

**`SPATIAL ANALYSIS OF URBAN HEAT SPOTS AND GREEN BELTS
FOR ENHANCING CARBON SEQUESTRATION IN CHENNAI
METROPOLITAN DEVELOPMENT AUTHORITY**

Submitted in partial fulfillment of the requirements for the award of

Bachelor of Engineering in Civil Engineering

By

ADAM F MAXWELL (39200002)

SAHAYA VALAN. C (39200702)



DEPARTMENT OF CIVIL ENGINEERING

SCHOOL OF BUILDING AND ENVIRONMENT

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade “A” by NAAC | 12B Status by UGC | Approved
by AICTE JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119.**

APRIL 2023



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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of ADAM F MAXWELL (39200002) and SAHAYA VALAN. C (39200702) who carried out the project "Spatial analysis of Urban heat spots and Green belts for enhancing Carbon sequestration in Chennai Metropolitan Development Authority".

Internal Guide

Dr. V.SAMPATH KUMAR M.E, Ph.D.,

Head of the Department

Dr. S. PACKIALAKSHMI M.E, Ph.D.,

Submitted for Viva voice held on:

20.04.2023

INTERNAL EXAMINER

EXTERNAL EXAMINER

DECLARATION

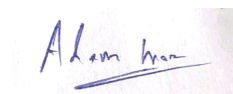
We, Adam F Maxwell (39200002) and Sahaya Valan. C (39200702) hereby declare that the Project Report entitled **“Spatial analysis of Urban heat spots and Green belts for enhancing Carbon sequestration in Chennai Metropolitan Development Authority”** done by us under the guidance of **Dr. V.SAMPATHKUMAR M.E, Ph.D.**, and **Dr. P. MOHANA M.Sc., Ph.D.**, is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Civil Engineering.

DATE: 13.04.2023

PLACE: Chennai

SIGNATURE OF THE CANDIDATE

1.

A handwritten signature in blue ink, appearing to read 'Adam F Maxwell', with a horizontal line underneath.

2.

A handwritten signature in blue ink, appearing to read 'Sahaya Valan. C', with a horizontal line underneath.

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ABSTRACT

The aim of the study is to assess the high carbon potential of plants and trees to mitigate urban climatic patterns and to store ecologically safer urban residents. So far, the study, we have taken the Chennai city boundary as the study area. we assist the Urban heat spot of Chennai CMDA, the area then demarketing the vacant land and parking landed, education digital elevation model then soils nature and land use map, we create various thematic layers and using weighted overlay analysis method. We have super invested in the layer, one layer to another one layer and we demarketing the area, where we have taken the necessary action for the Carbon potential source. So, from this study, we use this method and we have derived Carbon potential and suggested suitable land and trees sustain the development of the Urban Ecosystem. The use of green belts is a promising approach to mitigating the effects of urban heat spots and enhancing carbon sequestration in urban environments. In this study, we use spatial analysis techniques to identify areas within CMDA that are particularly vulnerable to urban heat spots and to determine the most effective placement of green belts for mitigating the effects of these spots. We analyze temperature data and other environmental variables to identify areas that are likely to experience the most intense heat and determine the optimal placement of green belts for enhancing carbon sequestration. Our results suggest that strategic placement of green belts can help to mitigate the effects of urban heat spots and enhance carbon sequestration in CMDA. This study highlights the importance of spatial analysis techniques in identifying areas of vulnerability and determining effective solutions for mitigating the effects of urban heat spots and enhancing carbon sequestration in urban environments in CMDA.

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CHAPTER 1

INTRODUCTION

The urban population and the built-up area are increasing steadily and rapidly in the entire globe. The investments in new infrastructure and buildings, and the residents demand for goods and services are major drivers of Global Green House Gas emissions and other environmental burdens. In addition, urban areas are part of the global carbon cycle and provide ecosystem services for their residents and visitors. Carbon skins inside and outside city boundaries have been suggested as a means of mitigating the global impacts of cities. Urban green infrastructure includes all the natural, semi-natural and artificial networks of ecological systems in urban and peri-urban areas, such as forests, parks, community gardens, private yards and street trees. Green factor is a planning tool and a sustainability metric that is used for increasing both the quality and quantity of green elements on private properties and government properties. It has previously been applied in several cities are planning to start using the tool in the near future. However, none of these planning tools address specifically about the Carbon Sequestration and Storage but instead, focus on other benefits of urban green.

Alamgir (2008) et al, Global climate is changing day by day as a result of natural variability and anthropogenic activities. Changes in the atmosphere, water cycle, solar inputs and land surface are evident. Tiwari (1987) et al, Among the few global issues that have received more attention from scientists, resource managers, policy makers and public is climate change. Al-Amim (2008) et al, Increase in carbon emission has become a major concern, which was well addressed in the Kyoto Protocol because it is the main causal factor in global warming. Mitra (2011) et al, Tropical forests represent 30-40% of the terrestrial net primary productivity. Nascimento (2002) et al, The rapid conversion of tropical forests was a major source of greenhouse gases such as carbon dioxide, methane, and nitrous oxide.

Chavan (2010) et al, The trees act as a major CO₂ sink which captures carbon from the atmosphere and store the same in the form of fixed biomass during the growth process. Ketterings (2001) et al, Carbon stock includes aboveground biomass measurements as an essential aspect. Salazar (2010) et al, Forest biomass can be determined either by direct methods or by indirect methods. Direct methods or destructive methods involve felling of trees to determine biomass. Verwijst (1999) et al, Destructive techniques for biomass estimation are time consuming and expensive due to the large dimensions and the amounts of biomass that have to be processed and also against conservation. Brown (1989) et al, Indirect means of estimation of forest biomass are based on allometric equations using tree inventory data. Nath (2009) et al, Allometric relationship is the most preferred method since it yields a non-destructive and indirect measurement of biomass components and it also consumes less time and less expensive. Crow (1978) et al, Allometric equation is a crucial step in the estimation of tree biomass, yet it is seldom directly tested. Shepashenko (1998) et al, Since, a hectare of tropical forest may be home to as many as 300 different tree species and one cannot use species-specific regression models, as in the temperate zone. Salazar (2010) et al, With regard to the estimation of tree biomass, allometric equations using the diameter of the tree are a strong predictor of biomass for practical purposes owing to the ease and precision with which it can be obtained and because it relates the total volume of biomass to functional processes such as transport and the age of the tree. In the other hand, allometric equations using tree height along with tree diameter is also used, but it does not improve the results, besides it represents an additional hindrance in data compilation. Segura (2005) et al, Further, it is often difficult to measure the height in dense forests. Hence, tree diameter alone was used as the independent variable for the estimation of forest biomass in most of the earlier studies. Murphy (1986) et al, Forest biomass data are available for different regions of the world but the biomass stock of the Pachaimalai forest of the Eastern Ghats in India was not estimated.

Trees are playing vital roles in forest dynamics. They constitute considerable proportion of tropical forest biodiversity in India and around the world. Eastern Ghats are less studied compared to Western Ghats in India. Baseline data such as density, species richness and biomass stockpile of trees are essential to formulate conservation measures. Conservation of trees in situ is a pre-requisite to protect gene pool of trees. Woody plants accumulate carbon in their wood and other organs, thereby acting as relatively a long term carbon stockpile. More than 50% of all terrestrial carbon stored in forests, contributing about three fourths of total carbon exchange between terrestrial ecosystem and the atmosphere, and sequestering up to three billion Mg (Mega gram = one tone) of carbon annually. Among world's forests tropical forests hold highest carbon stock followed by Boreal and temperate forests.

OBJECTIVE

The main objectives of the project are to estimate the Urban climatic factor especially urban heat spots of the Chennai city using Remote sensing approach. To demarcate the vacant land and parking yards of CMDA Chennai and to assess the digital elevation and soil nature. To identify effective means to increase carbon sink and storage potential of vacant yards. Suggesting the suitable carbon potential plants to increase the sustainable development of urban ecosystem.

- To estimate the Urban Heat Spots of the Chennai city using Remote Sensing Approach.
- To demarcate the vacant land and parking yards of CMDA Chennai and assess the Soil nature.
- To identify effective means to reduce carbon.
- Suggesting the Suitable Carbon Potential Plants to increase the Urban Ecosystem.

CHAPTER 2

LITERATURE SURVEY

Rodel D. Lasco (2002), Terrestrial ecosystems play an important role in the global carbon cycle. Tropical forests in Southeast Asia are constantly changing as a result of harvesting and conversion to other land cover. As a result of these changes, research on C budgets of forest ecosystems has intensified in the region over the last few years. This paper reviews and synthesizes the available information. Natural forests in SE Asia typically contain a high C density. Logging activities are responsible for at least 50% decline in forest C density. Complete deforestation results in C density of less than 40 Mg/ha. Conversion to tree plantations and other woody perennial crops also reduces C density to less than 50% of the original C forest stocks. While much information has been generated recently, there are still large gaps of information on C budgets of tropical forests and its conversion to other land uses in SE Asia. There is therefore a need to intensify research in this area.

Pulhin F.B. (2003) et al, Southeast Asia is rich in tropical forests and biodiversity but rapid deforestation and forest degradation have accelerated climate change and threatened sustainable development in the region. Carbon emission reductions through reducing deforestation and forest degradation, forest conservation, sustainable management of forests, and enhancement of forest carbon stocks have been a focal topic of the climate change mitigation since the Bali in 2007. However, only a handful of studies exist so far on this important issue that are suitable to inform the debate with estimates of carbon stocks and emission reductions or removals as a result of REDD+. Our study attempts to analyze the potential emission reductions and removals for a 35-year period under the REDD+ scheme. We start by developing land use change and forest harvesting models that are used to estimate carbon stock changes in natural forests and forest plantations in Southeast Asia. Carbon emissions from deforestation and forest degradation of natural forests were 1865.1, 1611.4, and 1300.4 TgCO₂ year⁻¹, respectively. With a hypothetical carbon project of 35 years beginning from 2015, carbon emission reductions were estimated at 817.6 TgCO₂ year⁻¹, of which about 10% was from reducing forest degradation. Carbon removals due to increase of forest plantations were 76.3 TgCO₂ year⁻¹ but the removals could be much higher if there is a new definition on the eligibility of

forest plantations. Summing up together, about 893.9 TgCO₂ of carbon credits could be achieved from implementing carbon project in Southeast Asia or about US \$6.6 billion annually between 2015 and 2050 if carbon price in 2012 is used. In addition to reducing emissions, there are other benefits from carbon project implementation. This study suggests that REDD+ has great potential for reducing carbon emissions and enhancing carbon stocks in the forests. Without financial incentives, carbon project would not happen and therefore climate change will continue to threaten future development.

Ma. Regina N. Banaticla (2007) et al, Estimation of the magnitude of sinks and sources of carbon requires reliable estimates of the biomass of forests and of individual trees. Equations for predicting tree biomass have been developed using secondary data involving destructive sampling in plantations in several localities in the Philippines. These equations allow estimates of carbon sequestration to be made at much lower cost than would be incurred if detailed stand inventories were undertaken. The species included in the study reported here include *Gmelina arborea* Roxb., *Paraserianthes falcataria*. Nielsen *Swietenia macrophylla* King and Dipterocarp species in Mindanao, and *Leucaena leucocephala* de Wit from Laguna, Antique, Cebu, Iloilo, Rizal, and Ilocos Sur. Non-linear regression was used to derive species specific, site specific and generic equations between yield and diameter of the form $y = \alpha D^\beta$. Equations were evaluated based on the correlation coefficient, standard error of estimate and residual plots. Regressions resulted in high r values. In some cases, non-homogeneous variance was encountered. The generic equation improved estimates compared with models used in previous studies.

Racelis, E.L., (2008) et al, This study determined the potential of tree plantations to sequester atmospheric carbon by measuring the amount of carbon stored in its biomass. The study involved a Dipterocarp and large leaf Mahogany stands located in Mt. Makiling Forest Reserve, Philippines. The carbon pools investigated included: above-ground biomass, ground-biomass, and below-ground biomass. Results showed that Mahogany stand has a total biomass of 605.25 t ha⁻¹ while the Dipterocarp stand has 563.93 t ha⁻¹. However, in terms of carbon content in its biomass, Mahogany has a lower value of 542.05 t C ha⁻¹ than the value of 639.81 t C ha⁻¹ for Dipterocarp stand. Estimation of biomass density to carbon accumulation per sink for both Mahogany and Dipterocarp stand showed the following results: above-ground; ground biomass; and below-ground biomass. Ranking the carbon deposits per sink, below-ground biomass has the highest carbon accumulation primarily due to its soil component.

Ernesto G. Guiabao (2010), The study was conducted in the reservation area of the Kalinga State University located in Tawi, Bulbul, Rizal, Kalinga. The study aimed to determine the above-ground biomass and carbon stock of the reservation area. The methodologies used includes, measurement of trees at the diameter at breast height, gathering of corner points with the use of GPS and processing of data in Arc GIS. Above-ground biomass was computed through the allometric equation developed by Brown. Result of the study revealed that site 6 had the highest biomass followed by sit 3, site 5, site 4, site 2 And site 1. Comparison of carbon stock, site 6 had the highest carbon stock which is equivalent to 174.87 t/ha. Followed by site 3, site 5, site 4, site 2 and lowest at site 1. Majority of the sites were fall under the optimum pH value. The study revealed that the reservation area has a good nitrogen level because majority of the species are nitrogen fixing trees. The reservation area has a mean of 14.5ppm. Based on Phosyn Chemicals Limited, the guideline level for phosphorus is 50ppm. The study site is described as moderately low level of phosphorus. Result of the study revealed that the study site has a high level of potassium content which has a mean of 509ppm. Based on Phosyn Chemicals Limited, the guideline level for potassium is 200 ppm.

Kuimi T. Vashum (2012) et al, Carbon exists as carbon dioxide in the atmosphere and constitutes about 0.04% of the atmosphere. In the recent past, it has gained a lot of attention as a greenhouse gas, as it has potential to influence the climate pattern of the world. Anthropogenic activities like industrialisation, deforestation, forest degradation and burning of fossil fuel, has caused an increase in the level of carbon in the atmosphere and disrupted the global carbon cycle. However, nature has its own mechanism of sequestering and storing the carbon in its “reservoirs” or “sinks”. Forest plays an important role in the global carbon cycle as carbon sinks of the terrestrial ecosystem. The carbon sequestered or stored on the forest trees are mostly referred to as the biomass of the tree or forest. The Intergovernmental Panel on Climate Change identified five carbon pools of the terrestrial ecosystem involving biomass, namely the aboveground biomass, below-ground biomass, litter, woody debris and soil organic matter. Among all the carbon pools, the above-ground biomass constitutes the major portion of the carbon pool. Estimating the amount of forest biomass is very crucial for monitoring and estimating the amount of carbon that is lost or emitted during deforestation, and it will also give us an idea of the forest’s potential to sequester and store carbon in the forest ecosystem.

Estimations of forest carbon stocks are based upon the estimation of forest biomass. Forest's carbon stocks are generally not measured directly; however, many authors assume the carbon concentration of tree parts to be 50% or 45% of the dry biomass. This paper, aims to review and summarise the various methods and studies that were carried out to estimate the above-ground biomass of the forest. Carbon exists in the earth's atmosphere primarily as the gas-carbon dioxide. It constitutes a very small percentage of the atmosphere about 0.04% approximately. However, it plays an important role in supporting life on earth, as plants make themselves from it. During photosynthesis, plants take up carbon dioxide from the atmosphere, converting it into carbohydrate and releasing oxygen into the atmosphere. When these plants or trees die or are burnt, the carbon stored in them are released back into the atmosphere. This natural cycling of the carbon is maintained and controlled by a dynamic balance between biological and inorganic processes since the geological history of earth.

Nevertheless, the atmospheric concentration of carbon dioxide in the last five decades explains a disturbingly increasing trend. The rate at which carbon dioxide is being added to the atmosphere is also observed to be much faster than at any time in the past 80,000 years. The carbon dioxide concentration in the atmosphere is continuously being measured and recorded since 1957. The carbon dioxide concentration in the atmosphere has increased from about 280 ppm, during the pre-industrial period, to approximately 390 ppm in the present-day. The rise in the carbon dioxide level in the atmosphere is mainly caused by anthropogenic activities. In the 19th century, with the advent of industrial revolution, humans have been burning a huge amount of fossil fuels, releasing the carbon stored in it back into the atmosphere as carbon dioxide. Since the industrial insurgency, the carbon dioxide level in the atmosphere has increased tremendously causing remarkable changes in the natural global carbon cycle. Besides the combustion of fossil fuels, other human activities such as deforestation also have a considerable impact on the ability of the terrestrial biosphere to emit or remove carbon dioxide from the atmosphere. Deforestation and degradation of forests lead to emission of carbon dioxide through burning of forest biomass and decomposition of plant parts and soil carbon. These human activities have accelerated and contributed to a long-term rise in atmospheric carbon dioxide level.

With all the carbon dioxide pumped into the atmosphere from the various human activities, the planet would have been overheated rapidly if not for the nature's mechanism

of sequestering the carbon from the atmosphere and storing it in its reservoirs like the oceans and the forests and soils. The nature's way of sequestering carbon from the atmosphere is a process of achieving balance of carbon dioxide levels in atmosphere and maintaining the global carbon cycle, and this cycle has been happening billions of years. However, humans have greatly disturbed this balance with various activities like combustion of fossil fuels and change in land-use patterns such as deforestation.

Why carbon cycle drew much attention is because carbon dioxide being the chief among the greenhouse gases, it has potentials to influence the global climate pattern, and it also has a relatively long residence time in the atmosphere. About 60% of the observed global climate change is attributable to this increasing carbon dioxide concentration in the atmosphere.

Nature has provided us with natural carbon "sinks" or "sponges" like the terrestrial ecosystem and the oceans. Forest's ecosystem is one of the most important carbon sinks of the terrestrial ecosystem. Forest's vegetation takes up the carbon dioxide in the process of photosynthesis. In this natural process, it removes the carbon dioxide from the atmosphere and stores the carbon in the plant tissues, forest litter and soils. Thus, forest ecosystem plays a very important role in the global carbon cycle by sequestering a substantial amount of carbon dioxide from the atmosphere. This process is more prolific in a relatively new forest where the growths of the trees are still rapid. It is estimated that about 86% of the terrestrial above-ground carbon and 73% of the earth's soil carbon are stored in the forests. The tropical forests are said to play a major role in the global carbon cycle, storing up to about 46% of the world's terrestrial carbon pool and about 11.55% of the world's soil carbon pool, acting as a carbon reservoir and functioning as a constant sink of atmospheric carbon. According to a study conducted by Lugo and Brown, it was suggested that half of the so called "matured forests" could also sequester carbon and the rate of sequestering carbon could be further increased if human pressures are reduced or removed from these forests.

In a tropical forest ecosystem, the living biomass of trees, the understory vegetation and the deadwood, which includes the standing deadwood and the fallen deadwood like fallen stems and fallen branches, woody debris and soil organic matters constitute the main carbon pool. Among the above mentioned carbon pools, the above-ground biomass of the tree is mainly the largest carbon pool and it is directly affected by deforestation and

forest degradation. The change in the forest areas and the changes in forest biomass due to management and regrowth greatly influence the transfer of carbon between the terrestrial forest ecosystem and the atmosphere. Hence, estimating the forest carbon stocks is mainly important to assess the magnitude of carbon exchange between the forest ecosystem and the atmosphere. Assessment of the amount of carbon sequestered by a forest will give us an estimate of the amount of carbon emitted into the atmosphere when this particular forest area is deforested or degraded. Furthermore, it will help us to quantify the carbon stocks which in turn will enable us to understand the current status of carbon stocks and also derive the near-future changes in the carbon stocks.

Jerry B. Superales (2016), In the light of increasing fears about climate change, green house gas mitigation is one of the today's major concerns. Carbon capture and storage are the options in the reduction of CO₂ emission intensity. Trees are among the most important and common sinks for atmospheric carbon. The carbon storage potential of Mahogany sapling has to be elucidated to shed light on the contribution of this sapling in greenhouse reduction. The study aimed to assess the aboveground standing biomass of the species, CO₂ capture and C storage potential of the leaves, bark and wood of this species. Allometric equation was used to calculate the above ground biomass which served as basis in the calculation of stored into a ratio of CO₂ captured by the species. The result showed that the wood of the samples had an average biomass of 268.26 g and captured more CO₂ compared to the leaves and bark. Each sample species have accounted storage of 4.458 g C in the wood, 3.325 g C in the leaves and 1.162 g C in the bark.

The above ground biomass of each sapling has potentially captured a total of 34.29 CO₂ from the atmosphere. The grams of C stored to the biomass of the saplings which largely contained in the wood, small amount in the leaves and least in the bark. Global warming is among the most dreaded problems of this millennium which just represents one aspect of climate change. The global warming is caused mostly by increasing concentrations of greenhouse gases in the atmosphere resulting to changes in climate pattern. Greenhouse gases which are primarily carbon dioxide, methane, nitrous oxide and others has influenced the earth's climate system. Reference reported that the concentration of atmospheric CO₂ has increased from 278 ppm in the pre-industrial era to 379 ppm in 2005 with an average increase of 1.9 ppm per year; largely attributing to human activities like burning of fossil fuels, land use change and deforestation especially

in the tropical forests.

The report has also precisely predicted an increase of 1.8 °C in global temperature at the end of this century. Thus, the provision of article 4 which states that necessitates on preventing and minimizing climate change by limiting anthropogenic emissions of greenhouse and protecting and enhancing the greenhouse gas sinks and reservoirs. Reference, in Manuscript received June 15, 2015; revised September 18, 2015. This work was supported by the Commission on Higher Education-Philippines through its financial support program for paper presentation in International Conferences. J. B. Suprales is with the J. H. Cerilles State College, Mati, San Miguel, 7029 Zamboanga del Sur, Philippines mitigating climate change, the society should immediately take significant steps to reduce greenhouse gas emissions through energy conservation and improved efficiency.

Forest can also play an important role in mitigating climate change by naturally taking carbon out of the atmosphere, thereby reducing the impact of CO₂ emissions. Higher temperatures, changes in precipitation patterns, and more frequent and severe disturbances are all the projected result of increased levels of atmospheric carbon dioxide. Major studies indicate that forestry activity is an important strategy for green house gas reduction and climate change mitigation. Tree is an important route for CO₂ to move from atmospheric gas to solid form. This carbon is sequestered, primarily in the new wood and increase soil organic matter that accompanies forest growth. Carbon is stored in tree biomass and in soil that helps protect natural carbon sinks through the improvement of land productivity and the provision of forest products on agricultural lands. Trees accumulate more carbon dioxide than the atmosphere and play an important role in global carbon cycle. With the increasing concern for rising CO₂ concentrations, its role on the long term carbon pool for assimilation of atmospheric CO₂ is being realized. CO₂ is taken up from the atmosphere during the growing season of vegetation and stored as plant biomass.

The fundamental science of carbon sinks is well understood-biological growth binds in the cells of trees and other plants while releasing oxygen into the atmosphere through the process of photosynthesis. Trees sinks have the potential to play a valuable role in carbon sequestration. Although sinks are only a partial solution to anticipated global warming, they do appear to have the potential to sequester 10 to 20% of the anticipated build-up atmospheric carbon over the next 50 years. Despite the widespread recognition of agroforestry for carbon storage there is still lack of quantitative data on specific systems

and their contribution to climate change mitigation particularly on the C stocks of nursery sapling species. Presently, there are no actual baseline data on carbon stocks of Mahogany sapling and can be found in literature. In consonance with the concerted efforts of the local community in promoting the reduction of CO₂ emissions, the conduct of this type of study is imperative. The main aim of this investigation is to calculate the properties of the aboveground standing biomass of Mahogany sapling in terms of moisture content, dry matter, and organic matter present in its wood, leaves and bark.

Further, the study has to estimate the amount of carbon stored in the wood and foliage of the samples and calculate its carbon dioxide ratio captured by the said parameters from the atmosphere. The results of the study may show the significance of local mahogany nurseries in reducing carbon dioxide from the atmosphere. This may also generate information and create ideas in modeling empirical and ecological phenomena on carbon capture and storage of mahogany saplings which may be used by other researchers in conducting relevant studies and academic exercises.

Udayakumar M. (2018) et al, This study is conducted to assess the amount of carbon stored in the above-ground biomass of the tree species at the Isabelia State University Wildlife Sanctuary. A total of 34 different tree species were found with 285 individuals were identified with a total of 47.50 t/ha Carbon stock and 164.09 t/ha of accumulated CO₂. It was found in the study that *Alstonia scholaris* contains the largest amount of above-ground biomass with a mass of 20.97 t/ha and Carbon stock of 9.44 t/ha followed by *Samanea saman* with a mass of 13.40 t/ha and Carbon stock of 6.03 t/ha. Based on the result and conclusion of this investigation, the following recommendations were drawn: Conduct a study concerning the carbon emission of the area to determine the relationship with its carbon sequestration potential; and conduct tree planting activity to open areas in the study site to increase its carbon stock potential and fully serve the purpose of the area as a wildlife sanctuary.

So therefore, from these literature surveys we can conclude that the urban heat spots can be found in vacant lands and parking lands and the carbon content can be decreased and also these authors have worked on various places and suggested different methods and ways to control the carbon content.

CHAPTER 3

METHODOLOGY

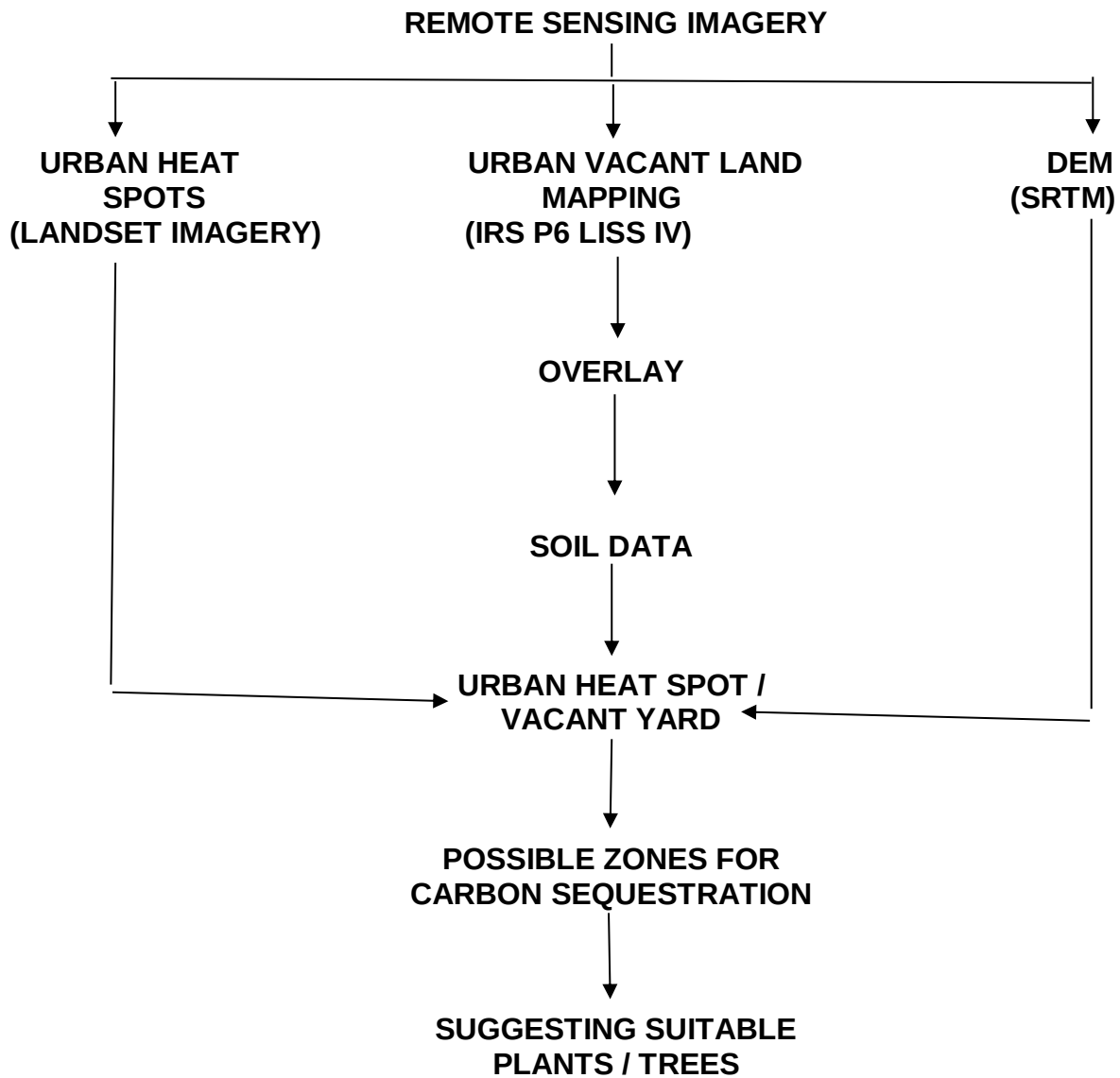


Figure 3.1: Methodology Chart

Remote Sensing Imagery

Remote sensing is the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance. Special cameras collect remotely sensed images, which help researchers "sense" things about the Earth. Some examples are:

- Cameras on satellites and airplanes take images of large areas on the Earth's surface, allowing us to see much more than we can see when standing on the ground
- Sonar systems on ships can be used to create images of the ocean floor without needing to travel to the bottom of the ocean
- Cameras on satellites can be used to make images of temperature changes in the Earth

Some specific uses of remotely sensed images of the Earth include:

- Large forest fires can be mapped from space, allowing rangers to see a much larger area than from the ground.
- Tracking clouds to help predict the weather or watching erupting volcanoes, and help watching for dust storms.
- Tracking the growth of a city and changes in farmland or forests over several years or decades.
- Discovery and mapping of the rugged topography of the ocean floor (e.g., huge mountain ranges, deep canyons, and the "magnetic striping" on the ocean floor).

DIGITAL ELEVATION MODEL

The Shuttle Radar Topography Mission (SRTM) was flown aboard the space shuttle Endeavour February 11-22, 2000. The National Aeronautics and Space Administration (NASA) and the National Geospatial-Intelligence Agency (NGA) participated in an international project to acquire radar data which were used to create the first near-global set of land elevations.

The radars used during the SRTM mission were actually developed and flown on two Endeavour missions in 1994. The C-band Space borne Imaging Radar and the X-Band Synthetic Aperture Radar (X-SAR) hardware were used on board the space shuttle in April and October 1994 to gather data about Earth's environment. The technology was modified for the SRTM mission to collect interferometric radar, which compared two radar images or signals taken at slightly different angles. This mission used single-pass interferometry, which acquired two signals at the same time by using two different radar antennas. An antenna located on board the space shuttle collected one data set and the other data set was collected by an antenna located at the end of a 60-meter mast that extended from the shuttle. Differences between the two signals allowed for the calculation of surface elevation.

Endeavour orbited Earth 16 times each day during the 11-day mission, completing 176 orbits. SRTM successfully collected radar data over 80% of the Earth's land surface between 60° north and 56° south latitude with data points posted every 1 arc-second (approximately 30 meters).

Urban Heat Spots in CMDA Chennai

Urban Heat spots is a Geoportal extension which simplifies the process of heat spots mapping and data analytics. Process to find Urban Heat spots:

1. Log in to the Geoportal.
2. Select Urban Hotspots from the Geoportal's Tools menu icon in the top right corner.
3. Select a study area.
4. Select which layers to include in the analysis and click "Evaluate". You should see a hotspot map on the screen after a few seconds. The total computation time depends on the size of the selected layers. Now, let's have a more detailed look at each step and describe all required inputs. In the example above we have considered that data is already available at the Geoportal, and that someone has set up Urban Hotspots before. In the following section we will describe how to set it up from scratch.

An urban heat island occurs when a city experiences much warmer temperatures than nearby rural areas. The difference in temperature between urban and less-developed rural areas has to do with how well the surfaces in each environment absorb and hold heat.

Soil Data in CMDA Chennai

Soil information is derived from data on soil profiles, soil properties, soil quality, and data on the functions and use of soils. The processing of data on soil into meaningful information products – such as maps - requires a workflow of collection, organization and management, analysis and publication of soil data.

Harmonized methods and data infrastructures will allow easier sharing of soil data in Europe, which is essential for research and for policy advice on agricultural land.

Water erosion reduces soil quality and causes ecological and economical damages to the environment, to farmers and the society by loss of water storage capacity, organic carbon and essential nutrients, and by their transfer into aquatic

environments and urban areas. Modelling and scaling can help us understand how fields, rivers and streets are connected. This insight can help reduce damages from water erosion impacts and provide recommendations for improved mitigation strategies. Strategies for connected landscape elements help reduce water erosion.

POSSIBLE ZONE FOR CARBON SEQUESTRATION IN C CHENNAI METROPOLITAN DEVELOPMENT AUTHORITY

Carbon sequestration is essential to mitigate global climate change. Approximately 53% of carbon is stored in temperate and boreal regions, while the remaining 37 % is stored in tropical areas. Half of the terrestrial carbon sink is located in forest ecosystems. Forest ecosystems take a large amount of CO₂ from the atmosphere *via* photosynthesis. They also contribute a large amount of fixed carbon in the form of organic matter in the lithosphere. However, a small portion of integrated carbon has been stored in the belowground biomass, litter, and soil. According to United Nations Food and Agriculture Organization statistics, forests contain 234 Pg of carbon in the above-ground forest, 62 Pg below ground, 41 Pg in the form of deadwood, 23 Pg in litter form, and 398 Pg in the forest soils. Forest ecosystems occupy the most significant part of the free-ice land surface in the entire terrestrial world. Trees are the main component of the forest ecosystem and contain the entire quantity of forest living biomass. Forests' total biomass and trees contribute about 80% of the world's total biomass.

Several biotic and abiotic factors influence carbon sequestration in forest ecosystems. Trees continuously sequester CO₂ from the atmosphere and store it in their different parts, i.e., stem, root leaves, and branches. The carbon sequestration rate depends on plant growth, individual characteristics of the tree species, the wood density, and its growing conditions. Trees store most of the atmospheric carbon because of their larger size, volume, and long-lived storage capacities, i.e., tree trunks, leaves, roots, and the soils in which they exist. Carbon sequestration is mainly driven through huge tree biomasses.

The scientific community is committed to reducing atmospheric CO₂ emissions and storing them in any other form to improve the quality of the atmosphere. Various biological and geological mechanisms bring free carbon down from the atmosphere. However, due to the enormous rise in human population, there is a continuous degradation of the land and deforestation, which results in the irreversible loss of forest functions. Plants are the primary producers of the world's biodiversity. They capture atmospheric CO₂ and convert it into glucose, the first organic molecule of life. Degraded forests lead to low carbon storage and poor biodiversity, which in turn cause global warming and climatic changes. Anthropogenic activities drastically add massive amounts of greenhouse gases, mainly CO₂, into the atmosphere. The rapid increase in the concentration of CO₂, methane, and methane dioxide is the major cause of global warming. Characteristically, above-ground biomass decreases along the elevation, but precipitation influences the biomass variations alongside the elevation gradient. Carbon sequestration is mainly determined by the biotic determinant of trees, such as variations in diameter, height diversity, stand density, and stand basal area. The individual tree height is not associated with diameter, but the ratio is correlated to the species genetic nature, intraspecific competition, and abiotic drivers like precipitation, temperature, and soil types. However, tree heights decline with increasing elevation, generally.

Study Area in CMDA Chennai

- CMDA Chennai Boundary taken as a study area
- It lies in-between 79° 56' 5.395" to 80° 22' 25.323" E Longitude and 12° 50'45.42" to 13° 17' 48.246" N Latitude and covers approximately 1217 Sq. Km

Data Used in CMDA Chennai

- Landsat Satellite Imagery - 2020
- SRTM DEM Data
- IRS P6 LISS IV Data - 2020

Software used:

Arc GIS 10.5

Arc GIS is a cloud-based mapping and analysis solution. Used to make maps, analyze data, and share and collaborate. Get access to workflow-specific apps, maps, and data from around the globe, and tools for being mobile in the field. This software consists of Arc Map, Arc Catalog, ArcGIS Pro, Arc Scene, and Arc Globe. Arc Map provides a simple user experience for publishing your map documents as map services using ArcGIS Server or ArcGIS Online. Share maps, layers, geoprocessing models, and geodatabases with other users—ArcMap includes tools that make it easy to package and share GIS datasets with other users. The Arc Catalog application provides a catalog window that is used to organize and manage various types of geographic information for ArcGIS Desktop.

Envi 5.5

The ENVI Modeler is a visual programming tool that you can use to create custom task-based workflows in ENVI. It combines the power of the ENVI application programming interface with a simple and intuitive user interface to help you build workflows without any knowledge of ENVI programming.

CHAPTER 4

RESULT AND ANALYSIS

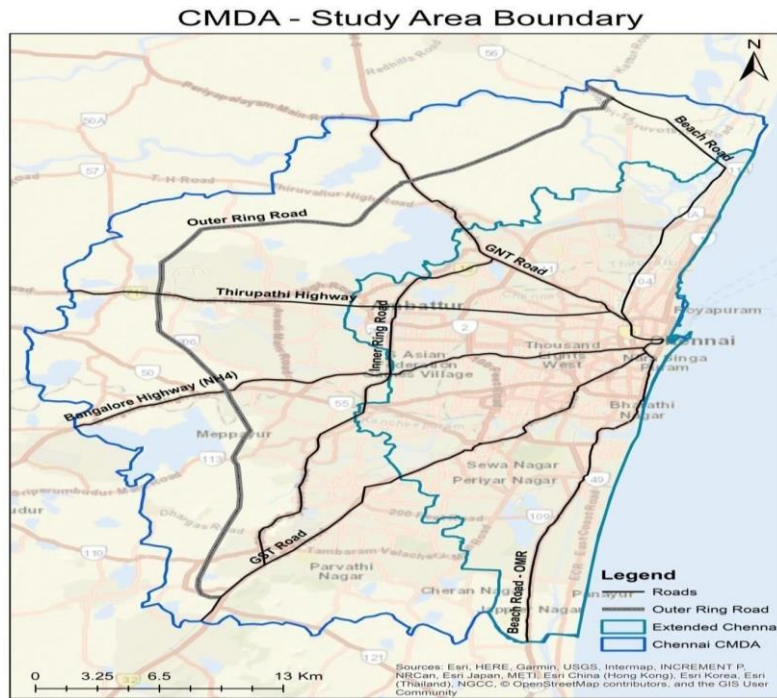


Figure 4.1: CMDA Boundary and overlaid above the Topo map

Chennai, the capital City of Tamil Nadu is the fourth largest Metropolitan City in India.

The expanded Chennai Metropolitan Area (CMA) comprises the Greater Chennai Corporation, Avadi Corporation, Tambaram Corporation, Kancheepuram Corporation, 12 Municipalities, 13 Town Panchayats, 1 Special Grade Town Panchayat and 22 Panchayat Unions (Comprised of 1321 villages). The present extent of CMA is 5904 Sq.km. (*The setting of Chennai is presented in the Figure*).

The expanded CMDA falls in five Districts of the Tamil Nadu State viz. Chennai District, parts of Thiruvallur District, Kancheepuram District, Chengalpattu District, and part of Arakkonam Taluk of Ranipet District.

CMDA comprised of Greater Chennai Corporation, Avadi Corporation, Tambaram Corporation, 5 Municipalities & 3 Town Panchayats and 10 Panchayat Unions (comprising of 179 villages) with a total extent of 1189 sq.km. under Chennai District and parts of Thiruvallur, Kancheepuram. In October 2022, the jurisdiction of CMA was expanded by inclusion of contiguous areas in 1225 villages.

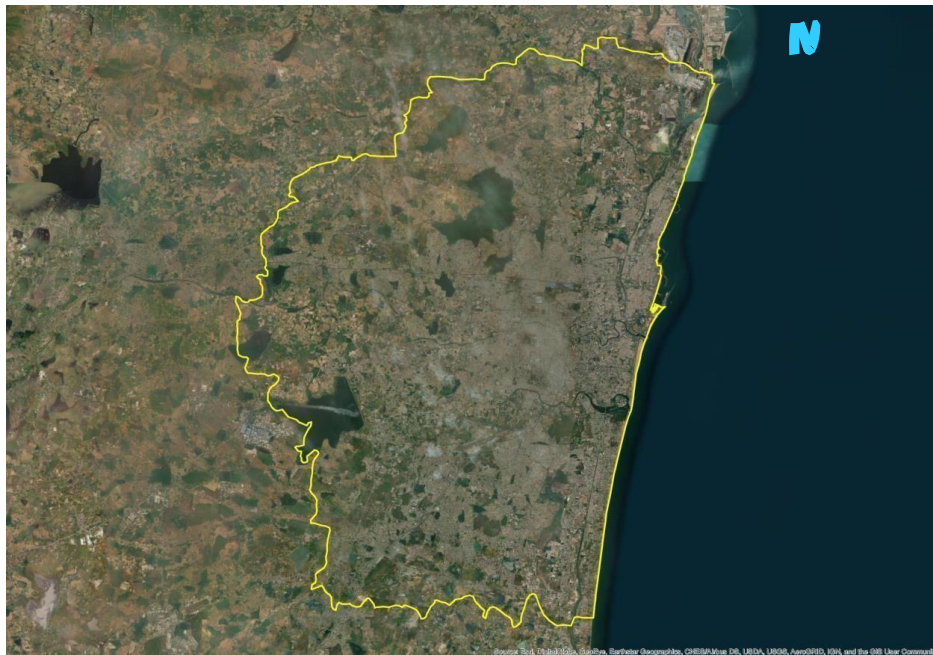


FIGURE 4.2: CMDA boundary derived using ARC GIS Software

Base maps serve as a reference map on which you overlay data from layers and visualize geographic information. An individual base map can be made of multiple feature, raster, or web layers.

The ArcGIS Pro base map gallery includes several premade base map layers for you to use in your maps. After you add a map to your project, the base map can be changed from the Map tab.

When a new base map is added to a map, it includes an elevation surface. The elevation surface is included in case you want to use the base map in a scene. When you add a custom base map to a 2D map from the base map gallery, the elevation surface is not included.

The other predefined base maps included in the base map gallery are designed to be used at multiple map scales so the base map portrays appropriate content at each range of map scales. These base maps are relatively static and are updated on an infrequent basis.

Some base maps (such as the Terrain with Labels base map) include an independent reference layer with labels, which allows you to turn on and off its labels. In other base maps, the labels are included within the map layer.

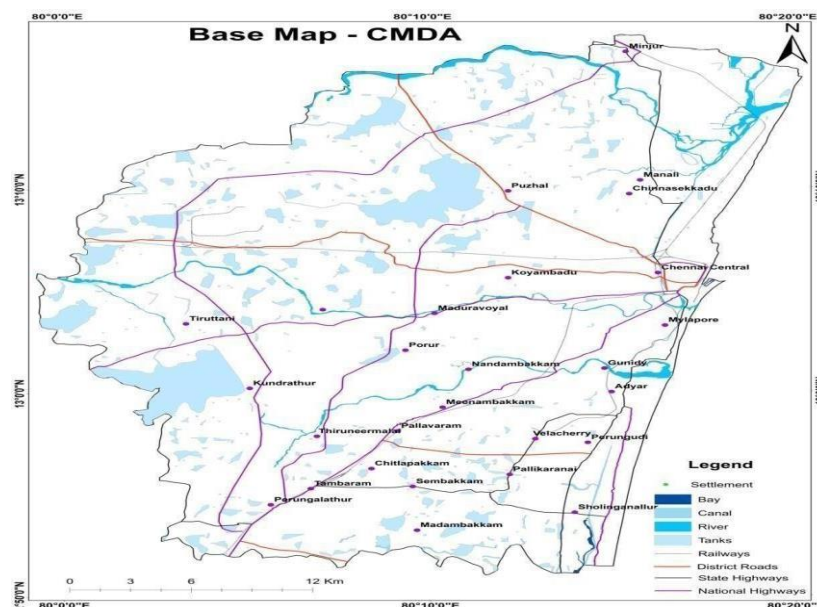


FIGURE 4.3: CMDA BASE MAP

CMDA – Base Map in Chennai

- Study area Chennai CMDA boundary covers approximately 1217 Sq. Km
- It lies in-between 79° 59' 32.461" to 80° 20' 45.157" E Longitude and 12° 52' 8.205" to 13° 17' 18.177" N Latitude
- The CMDA boundary covers 5 districts in Tamil Nadu State viz. Chennai, parts of Kancheepuram, Thiruvallur, Ranipet, Chengalpattu districts. The study area receives a rainfall of 1400 mm/annum
- Coovum and Adyar is the term to be important river. Kosasthalaiyar and Araniyar is the another main waterbodies.

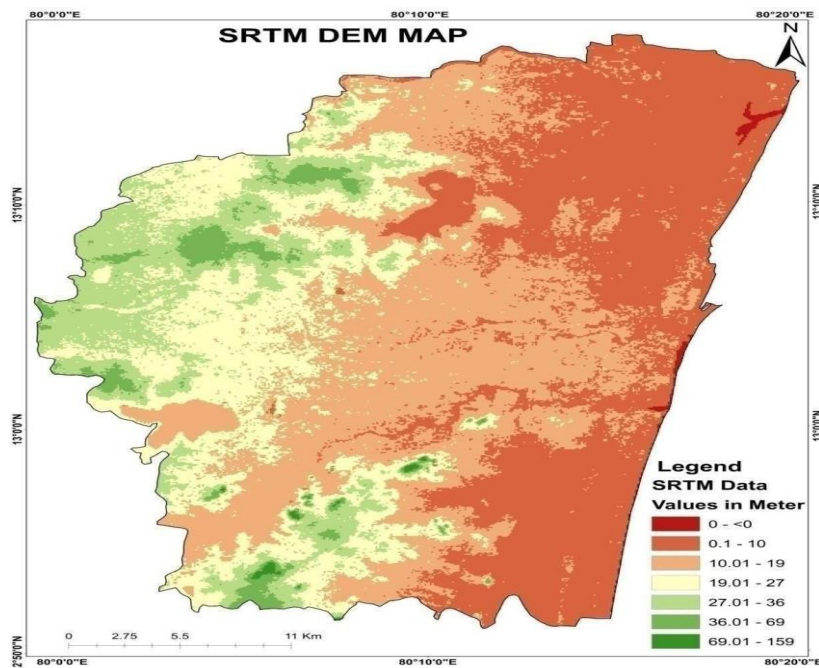


FIGURE 4.4: SRTM DEM MAP

SHUTTLE RADAR TOPOGRAPHY MISSION AND DIGITAL ELEVATION MODEL

The Shuttle Radar Topography Mission (SRTM) is an international research effort that obtained digital elevation models on a near-global scale from 56°S to 60°N, to generate the most complete high-resolution digital topographic database of Earth prior to the release of the ASTER GDEM in 2009.

SRTM uses the radar interferometry technique. In radar interferometry, two radar images are taken from slightly different locations. Differences between these images allow for the calculation of surface elevation or change. SRTM was launched into an orbit with an inclination of 57 deg.

SRTM data values in meter.

The Red color in the map indicates that the place is with the highest heat spots and the value is 0 - <0. The dark orange color in the map indicates that the place has a bit less heat spots than red color places and the value is 0.1 - 10. The light orange color in the map has a value of 10.01 - 19. The white color has a value of 19.01 - 27 and the vegetation lands colors are dark green, green and light green, which have a values of 27.01 - 36, 36.01 - 69, 69.01 - 159 respectively.

SRTM satellite data downloaded from USGS Glovis Website and subsetting using CMDA boundary.

Density slices the data to demarcate elevation levels. From this, Chennai CMDA limit covers the minimum of 0 meter to maximum of 159m elevation.



FIGURE 4.5: IRS P6 - 2020 Satellite Imagery

Indian Remote-Sensing Satellite-P6 (IRS-P6), renamed ResourceSat-1, was an optical imaging satellite operated by the Indian Space Research Organisation (ISRO). As the last satellite of the IRS series, it monitored the natural resources and environments of India from its launch in October 2003 until its operation ended in 2013.

IRS-P6 / RESOURCESAT-1. RESOURCESAT-1 is the tenth satellite of ISRO in IRS series, intended to not only continue the remote sensing data services provided by IRS-1C and IRS-1D, both of which have far outlived their designed mission lives, but also to vastly enhance the data quality.

- Resolution - 5.6meter
- Band - 4,3,2

IRS-P6 (also known as ResourceSat-2) launched on 17 October 2003 from Satish Dhawan Space Centre by the Indian PSLV-C5, and came to an end. The mission was part of the IRS, Indian Remote-Sensing Satellite series of ISRO (Indian Space Research Organization).

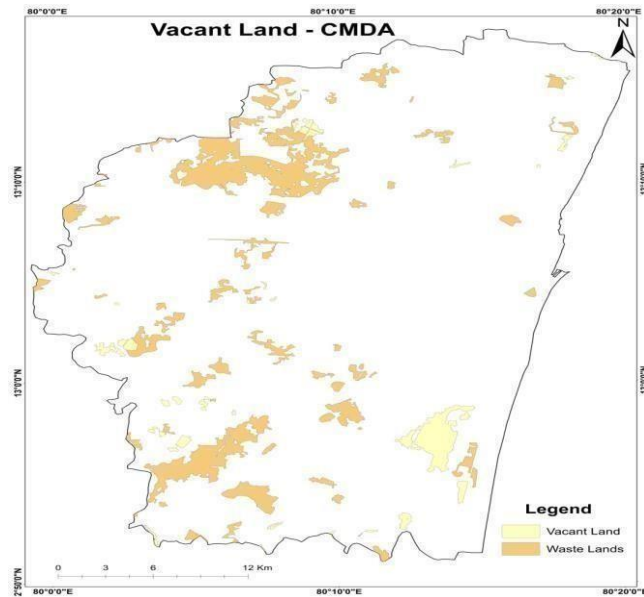


FIGURE 4.6: VACANT LAND-CMDA IN CHENNAI

Vacant Land means all properties without any buildings or structures that could be used for residential or other purposes.

The cream color on the CMDA map indicates Vacant land and the orange color on the CMDA map indicates Waste lands.

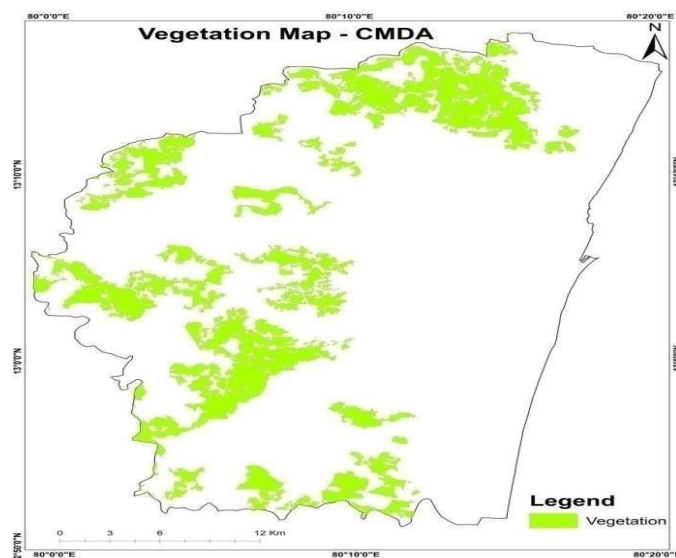


FIGURE 4.7: VEGETATION MAP-CDMA CHENNAI

All the green color spots on the CMDA map indicates vegetation.

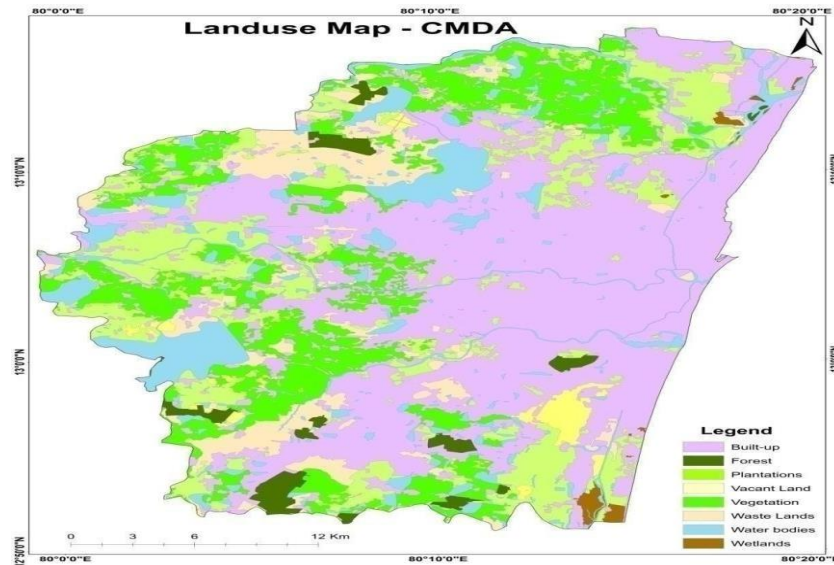


FIGURE 4.8: LANDUSE MAP-CDMA CHENNAI

In the land use map of CMDA the violet color indicates the Built-up, Dark green color indicates Forest, Light green color indicates Plantation, White color indicates Vacant land, Green color indicates Vegetation, Cream color indicates Waste land, Blue color indicates Water bodies and the brown color indicates Wetlands.

land use classification

TABLE 4.1: AREA OF LAND USED

LANDUSE	AREA (in Km²)
Built-up	542.36
Vegetation	202.71
Plantations	195.5
Forest	25.88
Water bodies	130.55
Waste land	93.86
Vacant land	19.8

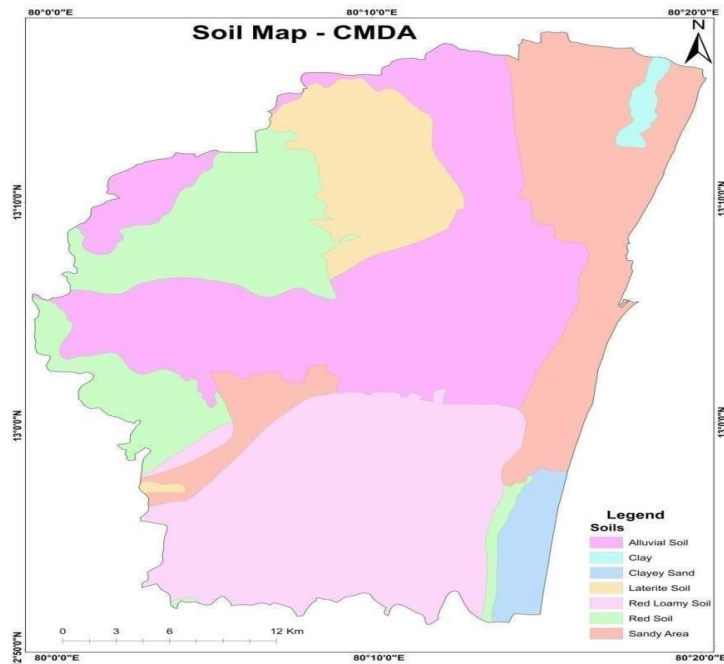


FIGURE 4.9: SOIL MAP

In the Soil map Lavender color indicates Alluvial soil, Turquoise blue indicates Clay, Blue color indicates Clayey sand, Orange color indicates Laterite sand, Pink color indicates Red loamy soil, Green color indicates Red soil and Brown color indicates Sandy area.

Urban Heat Spot (Landsat ETM + Imagery)

Image Preprocessing: (Envi Software) - 2020 year, 2 season

- Downloaded the Chennai CMDA study area - Landsat Satellite Imagery using Glovis USGS Website
- Converted all 8 bands into Imagery Format
- Layer Stacking the Satellite Imagery for further processing
- After Layer Stacking taking Landsat Band 6¹ and 6² for Temperature Studies
- Using Data Merging, Merge Band 6¹, 6² for temperature derivation
- All the process carried out by 2 seasons

Steps to find Urban Heat Spot in CMDA Chennai

- Subset the imagery as per the Study Area
- Thermal Calibration
- Emissivity Calculation
- Thermal Radiance Calculation
- Land Surface Temperature Calculation using LST tools in ENVI Software
- Temperature Calculation
- Convert the Imagery in to GIS Software
- Convert the Imagery files to shape files in ARC GIS to understand the easiest way to understand the urban hotspots.

A thermal calibration is a reliable, reproducible and documented comparison of one piece of equipment under test (data logger, sensor, thermometer) with another piece of equipment that has been temperature calibrated and referenced to a known set of parameters.

Emissivity can be defined as the ratio of the emissive power of body temperature and emissive power of the black body at same temperature. It is a dimensionless quantity.

Thermal radiation is electromagnetic radiation that is emitted by a body as a result of its temperature. All objects with a temperature above absolute zero emit thermal radiation in a spectrum of wavelengths.

Temperature is the degree of hotness or coldness of an object.

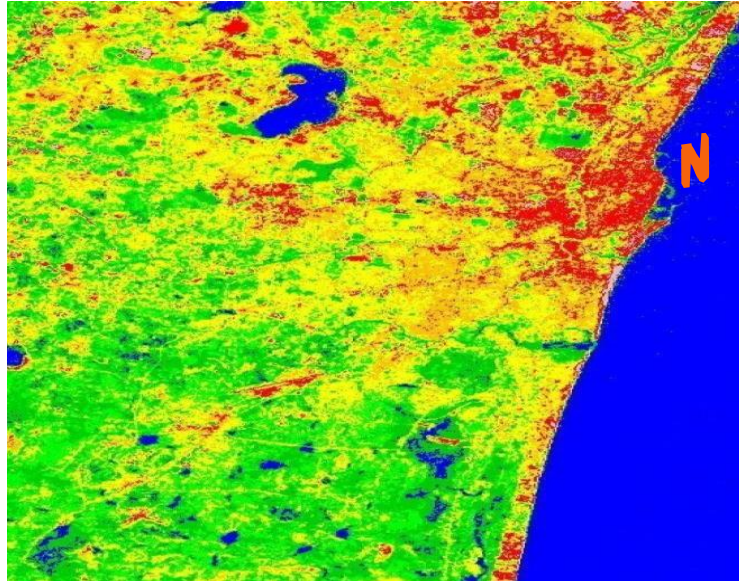


FIGURE 4.10: Land Surface Temperature (LST) of Landsat Enhanced Thematic Mapper + imagery

The image clearly indicates the Urban Heat Spots are indicated in the red colour in the imagery, Green color indicates the less temperature area and the waterbody indicates in blue color.

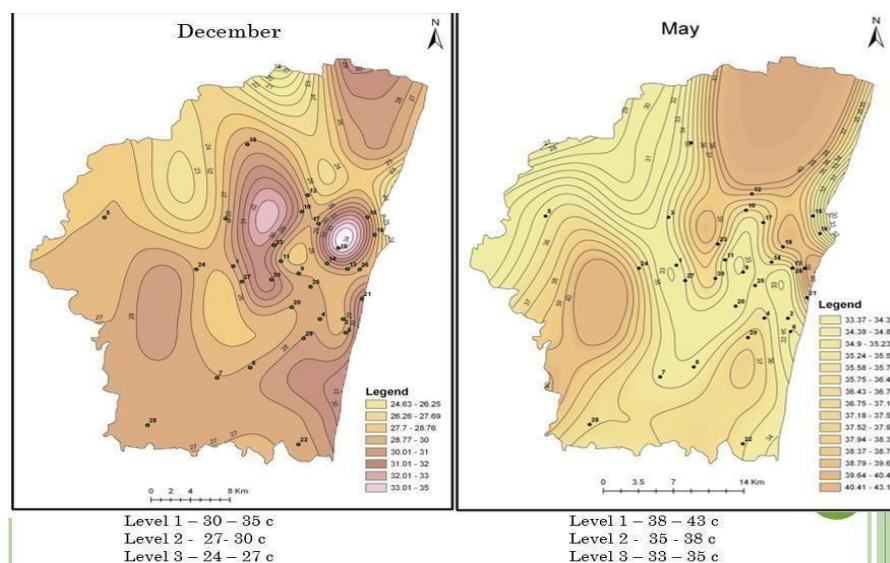


FIGURE 4.11: CONTOUR MAP

Overlay analysis is a group of methodologies applied in optimal site selection or suitability modeling. It is a technique for applying a common scale of values to diverse and dissimilar inputs to create an integrated analysis. Suitability models identify the best or most preferred locations for a specific phenomenon.

Overlay analysis is one of the spatial GIS operations. Overlay analysis integrates spatial data with attribute data. (Attributes are information about each map feature.) Overlay analysis does this by combining information from one GIS layer with another GIS layer to derive or infer an attribute for one of the layers.

In May month, since the heat is high it's difficult for plants to grow but in December the climate is perfect for the plants to grow. There are three levels of temperature in May and December. In December the Level 1 temperature is 30 - 35 degrees, Level 2 temperature is 27 - 30 degrees and Level 3 temperature is 24 - 27 degrees. While in May the Level 1 temperature is 38 - 43 degrees, Level 2 temperature is 35 - 38 degrees and Level 3 temperature is 33 - 35 degrees.

TABLE 4.2: Overlay Analysis

S.NO	LEVEL 1	LEVEL 2	LEVEL 3
Landuse	Waste land,vacant land	Vegetation,plantation, forest	Built-up waterbodies
DEM	0-19m	19-36m	36-159m
Soil	Alluvial and red loamy soil	Laterite and clay soil	Sandy soil and other areas
Urban heatspots	Ranges of level 1	Ranges of level 2	Ranges of level 3

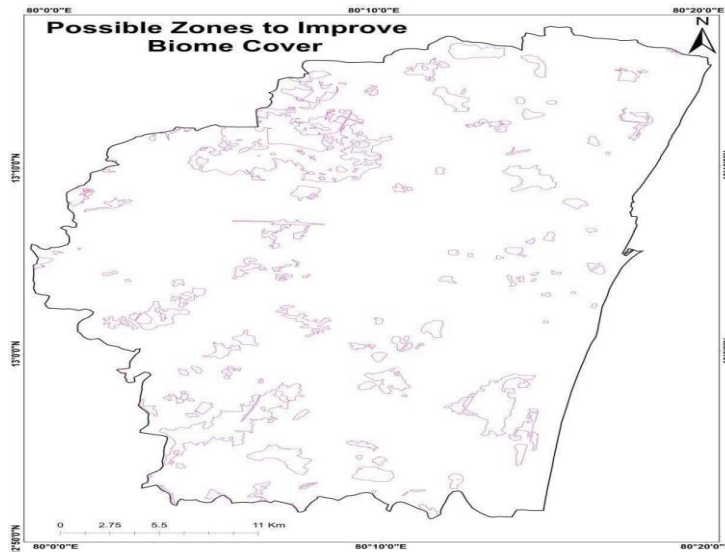


FIGURE 4.12: POSSIBLE ZONES TO IMPROVE BIOME COVER IN CMDA CHENNAI

As per the thematic layer and its Level the weighted overlay analysis was carried out in ARCGIS Software and we derived the zones to improve the Biome cover.

Total Possible zones to improve Biome Cover is 116.81 Sq.Km.

The possible ways to improve Biome cover are:

- 1. Reforestation:** Planting new trees on deforested land can help to restore the area's original biome cover.
- 2. Land restoration:** By removing invasive plant species and restoring natural soil conditions, it is possible to encourage the growth of endemic plant species and improve the overall biome cover in the area.
- 3. Encouraging native species:** When developing new areas, it is important to select native plants and trees that will thrive in the soil and climate of the region. This can help to ensure that the new developments will not displace existing ecosystems.
- 4. Reducing pollution:** Pollution can greatly impact the health of plants and trees, making them more susceptible to diseases and pests. By reducing pollution, plants and trees will be better equipped to thrive and improve the biome cover.

5. Sustainable land use: Developing land in a way that supports the existing biome can go a long way toward preserving biodiversity. This can include practices such as avoiding excessive clearing of land, using environmentally conscious farming methods, and avoiding the overuse of fertilizers and pesticides.

By taking these steps, we can work to preserve and improve the health of our planet's diverse biomes. As the saying goes, "We do not inherit the earth from our ancestors; we borrow it from our children." Let's work together to ensure that future generations have a planet that is healthy, diverse, and thriving.

Therefore,

- As per the objective, generated the spatial database of Urban Hotspots of CMDA area and digitized the land use/land cover map. From the Land use/land cover map we derived the vacant land map
- From SRTM DEM, we derived the ranges of elevation in-between 0- 159m
- Soil Map also derived from the Indian Soil Data (Source: CRSG (NBSS))
- Integrated the above thematic layers and generated the ranges for Weighted Overlay analysis, and performed in ARCGIS Software
- From the above method, the resulted thematic layer is the vacant land which is possible to plant more number of high carbon potential trees and to reduce the impact of heat spots in the urban environment.

From the above results, as per the recommendation by the Agricultural and Forest Department of Government, the complete vacant land is converted as a sample plot in to 3 ha. In that particular 3 ha, the region housed 438 trees of 37 species and 17 families, with an accumulated biomass of 101.44 t, 48.18 t of carbon and 176.64 t of CO₂. *Delonix regia* had the largest amounts of species-specific biomass and CO₂ stocks, followed by *Tamarindus indica*, *Ficus religiosa*, *Albizia lebbeck* and *Ficus benghalensis*. *Azadirachta indica*, *Peltophorum pterocarpum*, *Samanea saman* and

Senna siamea had the highest numbers and relative abundances in roadside plantations. The 10 tree species that sequestered more than 80% of CO₂ were, in order of highest to lowest sequestration, Delonix regia, Samaneasaman, *Tamarindus indica*, Azadirachta indica, Ficus religiosa, Peltophorumpterocarpum, Albizia lebbeck, Terminalia catappa, Ficus benghalensis and Terminalia arjuna. These tree species are therefore recommended for roadside plantations and vacant land plantations to sequester large amounts of CO₂ from the city and contribute to offsetting warming and mitigating the impact of climate change.

TABLE 4.3: Carbon sequestration of plants

TREE SPECIES	HEIGHT (ft)	WIDTH (ft)	CARBON SEQUESTRATION (m ³ /yr)
Oak	80	70	48
Maple	60	50	35
Pine	50	30	25
Elm	70	60	42
Birch	40	35	20

TABLE 4.4: Botanical names of plants and Carbon sequestration

S.NO	BOTANICAL NAME	COMMON NAME	CARBON SEQUESTRATION (m ³ /yr)
1.	Azadirachta indica	Neem	7
2.	Phyllanthus emblica	Nelli	9
3.	Ficus benghalensis	Alamaram	6
4.	Euphorbia antiquorum	Sadurakalli	9
5.	Memecylon umbellatum	kasan	14

CHAPTER 5

CONCLUSION

Therefore, in this project, the outcome that we have got is that, Generating a spatial database of Urban hotspots and vacant land information. Creating a database about the high carbon potential of trees and plants to reduce the impact of climatic changes. The last outcome is that, Integrating the above two aspects and generating a database for high-carbon biomass trees and recommending this to policy planners to reduce the impact of global warming and to maintain the sustainable ecosystem of the urban environment. The generated spatial database of Urban hotspots and vacant land information Created a database about the high carbon potential trees and plants to reduce the impact of climate change. Integrated the above two aspects and generating a database for high carbon biomass trees and recommending this to policy planner to reduce the impact of global warming. Spatial analysis can be a useful tool for studying urban heat spots and green belts, which are critical components of urban ecosystems. By identifying these areas, it becomes easier to enhance carbon sequestration and mitigate the effects of climate change. The spatial analysis helps policymakers and urban planners to make better decisions related to urban development and management. Green belts play a vital role in mitigating urban heat spots by providing shading and cooling effects. Furthermore, urban green belts are known to have a significant impact on carbon sequestration, contributing to the reduction of greenhouse gas emissions. Therefore, it is essential to prioritize the protection and development of green belts within urban settings. Carbon sequestration is a critical aspect of climate change mitigation, and urban green spaces are central to this process. Through strategic spatial analysis, policymakers can identify areas within urban landscapes that provide the most significant potential for carbon sequestration. This information can then be utilized to develop targeted urban forestry programs that enhance carbon sequestration while promoting sustainable urban development.

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