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Environmental Benefits of Trees Outside Forest (TOF)

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***Abstract*—**As per the Forest Survey of India (FSI), Trees Outside Forest (TOF) ―are in the form of small woodlots and block plantations, trees along linear features, such as roads, canals bunds, etc. and scattered trees on farmlands, homesteads, community lands and urban areas. Trees serve multiple environmental purposes such as supporting other biodiversity, scavenging pollutants off the ambient air, attenuating noise, enriching soil, enhancing groundwater quality and sequestering carbon. The number of TOF in urban areas is substantial and they constitute a massive opportunity for trees to serve environmental purposes in urban areas, where they are needed the most. The need is compounded more in metropolitan cities and their suburbs as there is more dense population and consequently more pollution. To combat this stress on environment, studies are essential at various levels so that remedial steps can be taken judiciously for the betterment of the planet earth. To assess the total estimate of the environmental services yielded by trees in the Thane city of Maharashtra, the i-Tree Eco model was used. The findings elaborate on the green wealth that trees provide and sharpen the focus on ecological conservation outside forest areas.

1. INTRODUCTION

Trees outside forest (TOF) have been defined by the Forest Survey of India (FSI) as "small woodlots and block plantations, trees along linear features, such as roads, canals bunds, etc. and scattered trees on farmlands, homesteads, community lands and urban areas". While a critical aspect of conservation is to prioritize, earmark and protect undisturbed ecosystems, another equally important activity must be to conserve species in disturbed and manmade habitats like towns and cities.

According to Maharashtra (Urban Areas) Protection & Preservation Of Trees Act 1975 chapter four section 7 (b) once before December 1996 and thereafter once in every five years, carrying out a census of the existing trees in all land within its jurisdiction is mandatory for all municipalities. Thus, all major cities in Maharashtra are supposed to allocate a budget for the tree census activity and ensure that the same is carried out as per the stipulated guidelines. To give an estimate, the city of Thane has 7,23,000 trees. Mumbai has 29,00,000 trees while Nashik and Pune have 47,00,000 trees each.

From this perspective, TOF acquire immense importance, for these lakhs of trees in bustling human settlements are providing their multifarious goods and services in locations where they are much sorely needed.

Trees provide a host of ecosystem services. Apart from being a source of food, clothes, medicines, fuel, wood etc. (provisioning services), trees maintain genetic diversity and support other biodiversity (supporting services), ameliorate the biosphere, aid in pollination, check climate change, and regulate flooding (regulating services) and also provide opportunities for eco-tourism, nature-based adventure, spiritual healing, horticultural therapy and other socio-cultural services (cultural services). Indeed, research has proved that trees attenuate air, noise and thermal pollution, trap greenhouse gases like carbon dioxide into their biomass, enrich soils, provide habitat for other fauna and above all, provide solace and positivity to human beings [1-7].

However, most of the times, local citizens are unaware of the worth of the multifarious tangible and intangible benefits that we obtain from trees (and other ecosystems and species). For instance, we as urban citizens cannot estimate the true worth of the lakhs of trees growing around us, making our lives healthier amidst the various types of pollutions in the city.

Ecosystem Valuation is a well-approved economic tool to provide a price tag to the goods and services that nature provides to us. As per [8], ecosystem valuation is "the attempt to assign quantitative values to the goods and services provided by environmental resources, whether or not market prices are available to assist us."

There are several methods by which it becomes possible to provide a monetary basis to the benefits that nature provides us. The Replacement Cost Method is one such method in which the cost of replacing an ecosystem or its services is used as an estimate of the value of the ecosystem or its services. E.g., the flood protection services of a wetland might be replaced by a retaining wall or levee.

'i-Tree tools' is a set of several software-based solutions to calculate the value of a tree. These tools attempt to quantify the benefits of trees so as to ensure better tree and forest management.

Based on the above, the aim of this paper is to estimate the worth of the trees outside forest in the city of Thane using the 'my tree' web-based application of the i-tree set of tools.

2. METHODS

2.1 Tree Census Data

The data regarding TOF in the city of Thane was obtained from the Tree Census report prepared by the Garden Department of the Thane Municipal Corporation. This is a very comprehensive report that enlists each tree more than 10cm in girth, noting its species name, local name, height, girth at breast height, canopy diameter, health, and also its global coordinates.

2.2 i-tree tools

Several researchers have used the i-tree tools for the purpose of assigning a price tag to the various goods and services provided by trees [9-11].

'My tree' application of the i-tree tools uses robust background research to arrive at the worth of three services provided by trees – carbon storage, air pollution removal and stormwater mitigation, in addition to the structural value of the tree. The basic flow of this conversion of tree structure to tree value has been clarified in Figure 1 below.

Figure 1: Logical Flow of Ecosystem Valuation Methodology Followed by the i-tree Tools

Structural Value of trees has been calculated as per the tree species and physical attributes, and this data has been obtained from the Council of Tree and Landscape Appraisers. The cost of Carbon Storage has been estimated as the social cost of carbon which is producer price index adjusted. For the service 'Air Pollution Removal,' i-tree tools estimate average externality values or health care expenses, productivity losses, and value of statistical life; this, too, is producer price index adjusted. For international estimates, regression equations based on population density can be used. For the service 'Stream flow and water quality,' average cost of storm water control or service fees was taken.

2.3 Connecting Tree Census Data with i-tree tools

As shown in Figure 2, the Thane Municipal Corporation (TMC)'s tree census report was analyzed with respect to the most common species. Then, the girth class in which most of the individuals of those species were reported was noted down. Next, the my tree tool was used to calculate the worth of that species with that girth measurement. Finally, the value was multiplied with the total tree number to obtain the total worth of those trees.

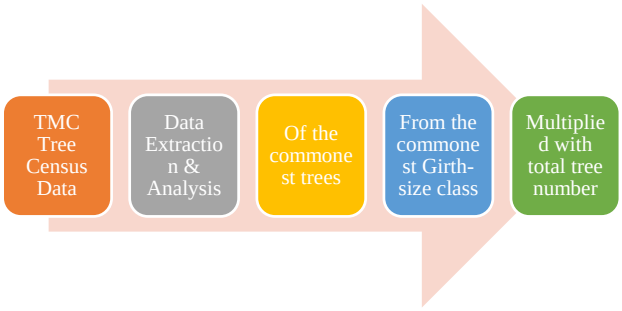

Figure 2: Flow of Methodology

3. RESULTS & DISCUSSIONS

The Maharashtra city of Thane lies adjacent to Mumbai, adjoining its northern boundary. Spread across 147 sq km, the city recorded a population of 1,886,941 in the 2011 census. As per the Maharashtra (Urban Areas) Protection & Preservation Of Trees Act 1975, tree census was conducted within the boundaries of the Thane city for the period 2017-2022. As per this report, 7,22,426 trees, belonging to total 271 species were found in Thane, of which 180 species were native and 91 were exotic. Highest number of *Leucaena leucocephala* (River tamarind or Subabul) trees were observed, which is an exotic species. At 1,11,634, they make up more than 15% of the total number of trees. Only 12 out of 271 species make up 56% of the total trees, indicating overall poor diversity. Table 1 displays the list of the most common (2% or above) 12 species.

Table 1: List of most common tree species in Thane city

Leucaena leucocephala	15.5%
Ficus hispida	6.2%
Trema orientalis	5.6%
Grewia tilifolia	5.1%
Pongamia pinnata	4.0%
Bombax ceiba	3.3%
Tectona grandis	3.1%
Holarrhena pubescens	3.1%
Polyalthia longifolia	3.0%
Cocos nucifera	2.7%
Mangifera indica	2.3%
Peltophorum pterocarpum	2.1%
Others	44%

The girth class in which these species fell has been mentioned in Table 2 below:

Table 2: The Most Common Girth Class for the Common Species

Leucaena leucocephala	0.1-0.3m
Ficus hispida	0.1-0.3m
Trema orientalis	0.1-0.3m
Grewia tilifolia	0.1-0.3m
Pongamia pinnata	0.1-0.3m
Bombax ceiba	0.1-0.3m
Tectona grandis	0.1-0.3m
Holarrhena pubescens	0.1-0.3m
Polyalthia longifolia	0.4-0.6m
Cocos nucifera	0.4-0.6m
Mangifera indica	0.1-0.3m
Peltophorum pterocarpum	0.1-0.3m
Others	0.1-0.3m

Details of each species and lower limit of the girth at breast height (GBH) were fed into the web application https://mytree.itreetools.org/#/ to obtain the current and future worth of that individual tree species in US dollars. As may be noticed from Table 2, *Cocos nucifera* and *Polyalthia longifolia* had higher number of individuals in the larger girth class of 0.4-0.6m. However, for comparison on the level of species, we brought this down to 0.1m to match with the others. The same has been depicted in Figures 3(a) and 3(b). While we had begun with 12 species, we had to drop *Holarrhena pubescens* from the list because even the genus was not included in the USDA database.

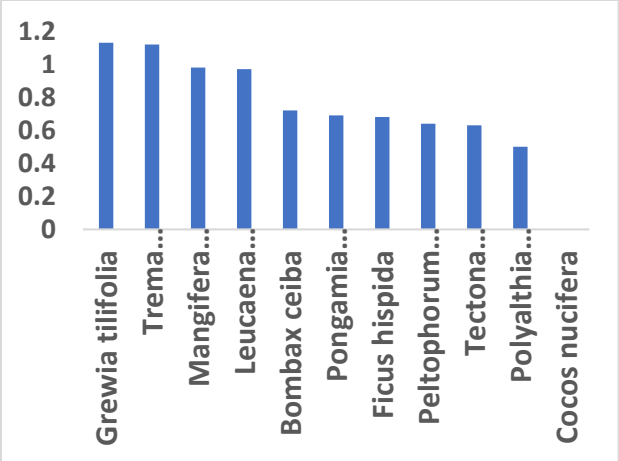

Figure 3(a): Species-wise Tree Benefits - Now

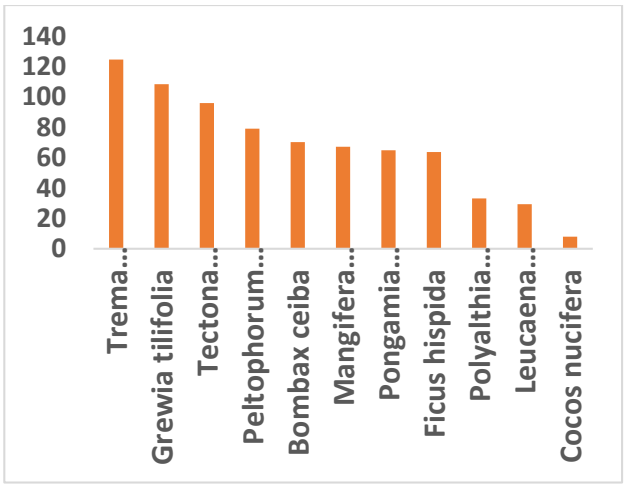

Figure 3(b): Species-wise Tree Benefits – After 20 yrs

From Figures 3(a) and 3(b), it is also apparent that over a period of twenty years, the services provided by different tree species get altered in magnitude. So *Tectona grandis* which was ninth in the list of current benefits rose to third in the list of benefits after two decades. Also, *Leucaena leucocephala*, came down from the fourth position to the tenth position. Commonly planted trees like *Cocos nucifera* and *Polyalthia longifolia* did not rise high in either list of the contributors and hence, future plantation exercises must consider the decision of continuing to plant them.

Next, we multiplied the individual value of the tree species with the total number of their individual numbers in the city of Thane. In this case, for *Cocos nucifera* and *Polyalthia longifolia* we used their high frequency girth class of 0.4-0.6m as now we intended to calculate the worth of trees in the Thane city. Also, it may be recalled that these 11 species made up only 53% of the total diversity in Thane. Hence, the average worth of the top 11 species, which was 0.73 USD, was applied to the remaining 47% species in the Thane city, we used this value to arrive at the total worth of all 7,22,426 trees.

For the current benefit, this value came to USD 7,94,858 or INR 6,16,88,932 (using the exchange rate of 77.61). For the coming twenty years, this benefit increased to USD 5,81,43,922 and INR 4,51,25,49,766.

Thus, to summarize the findings, it may be stated most emphatically that conservation cannot be merely forest-centric – trees outside forests are a substantial asset. Also, even when we attempt to assign a value to a tree - or for that matter any ecosystem good or service, the price we arrive at is a gross under-estimation. The worth of a tree or of nature's goods and services can never be fully evaluated. Also, when we select trees to plant, we cannot just randomly decide on the basis of availability of saplings - rather, this decision should be taken on the value of the ecosystem goods and services provided by the tree species. Lastly, the planning time-period for a tree

plantation project cannot be short-term - it must envisage at least twenty-twenty-five years.

4. LIMITATIONS OF THE STUDY

Benefits from trees are calculated on the basis of USDA Forest Service research – hence, their applicability to Indian cities will not be completely accurate. The actual values obtained are indicative and cannot be used for any compensatory payments etc. In fact, this Disclaimer "Benefits are based on USDA Forest Service research and are meant for guidance only" is displayed at the end of each analysis. Although most of the species commonly found in Thane were also recorded in the itree-tools database, we could not find *Holarrhena pubescens* and *Grewia tilifolia*. While we had to drop *Holarrhena pubescens* from our list because even the genus was not in the database, we selected *Grewia occidentalis* from the itree-tools database to replace *G. tilifolia* as a related species. Also, conversion of USD to INR for the twenty-year projection is also as per the current conversion rate, which can be completely different twenty years down the line.

5. RELATED FUTURE RESEARCH

Similar tree and ecosystem valuation applications need to be designed for the Indian scenario where the cost of health treatment, productivity loss calculated values, remediation measures etc. are all likely to be much different from values in the USA. Collection of baseline ecological and economic data has to be a massive citizen science project and must be envisaged and planned as such.

6. CONCLUSION

It may be concluded that TOF constitute a significant ecological and as well as financial asset. The existence, maintenance and good health of trees outside forest will be critical for healthy urban ecosystems and healthy urban life for the citizens.

7. ACKNOWLEDGEMENTS

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