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MINI PROJECT ON

ESTIMATION OF SPECIES DIVERSITY AND ON CAMPUS SEQUESTRATION

Report submitted in partial fulfilment of curriculum
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BACHLOR OF ENGINEERING
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By

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CERTIFICATE

This is to certify that the work entitled "ESTIMATION OF SPECIES DIVERSITY AND ON CAMPUS SEQUESTRATION (JSSSTU CAMPUS)" is a bonafide work carried out by SACHIN R S –(01JCE21EV032), VISHNU –(01JCE21EV049), SRINIDHI KUMAR R –(01JCE21EV043) in Partial fulfillment for the award of the Degree of BACHELOR OF ENGINEERING IN ENVIRONMENTAL ENGINEERING of Sri Jayachamarajendra College of Engineering, JSS Science and Technology University, Mysuru,during the year 2024. It is certified that all corrections / suggestions indicated during CIE havebeen incorporated in the report. The project report has been approved as it satisfies the academic requirements in respect of project work prescribed for the Bachelor of Engineering degree.

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ABSTRACT

The study Evaluation of On-Campus Carbon Sequestration for a Sustainable Future, investigates the role of campus green cover in carbon sequestration as a means to enhance sustainability. The research aims to quantify the percentage of green cover, assess species diversity, and understand the mechanisms of carbon dioxide uptake and storage in plants. Through a comprehensive literature survey and empirical data collection, the project assesses the percentage of green cover, identifies species diversity, and examines the process of carbon dioxide uptake and storage in plants. The methodology involves calculating Above-Ground Biomass (AGB) and Below-Ground Biomass (BGB) using tree diameter and height measurements to estimate carbon sequestration. The project underscores the importance of maintaining and expanding green spaces to enhance the ecological footprint and sustainability of the campus. Recommendations include tree planting initiatives, eco-friendly transportation, and community involvement to ensure the long-term success of greening efforts. This study contributes to environmental conservation efforts by providing valuable insights into urban green space management and carbon sequestration

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CHAPTER 1

Introduction

1.1 General:

Carbon dioxide is a heat trapping gas produced both in nature and by human activities. Man-made sources of carbon dioxide come from the burning of fossil fuels such as coal, natural gas and oil for uses in power generation and transportation. Carbon dioxide is also released through land use changes, biologically through oceans, the decomposition of organic matter and forest fires. The build-up of carbon dioxide and other greenhouse gases in the atmosphere can trap heat and contribute to climate change.

Learning how to capture and store carbon dioxide is one-way scientists want to defer the effects of warming in the atmosphere. This practice is now viewed by the scientific community as an essential part of solving climate change.

1.2 Carbon Sequestration:

Carbon sequestration secures carbon dioxide to prevent it from entering the Earth's atmosphere**.** The idea is to stabilize carbon in solid and dissolved forms so that it doesn't cause the atmosphere to warm. The process shows tremendous promise for reducing the human "carbon footprint." There are two main types of carbon sequestration: biological and geological.

1.3 The Role of Forests in Climate Change Mitigation:

Forests play a crucial role in the global carbon cycle by absorbing carbon dioxide (CO_2) through photosynthesis, functioning as terrestrial carbon sinks. Trees store large amounts of carbon in their biomass, encompassing roots, stems, branches, and leaves, sequestering CO_2 long-term.

Forests vary in carbon storage capacity depending on tree species, site conditions, and disturbance patterns. While some forests store carbon for centuries, others release it through frequent fires. Harvested forests can retain carbon in products like lumber, though only a portion remains in durable goods

. Mixed species plantations enhance carbon storage and offer additional benefits, such as biodiversity. Bamboo plantations sequester carbon faster than mature forests, highlighting their potential in carbon sequestration efforts.

1.4 Recent Extreme Climate Scenarios and Global Environmental Impact:

Recent times have witnessed extreme climate scenarios and their unprecedented impacts on the environment globally. These include record rains in Australia, a killer heat wave setting new records in the UK and Europe, wildfires in the US and Europe, snow avalanches in the Italian Alps, floods in Iran, and excessive floods in many cities of India.

These varied natural catastrophes have highlighted the excessive environmental degradation resulting from human intervention and abuse of nature. The past year has seen an enhanced focus and multiple initiatives aimed at addressing climate change. Key events include the United Nations Climate Change Conference (COP 26), the UN Climate and SDG Synergies Conference held in Tokyo, and various climate change workshops and seminars. These efforts demonstrate the visible commitment of both governmental and non-governmental institutions toward improving the climate scenario.

1.5 Objectives:

1.5.1 Main objective:

To present study aim at assessing land use pattern for university campus (JSSSTU) and calculating species diversity and sequestration of carbon dioxide.

1.5.2 Specific objectives:

- To carry out literature survey
- To assess the percentage of green cover and assess species diversity
- To understand the mechanism involved in uptake of gases (predominantly carbon dioxide), its storage and impact plant on growth
- Estimating carbon di-oxide sequestration using biomass method

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The increasing concern over climate change and the imperative need for sustainable practices have spurred interest in the potential of urban green spaces, particularly university campuses, to sequester carbon dioxide (CO_2). This literature review examines the existing body of research on carbon sequestration in university campuses, with a focus on assessing land use patterns, species diversity, carbon uptake mechanisms, and estimation methods.

2.2 Quantifying Carbon Sequestration on Campus

Cox (2012) conducted a sustainability initiative at a university campus to quantify the carbon sequestration potential of its trees. The study employed a combination of field measurements and allometric equations to estimate the biomass and carbon storage of individual trees. By extrapolating these findings to the entire campus tree population, the study revealed a significant contribution to carbon sequestration, highlighting the potential of campus trees as a valuable carbon sink.

Similarly, Saral et al. (2017) investigated carbon storage and sequestration by trees on the VIT University campus. The study utilized a non-destructive sampling method to assess the biomass and carbon content of different tree species. The findings underscored the role of campus trees in mitigating CO_2 emissions and emphasized the importance of species selection and planting strategies to maximize carbon sequestration.

2.3 Land Use Patterns and Species Diversity

Cox (2012) conducted a sustainability initiative at a university campus to quantify carbon sequestration by campus trees. The study involved assessing the land use pattern of the campus, identifying tree species, and measuring their diameter at breast height (DBH). The findings revealed a significant contribution of trees to carbon sequestration, highlighting the importance of maintaining and enhancing tree cover on campuses.

Saral et al. (2017) investigated carbon storage and sequestration by trees on a university campus in India. The study assessed the species diversity of trees, their DBH, height, and biomass. The results demonstrated the substantial potential of trees to store carbon and emphasized the role of species selection and planting strategies in maximizing carbon sequestration.

These studies underscore the significance of understanding land use patterns and species diversity in evaluating the carbon sequestration potential of university campuses. A comprehensive inventory of trees, including their species, size, and distribution, is essential for accurate estimation and management of carbon stocks.

2.4 Carbon Uptake Mechanisms and Impact on Plant Growth

The process of carbon sequestration in trees involves the uptake of CO_2 from the atmosphere through photosynthesis, its conversion into carbohydrates, and storage in various plant tissues, such as wood, leaves, and roots. The amount of carbon sequestered depends on several factors, including tree species, age, size, growth rate, and environmental conditions.

Reyes (1992) compiled data on wood densities of tropical tree species, highlighting the variation in carbon storage capacity among different species. Trees with higher wood density tend to store more carbon per unit volume, emphasizing the importance of species selection in maximizing carbon sequestration.

The impact of carbon uptake on plant growth is a complex phenomenon. While increased CO_2 concentrations can enhance photosynthesis and potentially stimulate growth, other factors, such as nutrient availability, water stress, and temperature, also play crucial roles. Furthermore, the long-term effects of elevated CO2 on tree growth and carbon storage are still under investigation.

Understanding the mechanisms involved in carbon uptake, storage, and impact on plant growth is crucial for developing effective strategies to enhance carbon sequestration in university campuses. This knowledge can inform decisions regarding tree species selection, planting density, and management practices.

2.5 Estimating Carbon Dioxide Sequestration

Several methods have been employed to estimate carbon dioxide sequestration in trees. One common approach is the biomass method, which involves measuring tree biomass and using conversion factors to estimate the amount of carbon stored. The biomass can be estimated through direct measurements of tree dimensions or using allometric equations that relate tree dimensions to biomass.

Bremer et al. (2020) engaged undergraduate students in a project to estimate carbon sequestration in a campus forest. The project involved measuring tree DBH, height, and species, and using allometric equations to estimate biomass and carbon storage. This hands-on experience provided students with valuable insights into the process of carbon sequestration and its importance for sustainability.

The accuracy of carbon sequestration estimates depends on the chosen method, the quality of data, and the underlying assumptions. The biomass method, while widely used, has limitations due to the variability in biomass equations and potential errors in tree measurements. Other methods, such as eddy covariance and remote sensing, offer alternative approaches but may require specialized equipment and expertise.

2.6 Need and Implications for the Present Study

The literature reviewed here underscores the growing interest in leveraging university campuses as sites for carbon sequestration research and implementation. Existing study demonstrate the feasibility of quantifying carbon sequestration on campuses, emphasize the importance of land use assessment, species diversity, and robust estimation methodologies.

The present study will build upon this knowledge base by evaluating the land use patterns and carbon sequestration potential of the JSSSTU campus. By assessing species diversity, quantifying biomass, and employing appropriate estimation methods, this study aims to provide valuable insights for enhancing carbon sequestration efforts on campus. The findings will not only contribute to the university's sustainability goals but also serve as a model for other institutions seeking to optimize their carbon sequestration strategies.

CHAPTER 3

METHODOLOGY

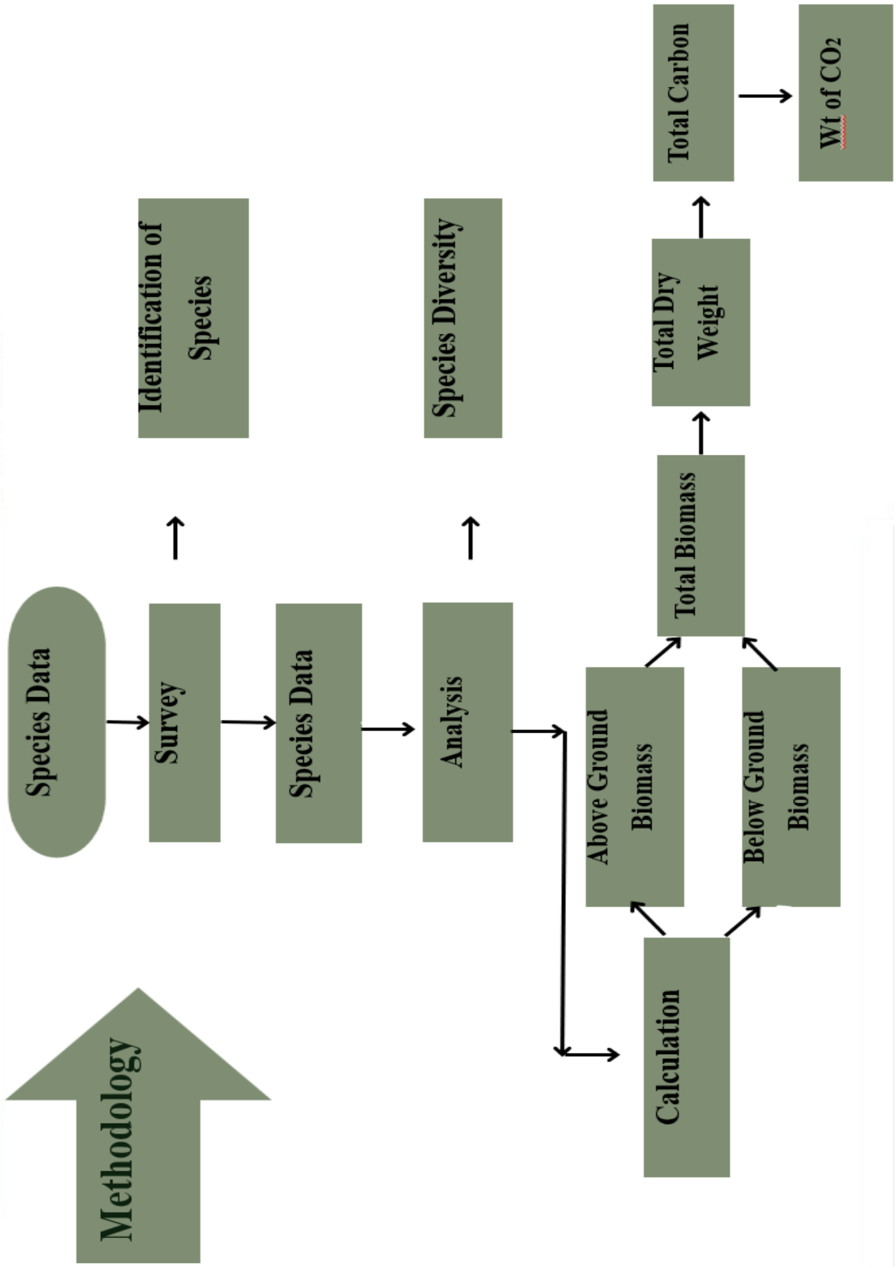

Fig: 3.1 Flow Chart Representing the methodology designed for present study

The study utilized a refined methodology to estimate the carbon sequestration potential of the JSSSTU university campus, specifically employing the biomass method. This approach involves a multi-faceted assessment of the campus tree population, incorporating field surveys, species identification, biomass calculation, and carbon content analysis. The detailed methodology is outlined below:

3.1 Comprehensive Tree Survey and Species Identification:

- **Detailed inventory:** A meticulous survey of the entire campus was conducted, ensuring the inclusion of all trees, irrespective of size or location. Each tree was assigned a unique identifier for reference and tracking purposes.
- **Accurate species identification:** Botanical keys, field guides, and expert consultation were utilized to accurately identify each tree species. This step is crucial as different species exhibit varying growth rates, biomass accumulation, and carbon storage capacities.

3.2 In-Depth Species Data Analysis and Diversity Calculation:

- **Species-specific characteristics:** The collected species data was analyzed to determine not only the diversity indices (Shannon-Wiener, Simpson's) but also species-specific characteristics such as average height, diameter, and growth patterns. This information aids in understanding the contribution of each species to the overall carbon sequestration potential.
- **Ecological implications:** The diversity analysis provides insights into the ecological health and resilience of the campus ecosystem, which indirectly influences carbon sequestration. A diverse tree population is generally more resilient to pests, diseases, and environmental stressors, ensuring sustained carbon uptake over time.

3.3 Rigorous Biomass Estimation using Allometric Equations:

- **Species-specific allometric equations:** For each identified tree species, appropriate allometric equations were selected from published literature. These equations establish mathematical relationships between easily measurable tree dimensions (e.g., DBH, height) and their corresponding biomass.
- **Accurate measurements:** Precise measurements of DBH and height were taken for each tree using standard forestry tools. These measurements were then input into

the species-specific allometric equations to calculate the above-ground biomass for each tree.

- **Below-ground biomass estimation:** To account for the significant carbon stored in tree roots, established root-to-shoot ratios were applied to the above-ground biomass estimates. These ratios vary across species and environmental conditions, hence species-specific or region-specific ratios were utilized to ensure accuracy.

3.4 Total Biomass Calculation and Carbon Stock Assessment:

- **Summation of individual tree biomass:** The individual tree biomass values were summed to obtain the total above-ground and below-ground biomass for the entire campus. This aggregate biomass represents the total organic matter (and thus, carbon) stored in the tree population.
- **Conversion to carbon stock:** The total biomass was then converted to carbon stock using a species-specific carbon fraction. This fraction represents the proportion of dry biomass that is composed of carbon. Typical carbon fractions for trees range from 45% to 50%.

3.5 Precise Determination of Dry Weight and Carbon Content:

- **Representative sampling:** For each dominant tree species, representative samples (e.g., branches, leaves) were collected. These samples were carefully selected to ensure they reflect the average composition of the species.
- **Laboratory analysis:** The collected samples were oven-dried to remove moisture and determine their dry weight. Subsequently, the carbon content of the dry matter was analysed using established laboratory techniques, such as elemental analysis or loss-on-ignition.
- **Species-specific carbon fractions:** The average carbon content obtained from the laboratory analysis was used to refine the species-specific carbon fractions used in the previous step. This iterative process ensures a more accurate estimation of the carbon stock.

3.6 Comprehensive CO_2 Sequestration Estimation:

- **Carbon to CO_2 conversion:** The total carbon stock was converted to the equivalent weight of CO_2 sequestered by using the molecular weight ratio of carbon to CO_2

(12:44). This final step quantifies the total amount of CO_2 removed from the atmosphere and stored within the biomass of the campus trees.

- **Time-bound estimation:** To provide a more meaningful estimate, the CO_2 sequestration rate was also calculated, which represents the amount of CO2 sequestered per year. This rate can be estimated by considering the average annual growth rate of the trees and their respective carbon fractions.

By employing this comprehensive and rigorous methodology, the study provides a reliable and accurate estimation of the carbon sequestration potential of the JSSSTU university campus. This information is crucial for understanding the role of urban green spaces in mitigating climate change and developing effective strategies for carbon management.

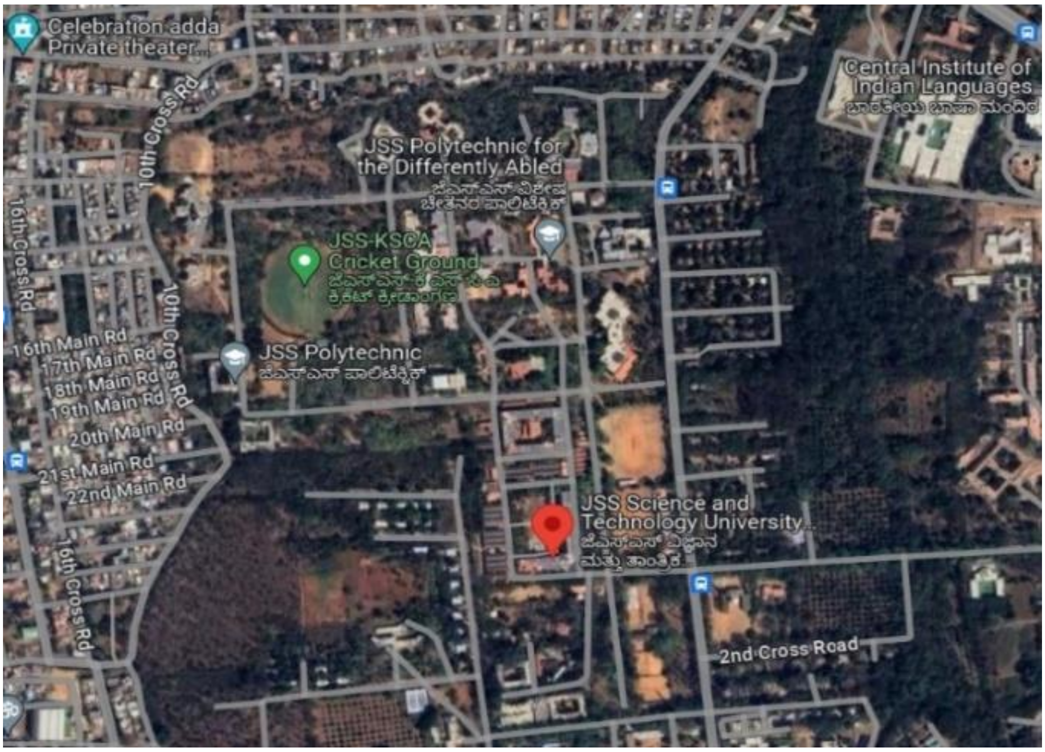

Fig:3.2 Aerial view of JSSSTU

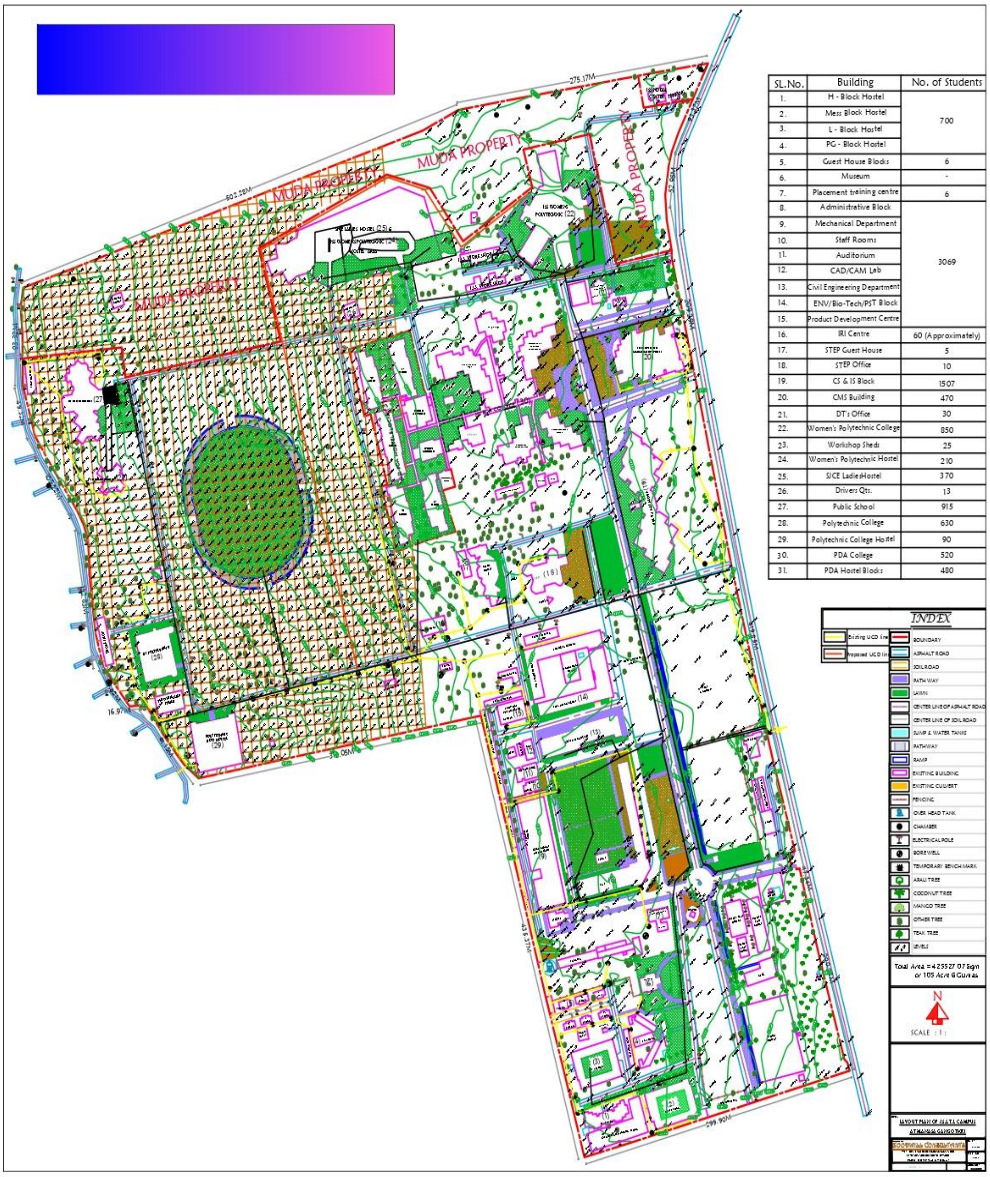

Fig: 3.3 Master Plan of JSSSTU

(SOURCE: SRI JAYACHAMARAJENDRA COLLEGE OF ENIGEERING COLLEGE)

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Tree Species Diversity

The survey conducted on the JSSSTU campus revealed a total of 7,636 trees representing 111 different species. This remarkable diversity is a testament to the ecological richness of the campus environment. While *Tectona grandis* (Teak) dominates the landscape, comprising over 50% of the total tree population (4,690 individuals), several other significant species contribute to the overall diversity. These include:

- *Swietenia macrophylla* (Mahogany) - 650 trees
- *Milletia pinnata* (Pongamia) - 225 trees
- *Grevillea robusta* (Silver Oak) - 174 trees
- *Saraca asoca* (Ashoka) - 157 trees

The presence of both native and exotic species indicates a deliberate effort to maintain a diverse tree population, potentially enhancing the campus's resilience to environmental stressors. The wide range of species also offers diverse habitats for various fauna, contributing to a balanced ecosystem.

4.2 Age Distribution and Spatial Patterns

The age distribution of trees on campus varies significantly. Notably, a cluster of mature *Tectona grandis* trees, estimated to be 20-25 years old, is located near the Basketball court and Boys Hostel. Younger teak trees (10-15 years old) are prevalent near the Cricket Ground, Polytechnic College, and Public School. Additionally, a venerable *Ficus religiosa* (Peeple tree) exceeding 120 years of age stands as a testament to the campus's long-standing commitment to green spaces.

These spatial patterns in tree distribution likely reflect a combination of historical planting practices, land-use changes, and environmental factors. Understanding these patterns is crucial for planning future tree planting initiatives and optimizing carbon sequestration efforts.

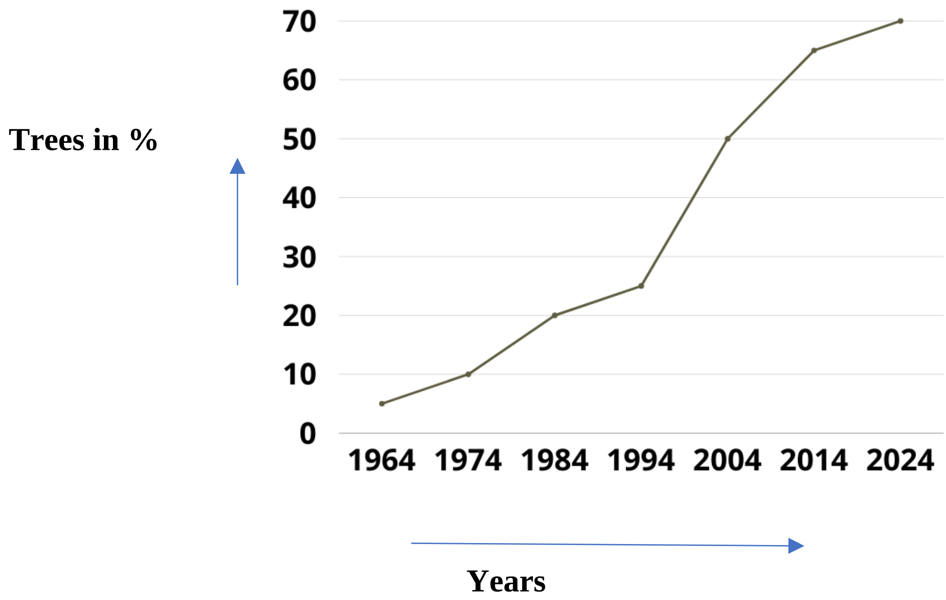

Fig: 4.1 Graph Representing increase in tree count over the year

4.3 Implications for Carbon Sequestration

The diversity and abundance of trees on the JSSSTU campus hold significant implications for carbon sequestration. *Tectona grandis*, being the dominant species, is likely to play a major role in carbon uptake and storage. However, the presence of other species, each with unique growth characteristics and carbon sequestration capacities, further enhances the campus's overall potential as a carbon sink.

The age distribution of trees also influences carbon sequestration. Mature trees generally have a larger biomass and therefore store more carbon than younger trees. The presence of both mature and young trees on campus ensures a continuous cycle of carbon sequestration, with younger trees gradually accumulating biomass and contributing to the carbon sink as they mature.

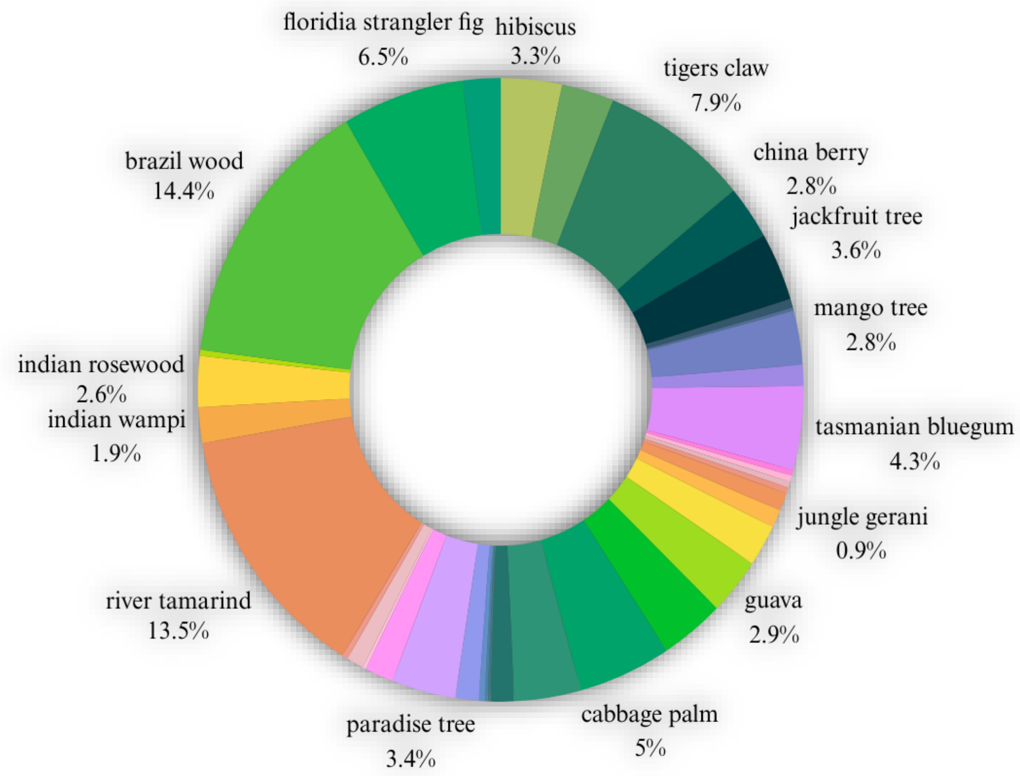

Fig:4.2 Pie Chart Describing Percentage of species count on JSS STU CAMPUS

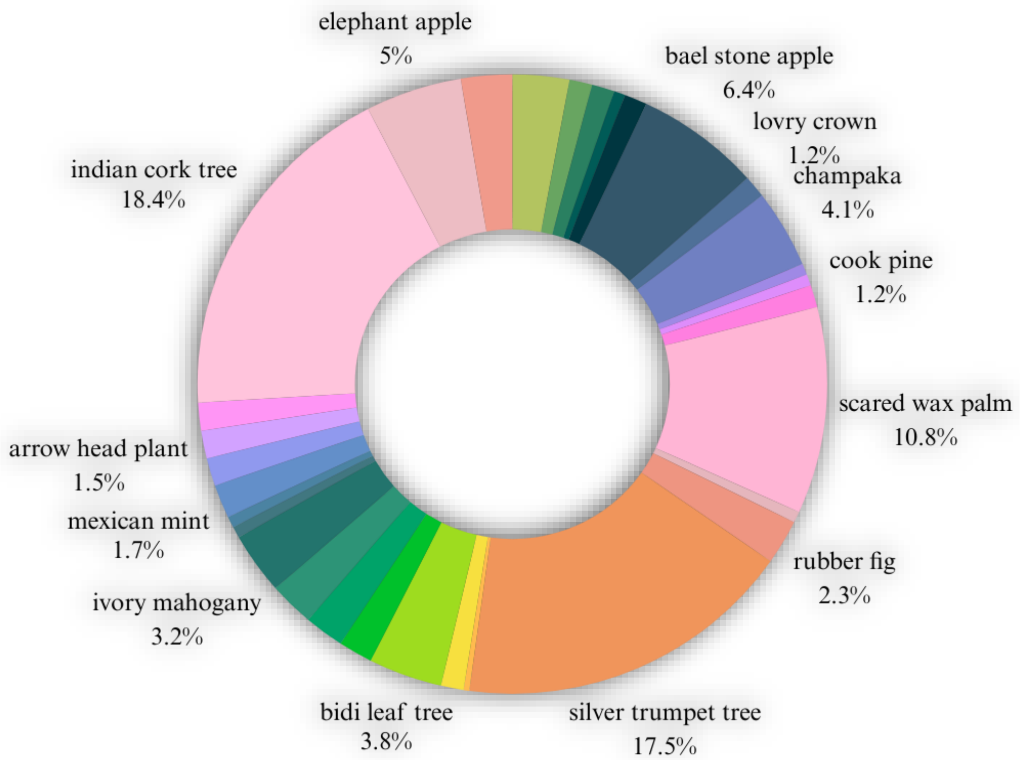

Fig:4.3 Pie Chart Describing Percentage of species count on JSS STU CAMPUS

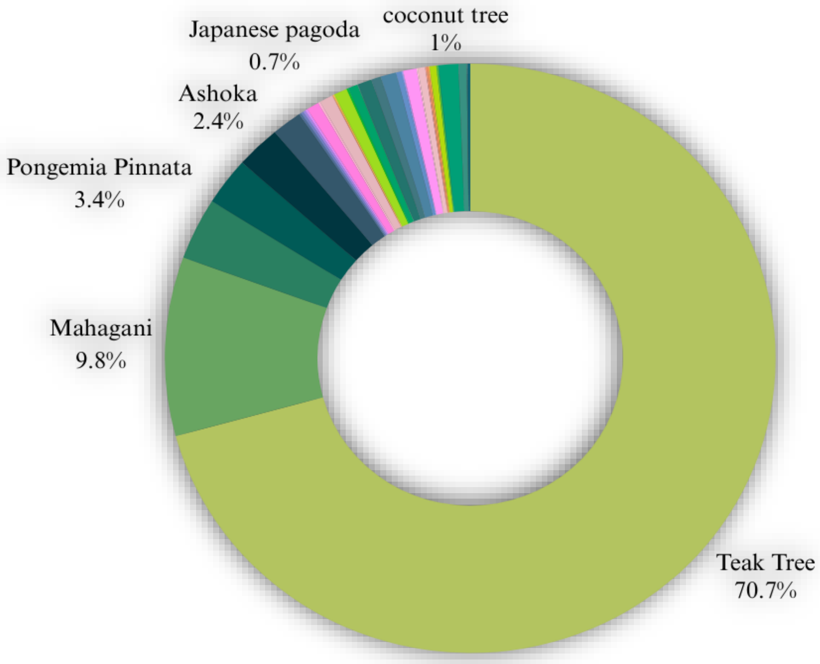

Fig:4.4 Pie Chart Describing Percentage of species count on JSS STU CAMPUS

4.4 Carbon Sequestration Calculation:

- AGB = 0.25 x D^2 x H

Where:

AGB: Above-Ground Biomass (pounds).

D: tree diameter measured at 1.37 meters from the ground (inches).

H: tree height (feet).

The overall green weight of the biomass is estimated to be 120% of the AGB value, based on the assumption that the BGB, which comprises the tree's root system, accounts for approximately 20% of the AGB Therefore, BGB can be calculated as follows:

- BGB = 0.2 × AGB

From these formulas, we can calculate the total biomass from a tree:

- Total Biomass (TB) = AGB + BGB

= AGB + 0.2 x AGB

= 1.2 × AGB

On average, a tree consists of 72.5% dry matter and 27.5% moisture content. To calculate the tree's dry weight, we could multiply the total weight of the tree by 72.5%.

- Total Dry Weight (TDW) = TB × 0.725

Carbon occupies 50% of the total dry weight. Therefore,

- Total Carbon (TC) = TDW × 0.5

With the value of total carbon, we can calculate the value of CO_2 equivalent sequestered on a tree. CO_2 has one molecule of Carbon and two molecules of Oxygen. The atomic weight of Carbon is 12u, and the atomic weight of Oxygen is 16u.
The weight of CO_2 in trees is determined by the ratio of CO_2 to C is 44/12 = 3.67.
Therefore, to determine the weight of carbon dioxide sequestered in the tree, multiply the weight of carbon in the tree by 3.67.

- CO_2 weight = TC × 3.67

TO Calculate annual CO_2 sequestration rate:

- CO_2 weight= (CO_2 weight)/(Age of the tree)

TOTAL CO_2 SEQUESTRATED BY OVERALL SPECIES AT JSSSTU CAMPUS

- **6945.391kg** of CO_2 Or **7 Tonnes** of CO_2

The detailed calculation of sequestration by individual species is shown in APPENDIX-1

4.5 Analysis of Results:

The table reveals that Tectona grandis (Teak) exhibits the highest total CO2 sequestration among the studied species, amounting to 5209.46 kg. This is primarily attributed to its high abundance (4690 trees) and relatively large size, as evidenced by the average height of 14 meters and diameter of 1.4 meters. The substantial carbon sequestration by teak underscores its crucial role in mitigating CO2 emissions on campus.

Swietenia macrophylla (Mahogany) ranks second in terms of total CO2 sequestration, with 773.72 kg. Despite having a smaller population (650 trees), Mahogany's larger size (17.4 meters in height and 1.3 meters in diameter) contributes to its significant carbon storage capacity.

The remaining species, Milletia pinnata (Pongemia pinnata), Grevillea robusta (Silver oak), and Saraca asoca (Ashoka), exhibit lower total CO2 sequestration values, ranging from 23.90 kg to 186.14 kg. This is due to their relatively smaller population sizes and, in some cases, smaller average tree dimensions.

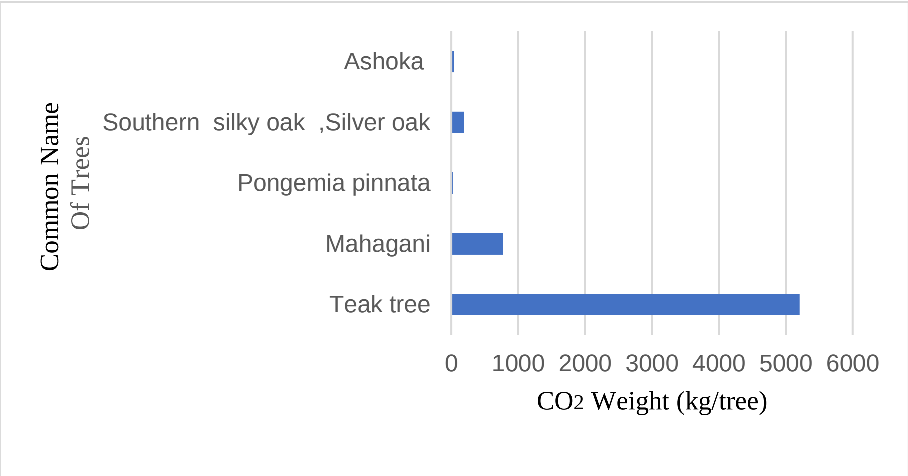

Fig: 4.5 Bar Graph Representing Top-5 (In number) Species of Carbon Sequestration

4.6 Total CO_2 Sequestration at JSSSTU Campus:

The cumulative CO2 sequestration by all the studied tree species at JSSSTU campus is estimated to be 6945.39 kg, equivalent to approximately 7 tonnes of CO_2. This substantial amount of carbon removal highlights the significant contribution of campus trees to climate change mitigation.

4.7 Discussion:

The findings of this study provide valuable insights into the carbon sequestration potential of different tree species at JSSSTU campus. The dominance of teak and the presence of other major tree species suggest that the campus has a well-established and diverse tree population capable of sequestering a substantial amount of CO_2. This natural carbon sink plays a crucial role in offsetting carbon emissions from campus activities and contributing to the overall sustainability goals of the institution.

The calculated CO_2 sequestration values can be used as a baseline for future monitoring and management efforts. By tracking the growth and carbon accumulation of trees over time, the effectiveness of tree planting and maintenance strategies can be assessed. This information can also be used to develop educational programs and raise awareness about the importance of trees in mitigating climate change.

Furthermore, the study highlights the potential of using the biomass method and allometric equations for quantifying carbon sequestration on campus. This approach is relatively simple, cost-effective, and can be easily replicated in other settings. By applying this methodology, universities and other institutions can assess their carbon footprint and develop strategies to reduce their environmental impact.

4.8 Future Directions

Further research is needed to quantify the carbon sequestration rate of each tree species on campus. This would involve measuring tree growth rates, estimating biomass accumulation, and analyzing the carbon content of wood samples. By combining this data with the species distribution and abundance information obtained from the survey, a comprehensive carbon sequestration model for the JSSSTU campus can be developed.

Moreover, ongoing monitoring of the tree population is essential to track changes in species composition, growth rates, and carbon sequestration over time. This information can inform adaptive management strategies to optimize the campus's contribution to climate change mitigation.

4.9 Quantifying Carbon Sequestration at JSSSTU

The calculations presented in the table provide a quantitative assessment of the carbon sequestration potential of the major tree species at JSSSTU campus. By employing the biomass method and utilizing allometric equations, the above-ground biomass (AGB), below-ground biomass (BGB), total biomass, dry weight, carbon content, and CO_2 sequestration were estimated for each species

CHAPTER 7
SUMMARY

The comprehensive assessment of the JSSSTU campus reveals a vibrant and diverse ecosystem, boasting 111 tree species that collectively contribute to a substantial carbon sink. The dominance of Teak (Tectona grandis) at 70.7% of the green cover, coupled with the presence of other notable species like Mahogany (Swietenia macrophylla) and Silver oak (Grevillea robusta), underscores the significant role played by these trees in sequestering atmospheric carbon dioxide (CO2).

Through meticulous field surveys, species identification, and biomass calculations, this study quantified the CO2 sequestration potential of the campus trees. The total CO2 sequestered by all species was estimated to be 6945.391 kg, a testament to the vital ecological service provided by the campus green cover. This substantial carbon sink not only mitigates the institution's carbon footprint but also contributes to the broader goal of combating climate change.

The JSSSTU campus boasts a diverse and abundant tree population, representing a valuable asset for carbon sequestration. The dominance of *Tectona grandis*, along with the presence of numerous other species, creates a heterogeneous landscape with varying carbon sequestration potentials. Further research and monitoring are crucial to fully understand and harness the campus's capacity to mitigate climate change through carbon sequestration.

Furthermore, the study found that the campus, spanning 411,056.2 square meters (approximately 101 acres), dedicates a significant portion (76.86 acres) to green cover. This commitment to maintaining and expanding green spaces is commendable and aligns with global efforts to promote sustainable development and environmental conservation.

In conclusion, the JSSSTU campus serves as a model for integrating ecological considerations into urban planning and development. By nurturing a diverse tree population and prioritizing green spaces, the campus not only enhances its aesthetic appeal but also actively contributes to carbon sequestration, air quality improvement, and overall environmental well-being.

Recommendations:

To further enhance the sustainability of the JSSSTU campus and maximize its carbon sequestration potential, the following recommendations are proposed:

1. **Expand Green Cover:** Explore opportunities to increase the green cover on campus by identifying areas suitable for tree planting. This could involve transforming unused spaces into mini-forests, planting trees along walkways and roadsides, and incorporating green roofs and walls into building designs.

2. **Diversify Tree Species:** While teak plays a crucial role in carbon sequestration, diversifying the tree population can enhance the ecosystem's resilience to pests, diseases, and climate change. Consider planting a wider variety of native and adaptive tree species that thrive in the local climate and soil conditions.

3. **Promote Eco-friendly Transportation:** Encourage the use of bicycles, electric vehicles, and public transportation for commuting to and within the campus. This can significantly reduce carbon emissions associated with transportation and contribute to a cleaner and greener campus environment.

4. **Implement Sustainable Landscape Management Practices:** Adopt sustainable practices for maintaining the campus landscape, such as using organic fertilizers, minimizing pesticide use, and conserving water resources. This will not only promote the health of the trees but also reduce the environmental impact of landscaping activities.

5. **Engage the Campus Community:** Foster a culture of environmental stewardship by involving students, faculty, and staff in tree planting initiatives, educational programs, and awareness campaigns. This will create a sense of ownership and encourage active participation in sustainability efforts.

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