Plants are most important biotic component of ecosystem, special attention must be given to research on improvement of plant growth and utilization of plants for sustainable development. This book comprises of research and review papers on various plants; on several aspects like Hypolipidemic activity, Biocontrol agent for sustainable environment, Antioxidant potential of wound healing plants, Effect of polyherbal preparation, Micropropagation, Natural regeneration, Carbon sequestration potential of tree species, Impact on rearing performance, Induced variations in quantitative traits, Effect of potting media, Effect of Azospirillum strains, Use of Gliricidia, Growth and sporulation of Alternaria, Effect of biomethaneted spent wash along with bio-compost, Ectoparasite control, Effect of zein protein coating, Phytochemical Effect, Effect of biofertilizers, Effect of garbage bio-pesticide, etc. written by professors and researchers. This book is useful for researchers, academicians, students, nature lovers, environmentalists, government officials and policy makers etc.

Dr. Pratap V. Naikwade is editor and one of authors of this book. He has completed post doc research from USA. He is author of several research papers and books, worked as invited speaker in International Conferences, recipient of Young Scientist, Outstanding Researcher, The Environmentalist and other Awards also got international recognition.

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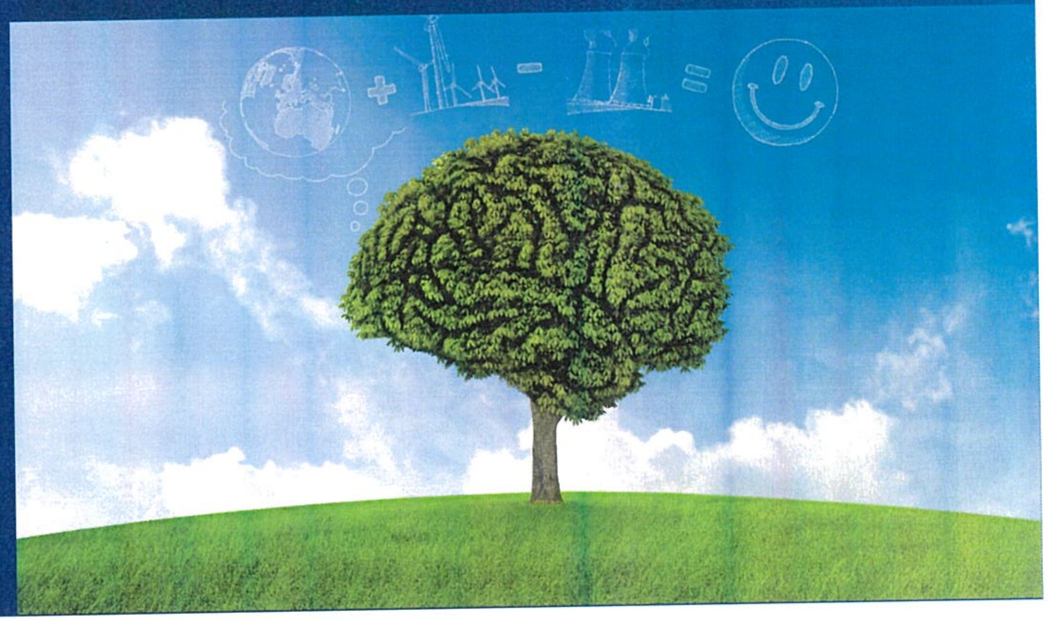
Plants: Growth and Uses

Naikwade (Ed.)





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# Plants: Measures to Improve Growth and Various Uses

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# CHAPTER 4

## Carbon Sequestration Potential of Tree Species along Road Side of N Ward, Mumbai, (Ms) India

Anil Avhad and Rajkumar Diwakar
Department of Botany,
R. J. College of Arts, Science and Commerce (Autonomous)
Ghatkopar (W), Mumbai, Maharashtra, India
E mail: anilavhad@yahoo.com

**Abstract**

Climate change is one of the major concerns in the twenty first century, not only as environmental issue but also with severe socioeconomic implications. The impact of climate change is wide spread, in different strata of the organisms around the globe. The urban areas are turning into heat islands, constructing cemented structures to accommodate increasing population. Trees are the major capital asset in cities, as we get variety of benefits like shade, filtration of air pollutants, better property and more aesthetic value. Trees are very important to sequest carbon-dioxide from the atmosphere, decreasing its concentration and reducing greenhouse effect. In the present investigation aboveground biomass and belowground biomass, carbon sequestration potential of tree species, growing along road side of N ward, Brihanmumbai Municipal Corporation (BMC) Mumbai, was measured. Total standing biomass of selected tree species was calculated. Total 6495 trees are assessed with 43 different species. Out of which 3240 trees are Exotic and remaining 3255 are endemic or native, Biomass and carbon sequestration rate of tree species have been estimated using non-destructive method. The aboveground and belowground biomass (tones/tree) and total organic carbon of each species were calculated and

compared with allometric model. *Ficus benghalensis* was found to be,sequestrated 640.4525 tons of carbon/Tree. *Petophorum pterocarpum* an exotic species found to be a dominant species with a count of 2324 trees and has sequestrated 447.09022 tons of carbon/tree. *Caryota urens* species were found as less carbon sequestrating species as sequestrating 2.8831887 tons of carbon/tree

**Key words:** *aboveground, belowground, organic carbon, carbon sequestration, total organic carbon, total biomass*

## Introduction

Trees in the urban forest provide multiple ecosystem benefits (Nowak, 2006; Stenger *et al.*2009). With increasing urbanization there is a need to incorporate the role of the urban forest into long term planning and climate adaptation strategies in order to improve environmental quality (Gill *et al., 2007).* Many studies have assessed the environmental value of an ecosystem qualitatively, listing the animals and plants found there and describing the network of systems — water, air, nutrients —that provide the underlying function. Some studies have also valued these services using contingent evaluation (willingness to pay. willingness to accept), hedonic pricing, or avoided cost methods. Yet, to incorporate the role of the urban forest in environmental policies the impacts of trees need to be quantified. Since the release of the Millennium Ecosystem Assessment (2005a) there has been increased interest in defining and valuing our ecosystem services because, as a direct result of undervaluation, over two thirds of our natural ecosystems have been degraded (Millennium Ecosystem Assessment, 2005b).

In order to develop viable strategies for conserving ecosystem services, it is important to estimate the monetary value so the importance can be demonstrated to the main stakeholders and beneficiaries (The Economics of Ecosystems and Biodiversity, 2009). Furthermore, the ecological state of a city depends heavily on the state of its urban trees (Whitford *et al.,* 2001: Dobbs *et al.,* 2011) and to estimate the structure, function and value of the urban forest is an important first step in the sustainable management of natural capital.

It is mandatory for each and every Municipal corporation to carry out a tree census in its jurisdiction and publish the data, therefore majority of the corporations are doing it for the sake of publishing the data. Such surveys are carried out with the help of private organizations which mentions the number and description of the plants observed. Rarely instruments like GPS are used to note the position of these plants. With increasing urbanization there is a need to incorporate the role of the urban forest into long term planning and climate adaptation strategies in order to improve environmental quality (Gill *et al.,* 2007)

Carbon is held in different natural stocks in the environment such as, oceans, fossil fuel deposits, terrestrial system and atmosphere. In the terrestrial ecosystem, carbon is sequestered in rocks and sediments, wetlands and forests, and in the soils of forestland, grasslands and agricultural land. Carbon sequestration phenomenon involves the extraction of the atmospheric carbon dioxide and its storage in terrestrial ecosystems for a very long period of time.

Plants store carbon in terms of the live biomass. Once they die, the biomass becomes a part of the food chain and enters the soil as soil carbon. If the biomass is incinerated, the carbon is re-emitted into atmosphere

(Suryawanshi *et al.,* 2014).Terrestrial storage of carbon is in tree trunks, branches, foliage, and roots which is called biomass. Terrestrial vegetation and soil represents important sources and sinks of atmospheric carbon (Watson *et al.*, 2000).

Trees act as a sink for $CO_2$ by fixing carbon during photosynthesis and storing excess carbon as biomass. Trees are carbon reservoir on earth. Forest ecosystem plays important role in the global carbon cycle by sequestering a substantial amount of carbon dioxide from the atmosphere (Vashum and Jay Kumar, 2012). As more photosynthesis occurs, more $CO_2$ is converted into biomass, reducing carbon in the atmosphere and sequestering it in plant tissue above and below ground (Gorte, 2009; IPCC, 2003) resulting in growth of different parts (Chavan and Rasal, 2010). Importance of forested areas in carbon sequestration is already accepted, and well documented (FSI, 1988; Tiwari and Singh, 1987).

Very few attempts have been made to study the potential of trees in carbon sequestration from urban area. Non-forested but tree dominated area in cities includes 'green pockets' such as institutions, avenues and public gardens. The role of such areas in urban ecosystem needs to be addressed. The present study was undertaken to evaluate the status of such green pockets, vegetation in fringe forest pockets and green areas.In the present investigation aboveground biomass and belowground biomass carbon sequestration potential of tree species growing along road side of N ward of Brihanmumbai Municipal Corporation (BMC) of Mumbai city was measured.

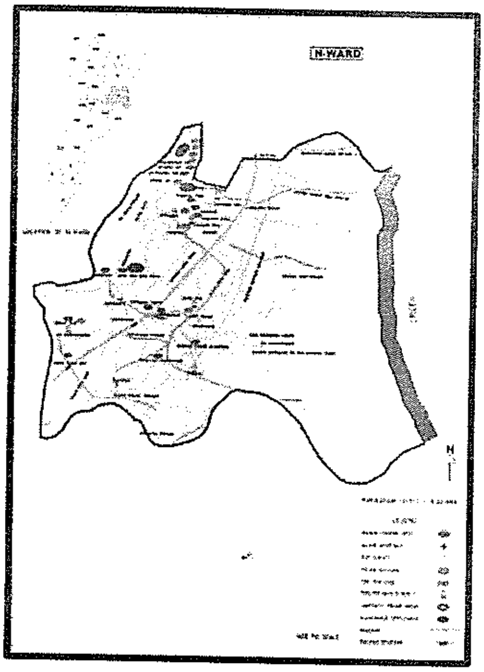



Fig 1.1: Map of N Ward, BMC



**Material and Methods**

In the present study most of the tree species encountered were identified in the field on the basis of their morphological characters. The Flora of Maharashtra, Flora of Delhi, online Flowers of India database and Bombay Presidency were used as references and online database of The International Plant Names Index (IPNI) were used to find the latest and acceptable international scientific name of the tree species.

GPS device (Trimble JUNO SA) along with the Tree mapping software (Terrasync) was used to record GPS positioning of each tree individuals and to caporal structural parameters. Arc GIS was used as a platform to create GIS-based maps.

Tree Census was conducted in “N ward of BMC”along various roads and public parks. For each tree parameters like Botanical name, Common name, probable age, type, girth, approximate height, roots and health was mentioned.For marking the position of those trees GPS system (Trimble Juno SA 7) was used. Calculation of annual $CO_2$ sequestered by certain dominant species with the help of girth and height of the tree. The non-destructive method for carbon estimation was employed, in this method we need not to harvest the entire bio-volume and sacrifice the tree. In the present study, the data of species complied, tabulated and below equations were inserted in MS-Excel-2007 and the following results were obtained. The girth of the tree is measured at the girth at breast height (GBH) 1.32m above ground surface. Tree diameter (D) was calculated with the formula shown in the reference (Bohre *et al.*, 2012) i.e. $(GBH/3.14)^2$. Biomass is evaluated in above listed tree species is calculated by simply applying of bio-statistics based allometric equations. Above ground Biomass (AGB) are estimated by multiplying the bio-volume to the green wood density of tree species. Tree bio-volume (TBV) value established by multiplying of diameter and height of tree species to factor 0.4.

**Bio-volume (T) = 0.4X (D) x H ......Eq.-1 [$D = (GBH / 3.14)^2$]**

**AGB=Wood density x T .......Eq. -2**

Where D is calculated from GBH, assuming the trunk to be cylindrical, H = Height. Wood density is used from Global wood density database, (Zanne *et al.*, 2009). The standard average density of 0.6 gm/ cm is applied wherever the density value is not available for tree species. The below ground biomass has been calculated by multiplying the above ground biomass (AGB) by 0.26 factors as the root: shoot ratio (Hangarge *et al.*, 2012).

**BGB=AGB x 0.26** ........Eq.-3

Total biomass is the sum of the above and below ground biomass. (Sheikh *et al.*, 2011)

Total Biomass (TB) = Above Ground Biomass + BelowGround Biomass .....Eq.-4

**Carbon Estimation**

Generally, for any plant species 50% of its biomassis considered as carbon (Pearson et al., 2005) i.e.

**Carbon Storage = Biomass x50%or Biomass/2**.......Eq.-5

**Results and Discussion**

**Table 1.2- Species composition at N ward of BMC**

| Sr No | Botanical Name | Family | Origin | Total Number | Avg GBH (Cm) | Avg Height (Cm) |
|---|---|---|---|---|---|---|
| 1 | *Peltophorum pterocarpum* | Caesalpinae | Exotic | 2324 | 145.1 | 242 |
| 2 | *Syzygium cumini* | Myrtaceae | Native | 115 | 112.3 | 1061 |
| 3 | *Samanea saman* | Mimosae | Exotic | 548 | 179.6 | 1322 |
| 4 | *Polyalthia longifolia* | Annonaceae | Native | 277 | 93.37 | 940 |
| 5 | *Pongamia pinnata* | Fabaceae | Native | 239 | 93.37 | 965 |
| 6 | *Ficus racemosa* | Moraceae | Native | 89 | 117.4 | 1000 |
| 7 | *Ficus religiosa* | Moraceae | Native | 358 | 152.0 | 1033 |
| 8 | *Ficus benghalensis* | Moraceae | Native | 143 | 187.5 | 1188 |
| 9 | *Delonix regia* | Caesalpinae | Exotic | 247 | 116.5 | 1068 |
| 10 | *Moringa oleifera* | Moringaceae | Native | 38 | 88.46 | 800 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 11 | *Cocos nucifera* | Palmae | Native | 260 | 122.5 | 1177 |
| 12 | *Muntingia calabura* | Eliocarpaceae | Native | 23 | 59.08 | 625 |
| 13 | *Ziziphus jujuba* | Rhamnaceae | Native | 74 | 89.45 | 831 |
| 14 | *Holoptelea integrifolia* | Ulmaceae | Native | 10 | 159.5 | 980 |
| 15 | *Thespesia popullina* | Malvaceae | Native | 291 | 111.5 | 1332 |
| 16 | *Thevetia peruviana* | Apocynaceae | Native | 5 | 53.84 | 700 |
| 17 | *Sterculia foetida* | Sterculiaceae | Native | 206 | 93.04 | 1280 |
| 18 | *Azadirachta indica* | Meliaceae | Native | 49 | 87.55 | 832 |
| 19 | *Ceiba pentandra* | Bombacaeae | Native | 39 | 133.2 | 1382 |
| 20 | *Cassia siamia* | Caesalpinae | Native | 37 | 102.74 | 915 |
| 21 | *Mangifera indica* | Anacardiaceae | Native | 83 | 108.4 | 1061 |
| 22 | *Psidium guajava* | Myrtaceae | Native | 29 | 72.13 | 785 |
| 23 | *Gliricidia sepium* | Fabaceae | Native | 8 | 123.8 | 975 |
| 24 | *Artocarpus heterophyllus* | Moraceae | Native | 31 | 101.2 | 958 |
| 25 | *Bombax ceiba* | Bombacaceae | Native | 7 | 153.8 | 1228 |
| 26 | *Alstonia scholaris* | Apocynaceae | Native | 127 | 87.73 | 807 |
| 27 | *Neolamarcki acadamba* | Rubiaceae | Native | 12 | 122.7 | 1244 |
| 28 | *Annona squamosa* | Annonaceae | Native | 12 | 57.0 | 572 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 29 | *Casuarina equisetifolia* | Casurinaceae | Exotic | 31 | 101.0 | 1083 |
| 30 | *Emblica officinalis* | Euphorbiceae | Native | 5 | 85.34 | 800 |
| 31 | *Areca catechu* | Palmae | Native | 37 | 51.23 | 766 |
| 32 | *Grevillea robusta* | Protaceae | Exotic | 2 | 77.47 | 1000 |
| 33 | *Roystonea regia* | Palmae | Exotic | 45 | 62.03 | 1143 |
| 34 | *Acacia auriculiformis* | Mimosae | Exotic | 20 | 107.74 | 1061 |
| 35 | *Lagerstroemia speciosa* | Lythraceae | Native | 281 | 104.85 | 983 |
| 36 | *Butea monosperma* | Fabaceae | Native | 121 | 56.36 | 629 |
| 37 | *Tectona grandis* | Verbenaceae | Native | 14 | 83.21 | 964 |
| 38 | *Caryota urens* | Palmae | Native | 01 | 51 | 723 |
| 39 | *Drypetes roxburghii* | Putranjivaceae | Native | 17 | 111.3 | 1157 |
| 40 | *Pithecellobium dulce* | Mimoceae | Exotic | 23 | 108.81 | 868 |
| 41 | *Plumeria alba* | Apocynaceae | Native | 02 | 54.61 | 526 |
| 42 | *Ficus benjamina* | Moraceae | Native | 19 | 106.5 | 900 |
| 43 | *Terminalia catappa* | Combretaceae | Native | 196 | 94.71 | 941 |
| | *Total* | | | **6495** | | |

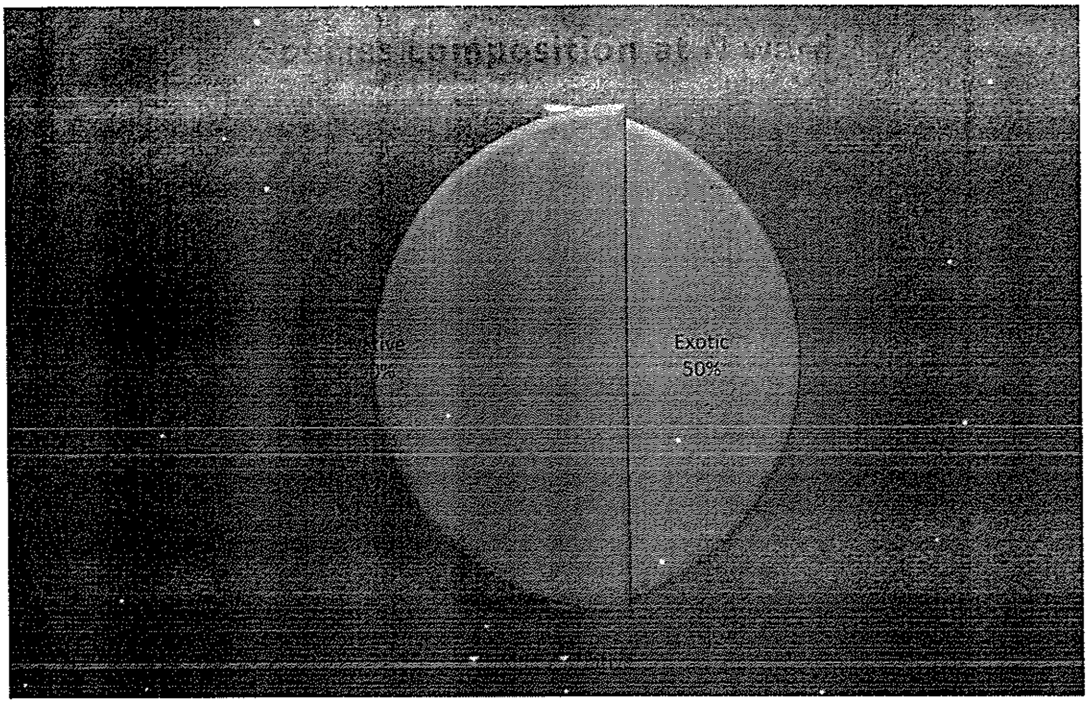
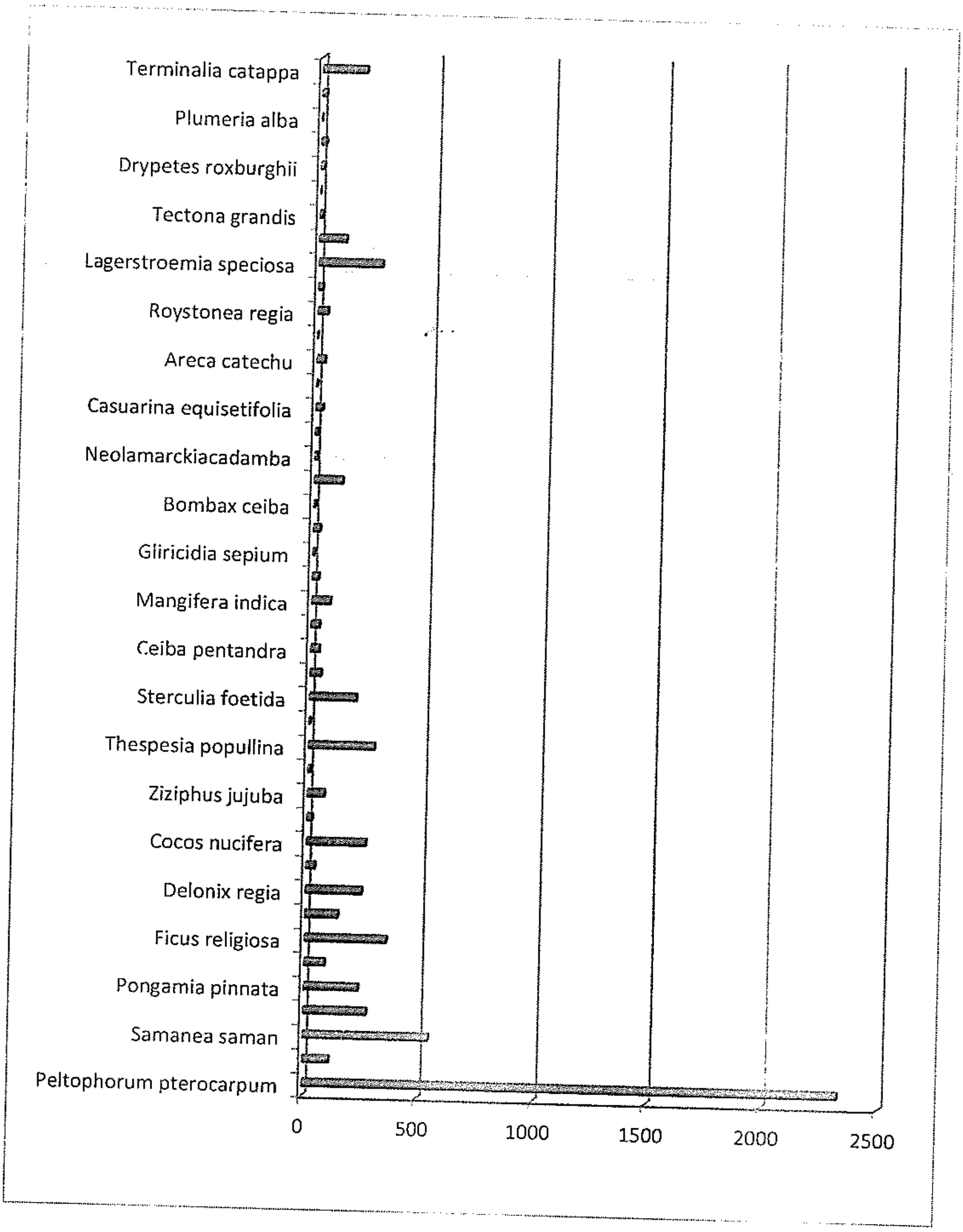



**Fig 1.2: Species composition at N ward**

Exotic Species: **3240**

Native Species: **3255**

**Chart 1.1: Species diversity and Dominance at N ward**



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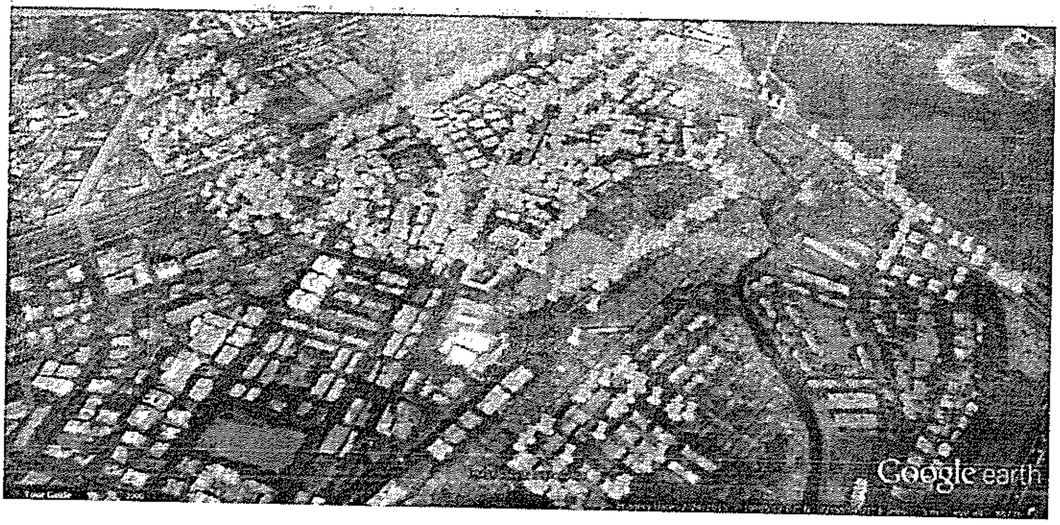
GPS Results


**Photoplate 1.6 Laxmi Nagar**


**Photoplate 1.8 Laxmi Nagar and Pant Nagar**




**Photoplate 1.9 Laxmi Nagar and Pant Nagar**


**Photoplate 1.10 Garodia Nagar**

Table 1.3 Carbon sequestration analysis

| Sr No | Species | Volume Cm$^3$ | AGB (kg) | BGB (kg) | TB (kg) | C (kg) | tC/Species |
|---|---|---|---|---|---|---|---|
| 1 | *Peltophorum pterocarpum* | 1059205 | 709667.015 | 184513.4 | 894180.4 | 447090.2 | 447.09022 |
| 2 | *Syzigium cumini* | 635373 | 444761.1 | 115637.9 | 560399 | 280199.5 | 280.19949 |
| 3 | *Samania saman* | 1729769 | 778396.26 | 202383 | 980779.3 | 490389.6 | 490.38964 |
| 4 | *Polyalthia longifolia* | 332400 | 169523.78 | 44076.18 | 213600 | 106800 | 106.79998 |
| 5 | *Pongamia pinnata* | 341240 | 204743.99 | 53233.44 | 257977.4 | 128988.7 | 128.98871 |
| 6 | *Ficus rasemosa* | 559033 | 335420.02 | 87209.21 | 422629.2 | 211314.6 | 211.31461 |
| 7 | *Ficus religiosa* | 968098 | 580859.18 | 151023.4 | 731882.6 | 365941.3 | 365.94128 |
| 8 | *Ficus benghalensis* | 1694318 | 1016591.27 | 264313.7 | 1280905 | 640452.5 | 640.4525 |
| 9 | *Delonix regia* | 588033 | 352819.58 | 91733.09 | 444552.7 | 222276.3 | 222.27634 |
| 10 | *Moringa olerifera* | 253953 | 152372.06 | 39616.74 | 191988.8 | 95994.4 | 95.994398 |
| 11 | *Coccos nusifera* | 716504 | 401242.44 | 104323 | 505565.5 | 252782.7 | 252.78274 |
| 12 | *Muntangia calabura* | 88478.9 | 53087.33 | 13802.71 | 66890.04 | 33445.02 | 33.445018 |
| 13 | *Zizipus maurencia* | 269682 | 204958.19 | 53289.13 | 258247.3 | 129123.7 | 129.12366 |
| 14 | *Holoptelia integrifolia* | 1011336 | 596688.03 | 155138.9 | 751826.9 | 375913.5 | 375.91346 |
| 15 | *Thespesia popullina* | 671642 | 349253.79 | 90805.99 | 440059.8 | 220029.9 | 220.02989 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 16 | *Thevetia peruvina* | 82289.5 | 49373.68 | 12837.16 | 62210.84 | 31105.42 | 31.105418 |
| 17 | *Sterculia foitida* | 449512 | 211270.82 | 54930.41 | 266201.2 | 133100.6 | 133.10062 |
| 18 | *Azadirachta indica* | 258704 | 178505.53 | 46411.44 | 224917 | 112458.5 | 112.45848 |
| 19 | *Ceiba pentandra* | 994748 | 328266.99 | 85349.42 | 413616.4 | 206808.2 | 206.8082 |
| 20 | *Cassia siamia* | 391716 | 235029.72 | 61107.73 | 296137.4 | 148068.7 | 148.06872 |
| 21 | *Mangifera indica* | 505730 | 262995.99 | 68378.96 | 331374.9 | 165687.5 | 165.68747 |
| 22 | *Pisidium guajava* | 165683 | 99409.56 | 25846.49 | 125256 | 62628.02 | 62.628023 |
| 23 | *Gliricidia sepium* | 606139 | 363683.39 | 94557.68 | 458241.1 | 229120.5 | 229.12054 |
| 24 | *Artocarpus heterophyllus* | 397926 | 238755.37 | 62076.4 | 300831.8 | 150415.9 | 150.41588 |
| 25 | *Bombax ceiba* | 2946075 | 972204.83 | 252773.3 | 1224978 | 612489 | 612.48904 |
| 26 | *Alstonia scholaris* | 251897 | 83126 | 21612.76 | 104738.8 | 52369.38 | 52.36938 |
| 27 | *Neolamarchiana cadamba* | 759694 | 455816.4 | 118512.3 | 574328.7 | 287164.3 | 287.16433 |
| 28 | *Annona squamosa* | 75383.8 | 45230.26 | 11759.87 | 56990.13 | 28495.06 | 28.495064 |
| 29 | *Casurina equisitifolia* | 448122 | 371941.21 | 96704.71 | 468645.9 | 234323 | 234.32296 |
| 30 | *Emblica officinales* | 236299 | 141779.63 | 36862.7 | 178642.3 | 89321.17 | 89.321167 |
| 31 | *Areca catacheu* | 81533.8 | 48920.25 | 12719.27 | 61639.52 | 30819.76 | 30.819758 |
| 32 | *Gravelia robusta* | 243463 | 146077.82 | 37980.23 | 184058.1 | 92029.03 | 92.029027 |