the root to shoot ratio (Cairns *et al.,* 1997; Ravindranath and Ostwald, 2008).

Belowground biomass (t/ha) = 0.26 X above-ground biomass (t/ha)

3.12 Total biomass (t/ha)

Total biomass: - Biomass, from the forest point of view, is defined as the total amount of aboveground living organic matter in trees expressed as oven-dry tones per unit area (tree, hectare, region, or country). The term Biomass density is used when the Biomass is presented as mass per unit area.

Total Biomass was the sum of Above Ground Biomass and Below Ground Biomass (Sheikh *et. al*, 2011).

Total Biomass (t/ha) = Above Ground Biomass+ below Ground Biomass

3.13 Carbon Estimation

The average Carbon content is generally 50% of the tree's dry weight total volume. Therefore, in determining the weight of Carbon in the tree, multiply the dry weight of the tree by 50 % (carbon content).

The Carbon of standing tree was estimated by using following equation given below (Pearson *et. al*., 2005 and IPCC, 2006)

$$\text{Carbon Storage (t/ha)} = \frac{\text{Biomass (t/ha)}}{2}$$

3.14 Total Carbon (t/ha)

Total Carbon Sequestered (t/ha) = Above Ground Carbon (t/ha)
+ Below Ground Carbon (t/ha)

3.15 Estimation of soil fertility

3.15.1 Soil sampling technique:

Soil sampling collection was carried out at all sites. The quadrates were laid out in particular plantation. The pit was dug at center of each quadrate with dimension 1m×1m×1m. The soil sample was collected from depth of soil 0 to 30 cm and 15 to 30 cm. soil samples was taken and tested in laboratory of Department of Soil Science and Agriculture Chemistry, Dr. PDKV Akola.

3.15.2 Soil parameters

a) Physical properties of soil

  i. Bulk density

b) Chemical Properties of Soil

  i. Organic Carbon

  ii. pH

  iii. EC

Table 3. Methods for soil analysis:

Sr. no	Parameters	Method adopted	Reference
A.	**Physical properties**		
1	Bulk density	Clod Coating Method	Blake and Hartge(1986)
B.	**Chemical properties**		
1	pH	Glass Electrode pH meter	Jackson (1973)
2	Electrical conductivity	By conductivity meter	Jackson (1973)
3	Organic carbon	Wet Oxidation Method	Walkley and Black (1934)

3.15.2.1 Soil physical properties

1) Bulk density (BD)

Bulk density (Mg m^{-3}) of soil was estimated using clod clotting method given by Blake and Hartge (1986).

3.15.2.2 Soil chemical properties

1) Soil pH

pH of soil was measured with 1:2:5 soil water suspension using glass electrode pH meter (Jackson 1973).

2) Electrical conductivity (EC)

The electrical conductivity (dS m^{-1}) was measured with 1:2:5 soil water suspension using conductivity meter (Jackson 1973)

3) Organic carbon (OC)

The organic carbon content (%) was estimated using wet oxidation method given by Walkley and Black (1934).

3.16 Statistical analysis

The data obtained underwent statistical analysis using a simple tabular form method. Simple statistical tools like per centages (%), averages, and mean were used for data analysis and presented in the form of tables.

CHAPTER IV

RESULTS AND DISCUSSION

The results emerging from the present investigation undertaken to explicate the **"TREE CENSUS AND ASSESSMENT OF CARBON SEQUESTRATION UNDER DIFFERENT TREE SPECIES AT AGRO ECOLOGY AND ENVIRONMENT CENTRE DR. PDKV AKOLA"** was carried out at Agro Ecology and Environment Centre Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra during 2022-23 are presented in this chapter.

4.1 Tree parameter

4.1.1Tree Census

4.1.2 Tree height and girth at breast height (GBH)

4.1.3 Basal area of different tree species

4.1.4 Volume of different tree species

4.2 Biomass of different tree species

4.2.1 Aboveground biomass of different tree species

4.2.2 Belowground biomass of different tree species

4.2.3 Total biomass of different tree species

4.2.4 Total CO_2 sequestration of different tree species

4.3 Status of Soil Fertility of different tree species

4.3.1 Bulk density of soil

4.3.2 pH and electrical conductivity of soil

4.3.3Organic carbon of soil

4.1 Tree parameters

4.1.1 Tree Census

The Agro Ecology and Environment Centre Dr. PDKV Akola conducted an extensive survey, which encompassed tree counting. Tree census app was used to document a range of tree characteristics, such as height, girth, health status, canopy coverage, and age. The site located approximately 10 distinct types of plantations. In total, we documented 1,723 plants across a 22.84-hectare area, each displaying a unique age pattern showed in Table 4.

Table 4. Data by using Tree census App.

Tree Species	Height (m)	Girth (cm)	Canopy cover	Age	Tree Condition	Latitude: Longitude:	Individual tree species
Anjan	11.49	54.97	Uncrowded	30	Healthy	20^{0}70’87”N 77^{0}04’95”E	553
Neem	4.69	51.93	Uncrowded	25	Healthy	20^{0}42’27”N 77^{0}03’08”E	194
Karanj	4.47	49.42	Dense	25	Healthy	20^{0}70’84”N 77^{0}04’87”E	102
Wood Apple& Bael	3.79	26.76	Uncrowded	30	Healthy	20^{0}70’84”N 77^{0}04’83”E	95
Teak	11.59	50.37	Dense	28	Healthy	20^{0}42’38”N 77^{0}02’51”E	344
Lemon	5.84	47.56	Dense	25	Healthy	20^{0}42’35”N 77^{0}02’59”E	37
Karonda	1.52	33.10	Dense	12	Healthy	20^{0}42’35”N 77^{0}02’58”E	117
Tamarind	9.61	103.9	Dense	30	Healthy	20^{0}42’36”N 77^{0}02’55”E	44
Aonla	9.25	51.47	Dense	25	Healthy	20^{0}42’22”N 77^{0}02’54”E	47
Custard Apple	3.9	19.55	Uncrowded	15	Healthy	20^{0}42’28”N 77^{0}03’02”E	190
Total							1723

4.1.2 Tree height and girth at breast height (GBH)

The tree growth observations were recorded as a basic reference to understand of the condition of tree plantations and presented in Table 5. The tree species vary considerably in their growth pattern. The present study looks into growth pattern of Ten different plantations. The 28-year-old Teak plantation accumulated maximum mean height (11.59 m) followed by 30-year-old Anjan plantation recorded (11.49m) and least was found in12-year-old karonda (1.52m) presented in Figure 1.

Dense plantation of teak can affect both girth and height. In a dense plantation, competition for resources like sunlight, nutrients, and water can lead to slower growth in height but potentially increased girth due to competition-induced stress, promoting radial growth. However, the specific effects may vary based on soil quality, climate, and management practices. The teak plantation has high density than other different tree species and hence teak has maximum mean height.

The findings indicate in Table 5. Tamarind at 30 years of age, exhibited the maximum mean Girth at Breast Height (GBH) measuring 103.9 cm, followed by Anjan (54.97 m) following at 30 years of age and minimum girth at breast height was recorded in Custard Apple (19.55cm). It is important to note that both tree height and GBH are growth parameters significantly influenced by the site conditions and the distinct growth behavior of various tree species showed in Figure 2. Previous studies (FSI, 1996; Jha, 1999; Kiyono *et al*., 2010) have reported a correlation between tree volume and biomass with tree diameter and height, indicating that these aspects are interdependent (Bohre *et al*., 2013).

4.1.3 Basal area of different tree species

The recorded data of basal area of different tree species is presented in Table 5. The study observed the highest basal area, measuring 51.25 m^2/ha, in the 30-year-old Anjan plantation, closely followed by Wood Apple at the same age with a basal area of 44.55 m^2/ha. In contrast, the lowest basal area, 3.4 m^2/ha, was found in the 15-year-old Custard Apple plantation display in Figure 3. Additionally, Das (2016) estimated the basal area of *H. binate* in the same tree plantation and reported a measurement of 28.36 m^2/ha. The variations in basal area among different tree species could be attributed to genetic diversity, growth habits, age, spacing, and other factors.

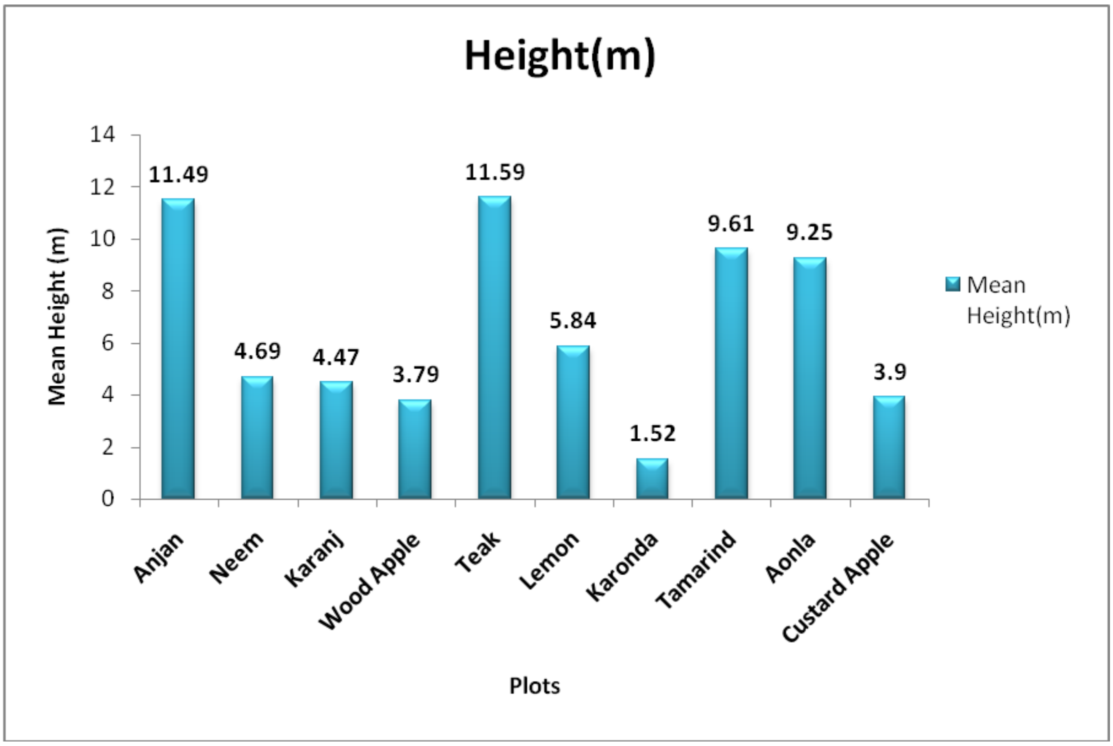

Figure 1: Height of different tree species

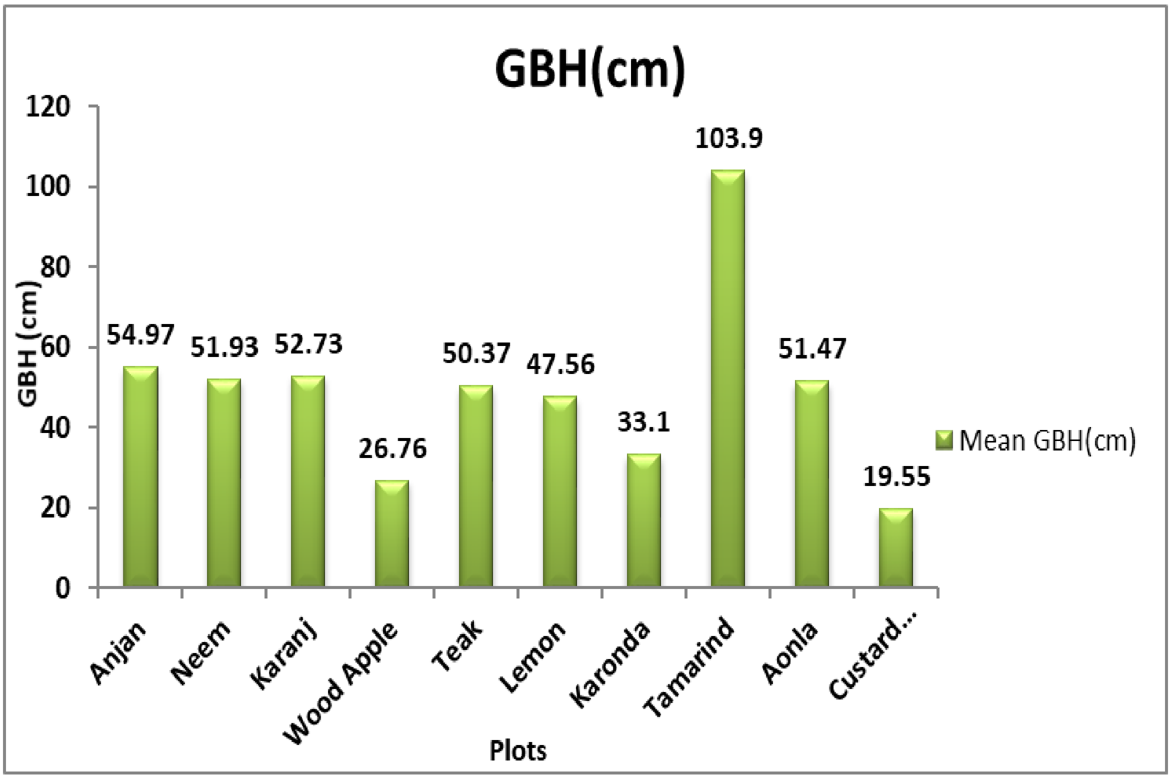

Figure 2: Girth at breast height of different tree species

Table 5. Growth performance of different tree Species at Agro Ecology and Environment Centre, Dr. PDKV Akola.

Tree Species	Girth (cm)	Height (m)	Basal area (m^2)/ha	Volume estimation (m^3)/ ha
Anjan	54.97	11.49	51.25	389.25
Neem	51.93	4.69	18.42	50.75
Karanj	52.73	4.47	17.97	50.25
Wood Apple	26.76	3.79	44.55	103.5
Teak	50.37	11.59	33.25	245.75
Lemon	47.56	5.84	7.5	25.25
Karonda	33.10	1.52	16.22	9.25
Tamarind	103.9	9.61	22.5	136.75
Aonla	51.47	9.25	12.6	74
Custard Apple	19.55	3.96	3.4	6.00

4.1.4 Volume of different tree species

To assess the condition of tree plantations, tree volume was recorded as a fundamental reference. These tree species exhibit significant variations in their growth patterns. To estimate tree volume, utilized growth parameters such as basal area, total tree height, and form factor, with the data summarized in Table 5. The results indicated in Figure 4, reveal that the highest volume, at 389.25 m^3/ha, was observed in the 30-year-old Anjan plantation, followed by Teak at 28 years with a volume of 245.75 m^3/ha. In contrast, the lowest volume, measuring 6.00 m^3/ha, was recorded in the 15-year-old Custard Apple plantation. Importantly, our findings align with similar studies conducted by Satheesan *et al*. (2016) and Chauhan *et al.* (2019).

4.2 Biomass different tree species

The production of biomass within a system is a reflection of the potential growth of its vegetation components, influenced by factors such as the environment, the number and types of constituent species, their age, and management practices (Swamy and Puri, 2006). The table presented in this

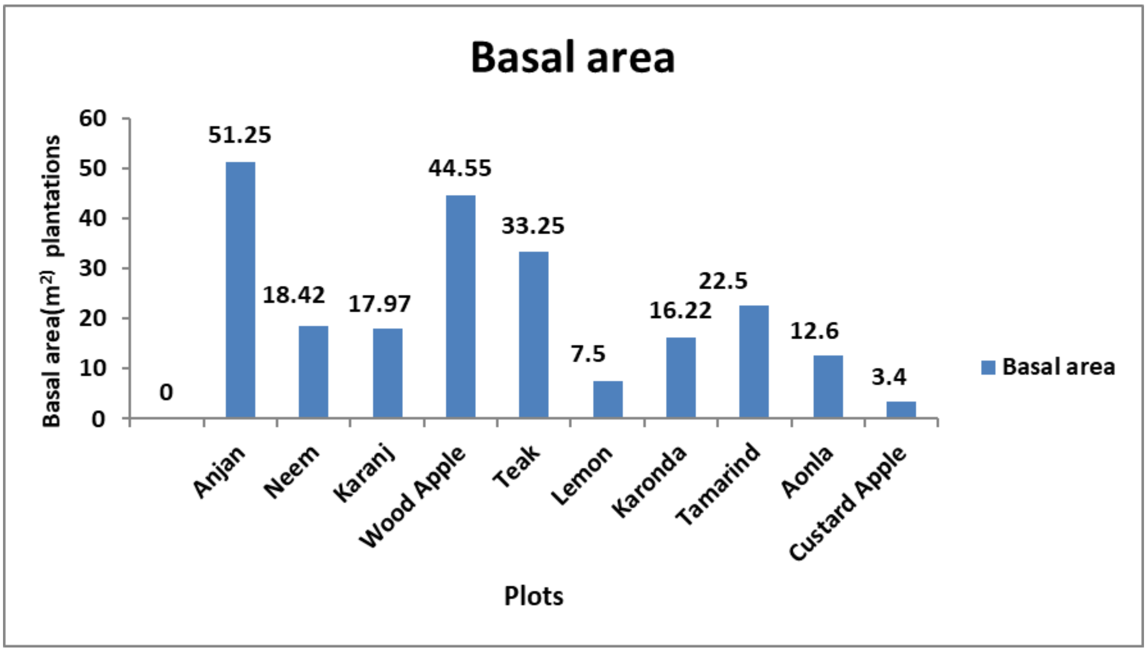

Figure 3: Basal area of different tree species

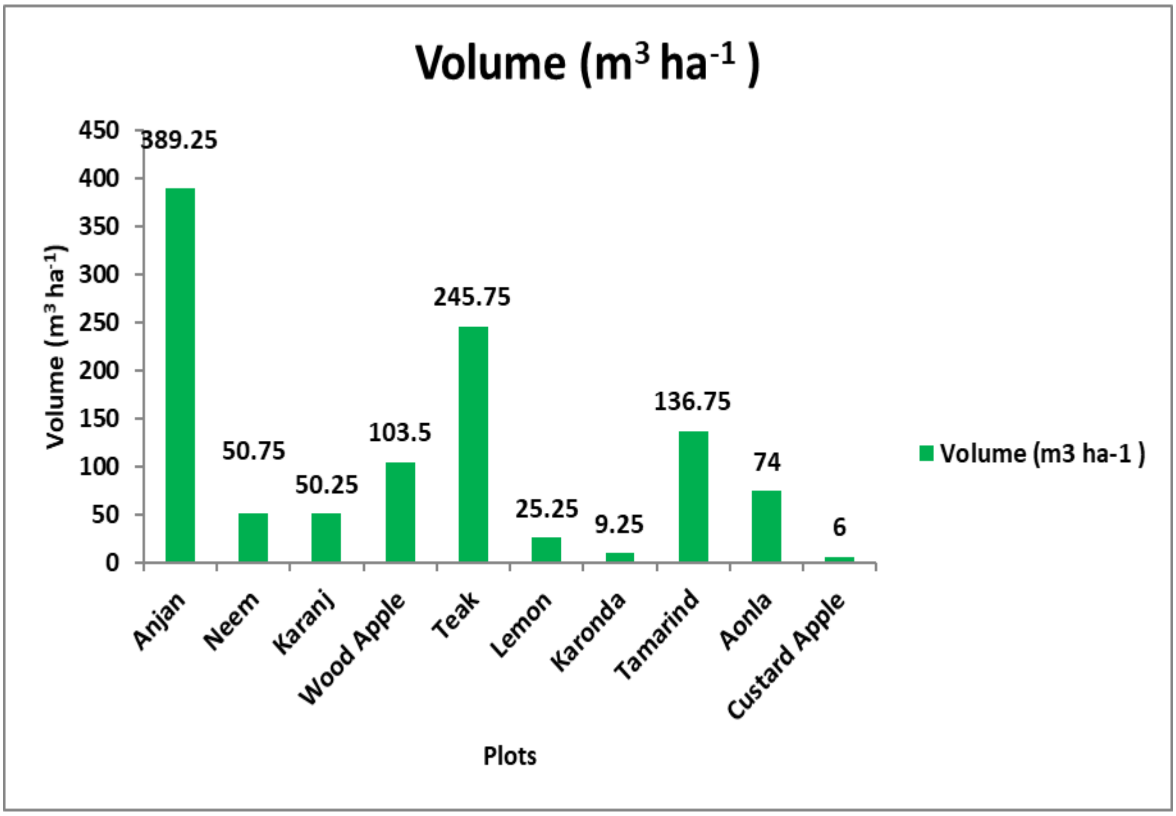

Figure 4: Volume of different tree species

study demonstrate that the environment has a significant impact on all biomass components, including above-ground, below-ground, and the total biomass.

Table 6. Biomass estimation and carbon sequestration of different tree species at Agro Ecology and Environment Centre, Dr. PDKV Akola.

Biomass						Carbon sequestration		
Tree Species	**Age (Years)**	**Girth (cm)**	**AGB (t/ha)**	**BGB (t/ha)**	**Total biomass (t/ha)**	**Carbon AGB/2 (t/ha)**	**Carbon BGB/2 (t/ha)**	**Total carbon (t/ha)**
Anjan	30	54.97	76.5	20	96.5	38.3 (79.37 %)	10.00 (20.72 %)	48.25
Neem	25	51.93	62.75	16.25	79	31.4 (79.49%)	8.13 (20.58%)	39.5
Karanj	25	52.73	55	14.25	69.25	27.5 (79.71%)	7.13 (20.66 %)	34.5
Wood Apple	30	26.76	16.75	4.25	21	8.4 (80%)	2.13 (20.28 %)	10.5
Teak	28	50.37	116.75	31	147	58.4 (79.45%)	15.50 (21.08 %)	73.5
Lemon	25	47.56	42	10.75	52.75	21.0 (80%)	5.38 (20.49 %)	26.25
Karonda	12	33.10	56	14.5	70.5	28.0 (79.43%)	7.25 (20.56 %)	35.25
Tamarind	30	103.9	59.75	15.5	75.25	29.9 (79.73 %)	7.75 (20.66%)	37.5
Aonla	25	51.47	43.25	11	54.25	21.6 (80 %)	5.50 (20.37 %)	27
Custard Apple	15	19.55	9.75	2.5	12.5	4.9 (78 %)	1.25 (20 %)	6.25

AGB= Above Ground Biomass, BGB= Below Ground Biomass.
*Figures in Parentheses are given in % of total carbon of Biomass

4.2.1 Aboveground biomass of different tree species

The data regarding aboveground biomass is presented in Table 6. Showed the impact of tree plantations on this specific biomass component. Teak exhibited the highest accumulation of aboveground biomass, reaching 116.75 (t/ha) at 28 years of age, however Anjan closely followed with an accumulation of 76.5 (t/ ha) at 30 years of age Figure 5. This disparity in aboveground biomass among the selected species in this study can be attributed to differences in the relative distribution of total biomass across various tree components, which are influenced by growth habits, clean bole length, rooting patterns, and age variations.

In the present investigation Teak achieved the highest above-ground biomass, totaling 116.75 (t/ha) at 28 years of age (Table 6). This can be attributed to improved access to essential nutrients, possibly due to the presence of abundant tertiary roots and root hairs, as indicated by Swamy *et al.* (2003). Their research suggested that in nutrient-rich soil, a greater allocation of biomass occurs in above-ground parts. Furthermore, Newaj *et al*. (2016) recommended utilizing equations from similar regions, when possible, to enhance the accuracy of estimating the above-ground biomass of tree species. Importantly, our study's findings align with those of earlier research conducted by Pandey *et al*. (1987), Cordeo and Kanninen (2003), Giri *et al*. (2014), and Nirala *et al.* (2018).

4.2.2 Belowground biomass of different tree species

The data presented in Table 6 examined the belowground biomass in plantations of different tree species. The findings revealed that Teak had the highest belowground biomass accumulation, reaching 31 (t/ha) at 28 years of age, followed closely by Anjan with 20 (t/ha) at 30 years of age and lowest belowground biomass was recorded in Custard Apple 2.5 (t/ha) showed in Figure 6. The elevated belowground biomass in Teak can be attributed to the high plantation density.

The belowground biomass production observed in our present study corresponds with the outcomes of several noteworthy previous research works. Notably, our results are in harmony with the investigations conducted by Newaj *et al*. (2016), Gupta *et al*. (2019), Giri *et al*. (2014), and Nirala *et al*. (2018). Collectively, these studies offer a robust and extensive foundation for comprehending belowground biomass production, underscoring the reliability and precision of our current findings.

4.2.3 Total biomass by different tree species

The data showed that total biomass can be found in Table 6. Teak recorded the highest total biomass, reaching 147 (t/ha) at 28 years of

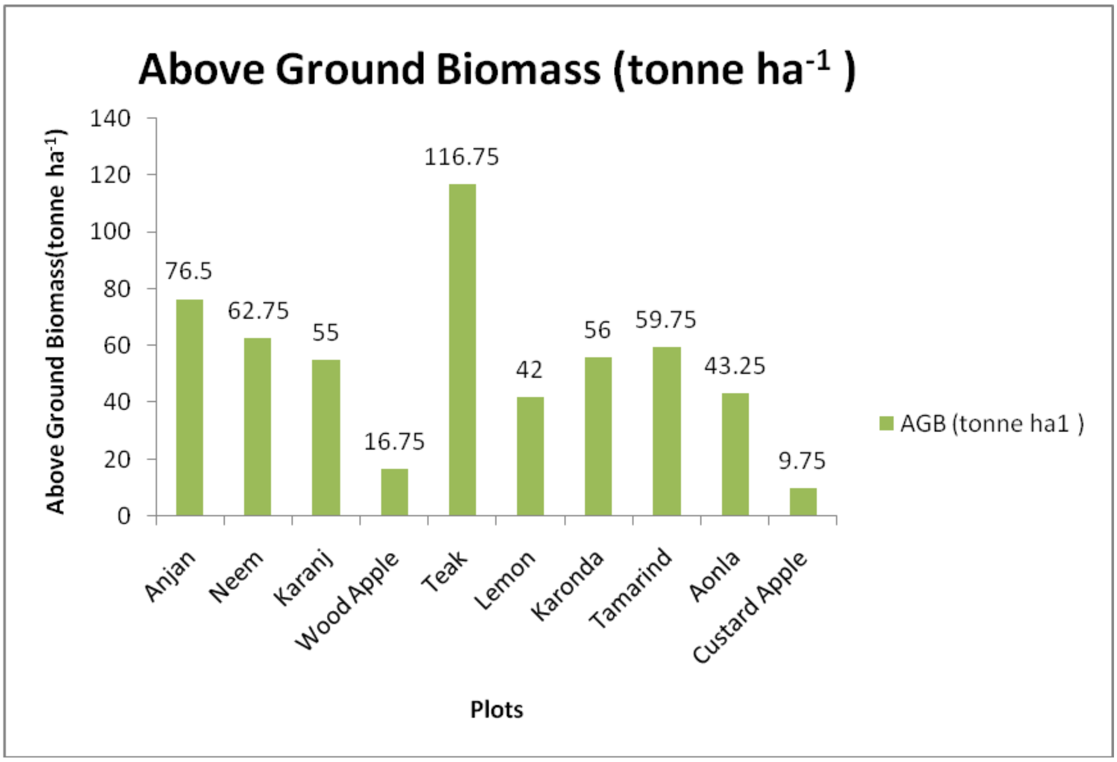

Figure 5: Aboveground biomass of different tree species

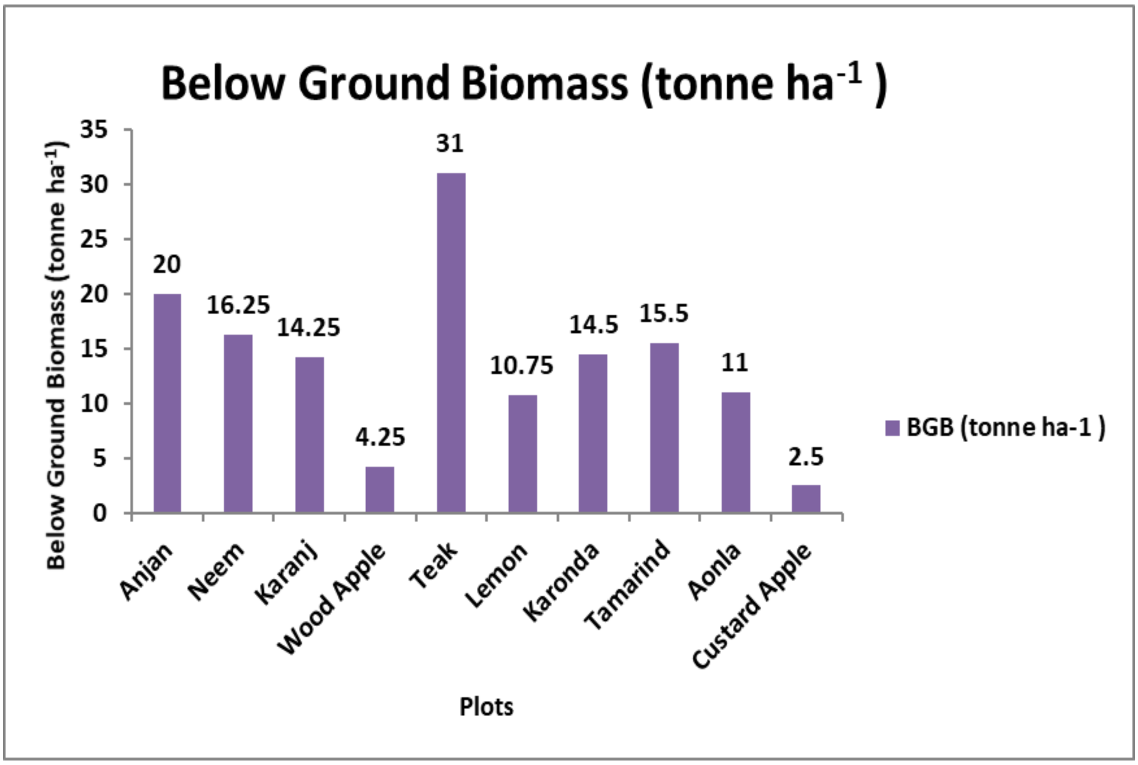

Figure 6: Belowground biomass of different tree species

age, followed closely by Anjan, which had a total biomass of 96.5 (t/ha) at 30 years of age Figure 7.

4.2.4 Total CO_2 sequestration by different tree species

The present study, assessed the carbon sequestration of various tree species and presented the results in Table 6. It was observed that Teak, at 28 years of age, sequestered the highest amount of carbon, totaling 73.5 (t/ha), followed by Anjan, (48.25t/ha) at 30 years of age. In contrast, the lowest carbon sequestration, measuring 6.25 (t/ha), was achieved by Custard Apple at 15 years of age. The above ground, below ground and total sequestrated carbon in per cent shown in figure 8.

While tree plantations effectively sequester carbon and contribute to reducing atmospheric carbon levels, their expansion is limited due to population pressure and the high demand for land in agriculture. Therefore, agroforestry systems emerge as a more viable option, offering the dual advantages of carbon sequestration and the opportunity for biodiversity conservation, while also benefiting society economically. This study's findings align with the research of Bohre *et al*. (2013) and Meshram *et al*. (2016), further supporting the potential of agroforestry systems.

4.4 Status of Soil Fertility of different tree species

4.4.1 Bulk density of soil

A comprehensive analysis of soil fertility status presented in Table 7. The result revealed significant variations in bulk density (BD) values among different tree species. The highest mean bulk density, (1.41 Mg m^{-3}), was observed under Aonla Plantation, followed by karonda and Karanj (1.40 Mg m^{-3}) with bulk density values increasing with soil depth. The increase in Bulk density can be attributed to greater clay content, soil compaction, and a decrease in organic carbon content in deeper soil layers depicted in Figure 9.

However the findings indicate that woody perennials within different tree species reduced soil bulk density. The mean bulk density of surface soils (0-15 cm) was the lowest at 1.35 Mg m^{-3}, gradually increasing with depth to a maximum of 1.38 Mg m^{-3} at 15-30 cm. This increase is primarily due to decreasing organic matter content and reduced aggregation with depth. Whereas reduced bulk density can be attributed to enhanced soil

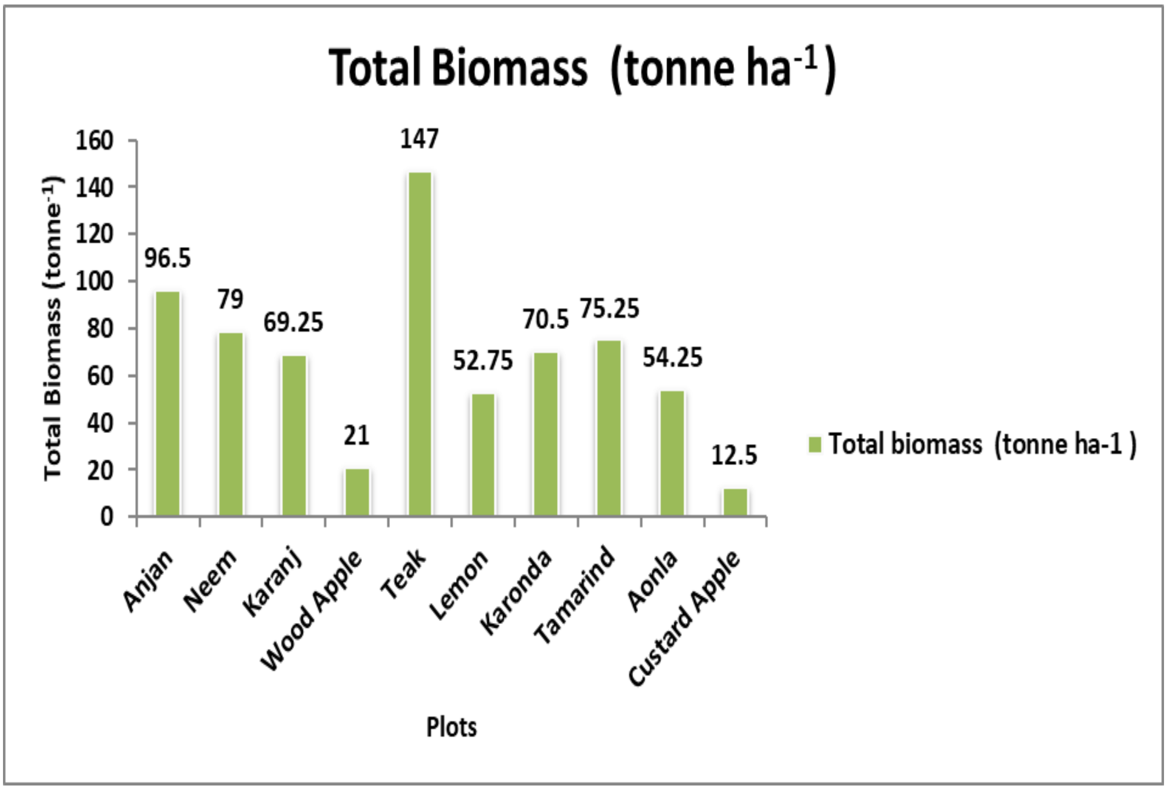

Figure 7: Total biomass under different tree species

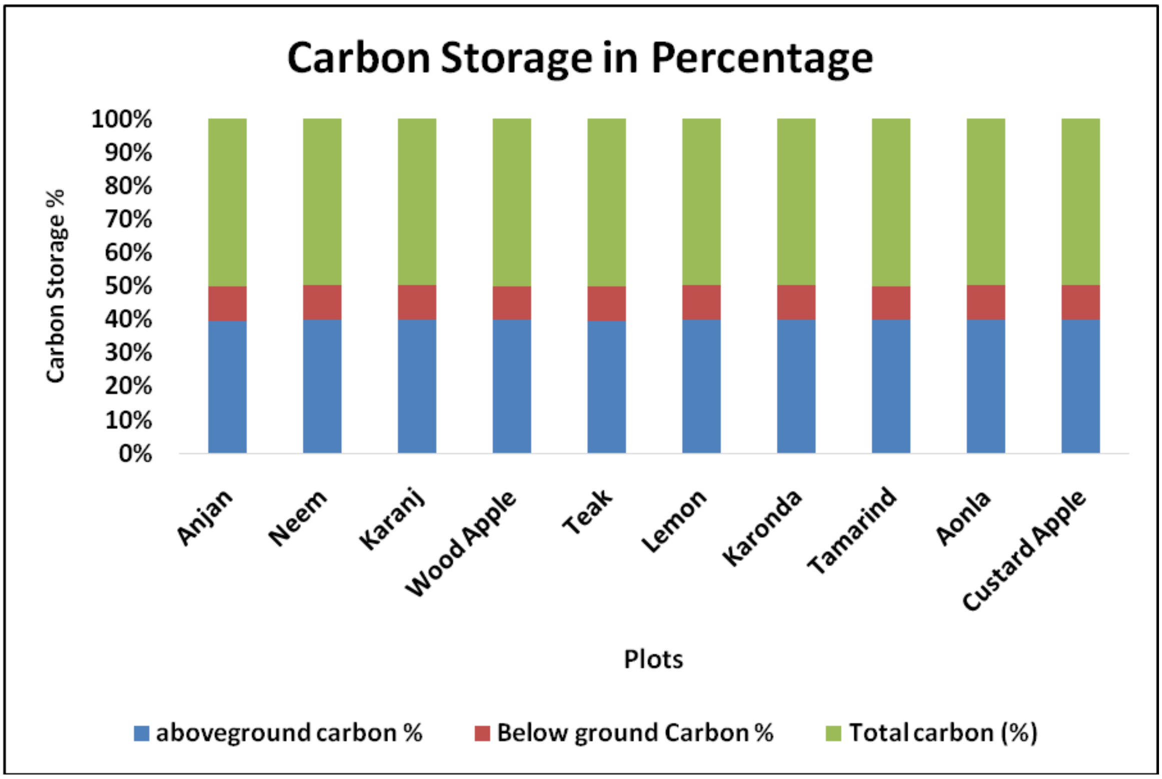

Figure 8: Above Ground carbon, below ground carbon and total carbon storage (%)

porosity and improved aggregation resulting from the decomposition of crop residues in the soil. These changes in bulk density are associated with improvements in soil properties driven by permanent vegetation, including roots, bio-pores, organic matter, fauna, and other biological processes, as well as management practices. These results are consistent with the findings of Sharma *et al*. (1995) and Stockfish *et al*. (1999).

4.3.2 pH and electrical conductivity of soil

The data on Ph and EC of soil under different tree species indicating in Table 7. That various tree species has a notable impact on soil pH levels. The highest pH value (8.0) was observed under Tamarind, followed by Wood Apple (7.9) and Teak (7.8), while Lemon exhibited the lowest pH value (7.3) illustrate in Figure 10.

Whereas the result on soil electrical conductivity (EC) recorded data in the same table shows that different tree species and soil depths influenced EC levels. The highest EC value (0.21 ds m^{-1}) was recorded under the Anjan species, while the lowest (0.11 dS m^{-1}) was observed under Neem. EC values across different soil depths (0-15 and 15-30 cm) ranged from 0.11 to 0.15 ds m^{-1} indicating a relatively low concentration of soluble salts. The variation in electric conductivity can be attributed to the significant litterfall under the tree plantations, particularly in the evergreen Anjan plantation, which experiences a substantial leaf litter fall it was summarized in Figure 11.

4.3.3 Organic carbon of soil

The present study also explored the impact of different tree plantations on soil organic carbon. Soil samples from two depths, 0-15 cm and 15-30 cm, were analyzed, with the results presented in Table 7. Interestingly, the highest organic carbon content (0.91%) was observed under Anjan, followed closely by Teak (0.84%), while the lowest organic carbon content (0.68%) was recorded under Custard Apple showed in Figure 12.

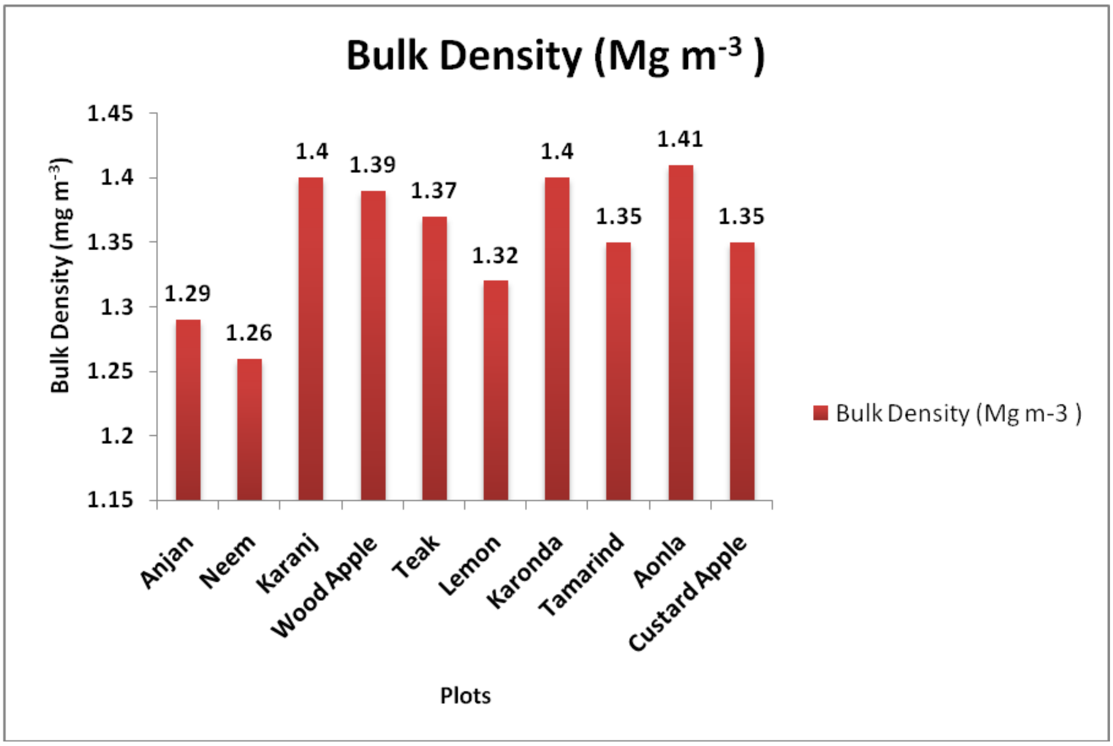

Figure 9:Bulk density of soil under different tree species

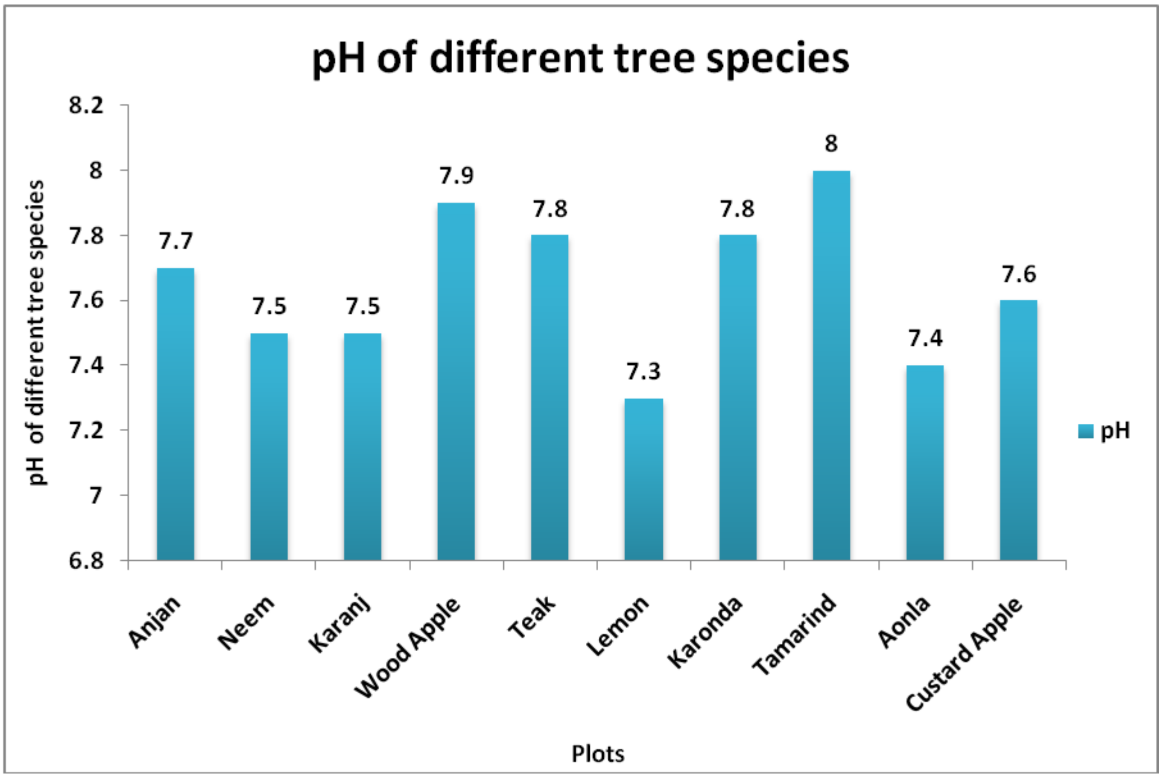

Figure 10:pHof soil under different tree species

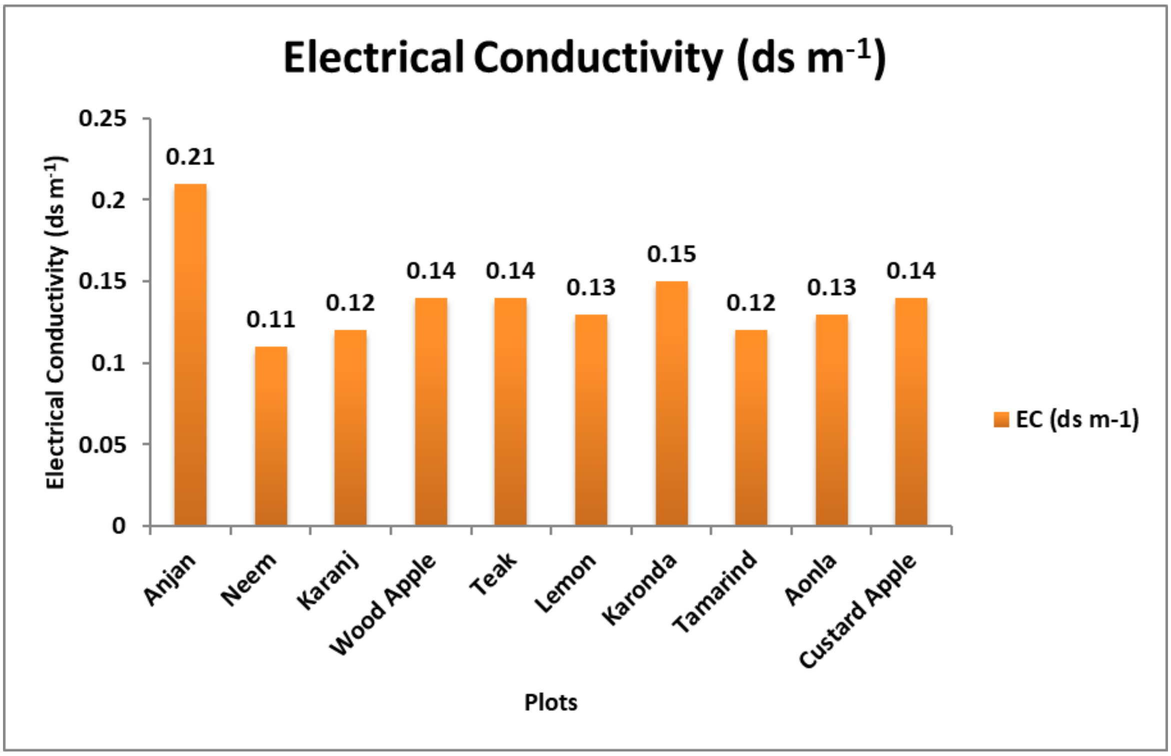

Figure 11: Electrical conductivity of soil under different tree species

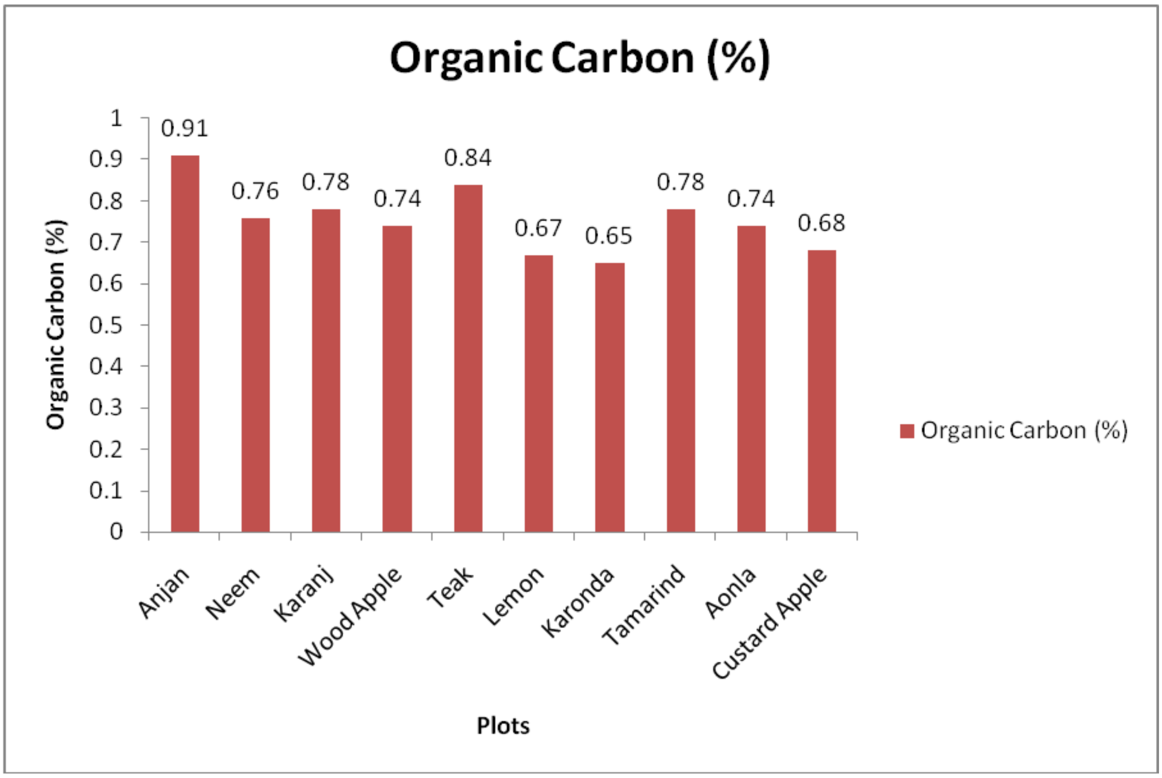

Figure 12:Organic carbon of soil under different tree species

Table 7. Status of Soil Fertility at Agro Ecology and Environment Centre, Dr. PDKV Akola.

Tree Species	pH			EC (ds m^{-1})			Bulk Density (Mg m^{-3})			Organic Carbon (%)		
	0-15 cm soil Depth	15-30 cm soil Depth	Mean	0-15 cm soil Depth	15-30 cm soil Depth	Mean	0-15 cm Soil Depth	15-30 cm Soil Depth	Mean	0-15 cm Soil Depth	15-30 cm Soil Depth	Mean
Anjan	7.6	7.9	7.7	0.19	0.23	0.21	1.28	1.30	1.29	0.92	0.90	0.91
Neem	7.4	7.6	7.5	0.10	0.12	0.11	1.39	1.41	1.26	0.79	0.73	0.76
Karanj	7.3	7.7	7.5	0.10	0.14	0.12	1.38	1.42	1.40	0.80	0.76	0.78
Wood Apple	7.8	8.0	7.9	0.12	0.17	0.14	1.37	1.41	1.39	0.76	0.72	0.74
Teak	7.7	7.9	7.8	0.11	0.16	0.14	1.36	1.39	1.37	0.85	0.83	0.84
Lemon	7.2	7.4	7.3	0.11	0.12	0.13	1.31	1.33	1.32	0.69	0.66	0.67
Karonda	7.7	7.9	7.8	0.12	0.18	0.15	1.38	1.42	1.40	0.67	0.64	0.65
Tamarind	8.0	8.1	8.0	0.10	0.11	0.12	1.34	1.37	1.35	0.80	0.77	0.78
Aonla	7.8	7.10	7.4	0.12	0.14	0.13	1.40	1.43	1.41	0.75	0.73	0.74
Custard Apple	7.4	7.9	7.6	0.11	0.16	0.14	1.34	1.37	1.35	0.70	0.66	0.68
Mean	**7.5**	**7.7**		**0.11**	**0.15**		**1.35**	**1.38**		**0.77**	**0.74**	
SD	**0.25**	**0.30**		**0.026**	**0.011**		**0.037**	**0.042**		**0.07**	**0.08**	
S.E. (m) ±	**0.08**	**0.09**		**0.11**	**0.16**		**0.032**	**0.013**		**0.024**	**0.025**	

The surface soil (0-15 cm) displayed a higher organic carbon content (0.77%) compared to the subsurface soil (15-30 cm) (0.74%).

Figure 12 indicated the accumulation of organic carbon in the upper soil layers is likely due to consistent litterfall deposition from tree species throughout their growth,

Which, over time, has contributed to increased soil organic matter content. This observation aligns with findings reported by Kumar *et al*. (1998), which emphasized an increase in organic carbon content under tree species due to the addition and decomposition of litterfall.

4.5 Floristic Diversity.

The phytosociological analysis of the Agro Ecology and Environment Centre, Dr. PDKV Akola, is shown in Table 8. The highest density was observed in the Teak plantation, with 310 per cent plants, followed by custard apple with 185 per cent plants in the same area. The lowest plant density was found in Tamarind, with only 55 per cent plants.

Table 8. Phytosociological analysis of plant species in Agro Ecology and Environment Centre, Dr. PDKV Akola

Tree Species	Density (%)	Frequency (tree/ha)	RF	RBA	RD	IVI
Wood Apple	125	10	10	0.195	0.083	10.278
Karanj	95	10	10	0.0788	0.063	10.1418
Anjan	170	10	10	0.224	0.11	10.334
Teak	310	10	10	0.146	0.2	10.346
Lemon	80	10	10	0.03	0.05	10.08
Karonda	185	10	10	0.071	0.12	10.191
Tamarind	55	10	10	0.098	0.03	10.128
Neem	175	10	10	0.08	0.11	10.19
Aonla	110	10	10	0.055	0.07	10.125
Custard Apple	185	10	10	0.015	0.12	10.135
Total	1490	100	100	0.9928	0.956	101.9488

D= Density, F= Frequency, RF= Relative Frequency, RBA=Relative Basal Area, RD= Relative Density, IVI= Important Value Index

The relative basal area of this site is presented in Table 8. The highest relative basal area was recorded in Anjan at 0.224, followed by Wood Apple at 0.195, while the lowest relative basal area was recorded in the Lemon plot at 0.03. Additionally, the important value index (IVI) of the site was recorded, with the highest IVI found in the Teak plot at 10.34, followed closely by the Anjan Plot at 10.33. The lowest IVI was found in the Lemon Plot at 10.08. Teak density was recorded high might be due to high density. (Kadiroo and Zeide, 2008). The frequency for each species was recorded as 10 per hectare.

CHAPTER V

SUMMARY AND CONCLUSION

The present investigation entitled "Tree census and assessment of carbon sequestration under different tree species at agro ecology and environment centre Dr. PDKV Akola" was carried out at Agro Ecology and Environment center Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra during 2022-23.

The investigation is being conducted with the following objectives:

1. To identify tree species at Agro Ecology and Environment Centre
2. To study floristic diversity and soil fertility under different tree species
3. To estimate carbon storage under different tree species

For study of tree productivity and biomass ten sample plots of 20 m x 20 m size were laid down under selected different tree species. In each sample plot one sub-plot of size 1 m x 1 m was mark for collection of soil samples at two different depth (0-15 cm and 15-30 cm).

The observations were recorded on phytosociology viz., basal area, volume, aboveground, belowground and total biomass, standing carbon of trees. Soil samples were analyzed for soil determination of its physico-chemical and biological properties viz., pH, electrical conductivity, bulk density, OC evolution.

A brief summary of the results emerging out from present investigation are presented as below:

5.1 Tree growth parameters

5.1.1Tree Census

The highest number of plants occurred in Anjan Plot about 553 plant species. This species was very important for fodder purpose because of *Hardwickia binata* was evergreen in nature they provide highly nutritive fodder for animal. All about 1723 Plant occurred at Agro Ecology and Environment Centre, Dr. PDKV Akola. It helps to improving the air quality of Akola city by sequestration of carbon dioxide and this tree provides shelter to various birds and animal its helps to maintain ecological balance of nature.

5.1.2 Mean height and girth (GBH)

The maximum mean height (11.59 m) was found in Teak plantation followed by Anjan (11.49 m) plantation, and the minimum mean height was recorded in karonda (1.52 m) also the mean girth at breast height was found to be in Tamarind plantation (103.9 m) followed by Anjan plantation (54.97 cm), whereas as the minimum mean girth at breast height was recorded in Custard Apple (19.55 cm).

5.1.3 Basal area of different tree species

The highest basal area was recorded in Anjan 51.25 m^2/ha followed by wood Apple 44.55m^2/ha. whereas the lowest basal area 3.4 m^2/ha was observed in Custard Apple.

5.1.4 Volume of different tree species

The maximum 389.25m^3/ha volume was recorded in Anjan, followed by Teak 245.75m^3/ha, while in Tamarind and Wood Apple, it was recorded 136.75 m^3/ha and 103.5m^3/ha respectively.

5.2 Above ground biomass

The highest Above ground biomass was recorded in Teak 116 (t/ha), followed by Anjan 76.5(t/ha). Whereas the minimum Above ground biomass was observed in Custard Apple 9.75 (t/ha).

5.3 Below ground biomass

In the present study the highest belowground biomass was observed in Teak 31(t/ha), followed by Anjan 20(t/ha). whereas the lowest belowground biomass was recorded in Custard Apple 2.5(t/ha).

5.4 Total biomass by different tree species

The minimum 12.25 (t/ha) total standing tree biomass was found in Custard Apple, whereas Highest Biomass was observed in 147(t/ha) in Teak, Followed by Anjan 96.5(t/ha).

5.5 Total carbon sequestrated by different tree species

The highest 73.5 (t/ha) total standing tree carbon stock was found in Teak, followed by Anjan 48.25(t/ha), whereas minimum 6.25(t/ha) total standing tree carbon stock was found in Custard Apple.

5.6Status of soil fertility of different tree species

5.6.1 Bulk density (BD)

The mean bulk density, in general was found to range from 1.35 to 1.38 Mg m^{-3} under different tree species. The bulk density of the soils under 10 different tree species types followed the order of Aonla (1.41 Mg m^{-3}) > Karonda (1.40 Mg m^{-3}) > karanj (1.40 Mg m^{-3}) > Wood Apple (1.39 Mg m^{-3}) plantation.

5.6.2 Soil pH and electrical conductivity (EC)

The soil under different tree species was neutral to slightly basic in reaction (7.5-7.7). Maximum (8.0) pH was observed under Tamarind followed by Wood Apple (7.9). Soil pH under the plantation increase with increased the depth (0-15 to 15-30 cm), whereas mean electrical conductivity was normal and ranged from 0.11to 0.15 dSm^{-1}. It increased with increased the depth from 0-15 cm and 15-30 cm.

5.6.3 Soil organic carbon (OC)

The organic carbon under Anjan plantation (0.91 %), was found higher than Teak (0.84 %), Karanj (0.74) plantation respectively. As per rating point of O.C. %, the soil of all the plantations comes under very high O.C. content.

5.7 Floristic Diversity

The phytosociological analysis of the Agro Ecology and Environment Centre, Dr. PDKV Akola, is presented. Plant density varied across different species in an area, with the highest density observed in the Teak plantation, totaling 310 per cent. Following this, the custard apple exhibited a density of per cent plants in the same area, while Tamarind had the lowest plant density, with only per cent plants. The highest relative basal area was recorded in Anjan at 0.224, followed by Wood Apple at 0.195. In contrast, the Lemon plot had the lowest relative basal area, which was measured at 0.03. Furthermore, the important value index (IVI) of the site was determined. The Teak plot exhibited the highest IVI at 10.346, closely followed by the Anjan Plot at 10.334. In contrast, the Lemon Plot had the lowest IVI, with a value of 10.08.

5.8 Conclusions

The extensive study carried out at the Dr. PDKV Akola Agro Ecology and Environment Centre, involving a variety of tree species, clarifies the complex relationships between soil properties and vegetation.Variations in tree parameters, including tree census, mean height, girth, basal area, tree volume, total biomass, and carbon sequestration, indicate the influence of tree density, composition, and structure on the overall ecosystem dynamics within the plantation. The Anjan Plantation showed highest number of individual trees (553) followed by Teak plantation (344). whereas Teak plantation indicated maximum canopy cover among the different tree species plantation.

Teak Plantation takes the lead in terms of biomass (147t/ha) and carbon sequestration (73 t/ha) contributing to improved soil fertility. It is important to note that the leaf area significantly affects a plant's ability to sequester carbon. Leaves play a vital role in photosynthesis, where they absorb carbon dioxide and convert it into organic compounds, primarily carbohydrates, storing carbon in the plant's biomass. A larger leaf area facilitates greater photosynthesis and, consequently, higher carbon sequestration. Healthy, leafy canopies, like those found in Teak trees, enhance carbon sequestration. On the other hand, Custard Apple showed the lowest values for biomass (12.5 t/ha) and carbon sequestration (6.25 t/ha) among the tree species.

The research also examines soil parameters, revealing crucial links between vegetation and soil characteristics such as soil pH, electrical conductivity (EC), bulk density (BD), and organic carbon (OC) ranges (0.74%) to (0.77%) in plantations. The consistent soil pH values suggest neutral to alkaline conditions. Low EC levels indicate low soluble salt concentrations, and higher bulk density in sub-surface horizons suggests soil compaction.

Among the ten tree species studied, Teak plantation holds the highest Importance Value Index at 10.34, while Lemon has the lowest index at 10.08. This information highlights the importance of promoting various tree species to enhance carbon sequestration and soil fertility, ultimately contributing to the long-term health and resilience of the ecosystem.

CHAPTER VI

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APPENDIX

Appendix -I Different tree species Identified during survey at Agro Ecology and Environment Centre, Dr. PDKV Akola.

Common name	Botanical name	Family	Purpose
Anjan	*Hardwickia binata*	Fabaceae	Soil reclamation
Neem	*Azadirachta indica*	Meliaceae	Medicinal purpose
Karanj	*Pongamia pinnata*	Fabaceae	Aesthetic
Wood Apple	*Limonia acidissima*	Rutaceae	Timber
Teak	*Tectona grandis*	Lamiaceae	Medicinal purpose
Lemon	*Citrus aurantifolia*	Rutaceae	Medicinal purpose
Karonda	*Carissa carandas*	Apocynaceae	Medicinal purpose
Tamarind	*Tamarindus indica*	Fabaceae	Medicinal purpose
Aonla	*Phyllanthus emblica*	Phyllanthaceae	Medicinal, Fencing Purpose
Custard Apple	*Annona squamosa*	Annonaceae	Medicinal Purpose