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Enhancing Carbon Sink: Challenges in Urban Forestry of Major Cities in Tamil Nadu, India

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Abstract **–** Recognizing the crucial role of green cover in mitigating climate change and improving environmental sustainability, the research aims to evaluate the existing potential urban green cover and its carbon sequestration potential, including Soil Organic Carbon (SOC) in the 21 Municipal Corporations of Tamil Nadu. The study employs latest geospatial technologies to analyze satellite imagery using NDVI and generate accurate data on the extent and distribution of green spaces in the selected cities. Additionally, field surveys and vegetation sampling are conducted to estimate the carbon stock of the identified green areas. It is observed that 11 cities (Avadi, Chennai, Coimbatore, Dindigul, Kancheepuram, Madurai, Tambaram, Thanjavur, Tirunelveli, and Tiruppur) out of the 21 cities do not meet the minimum recommendation of the World Health Organisation of 9 sq.m of urban green space per person, and is a critical point of consideration. The least proportion is found in the completely urbanized Greater Chennai Corporation, while Nagercoil is the only city with the highest proportion of urban green cover. The total biomass carbon sequestration by all the cities of Tamil Nadu was 4.25 Tg of CO_2-eq. In general, the total carbon stock in all the cities is very less when compared to the total carbon stock in the forests of Tamil Nadu. Therefore, there is an urgent need to improve the carbon stock in light to reduce the discomfort level, offset the emissions, and also to increase soil fertility. From the comprehensive assessment of green cover in all the 21 cities of Tamil Nadu, it is inferred that though urban forestry is man-made, there isn't much attention given to urban forest management. Hence, municipal authorities must pay heavy attention to increasing the green cover as a seamless effort involving the Forest Department, Urban Development Departments, and Non-Governmental Organisations.

Keywords: Urban forestry, Cities, Carbon Sequestration, Climate Mitigation, Tamil Nadu

Introduction

Climate change is a major threat facing humanity that needs to be addressed immediately as it is due to anthropogenic emissions of greenhouse gases. The recent Assessment Report – 6 (AR6) of the

Intergovernmental Panel on Climate Change (IPCC) envisaged that the unprecedented anthropogenic emissions have led to global warming of 1.1°C above pre-industrial levels. This has resulted in more frequent and more intense extreme weather events causing dangerous impacts on nature and people in every region of the world (IPCC, 2023)

There are two options to address climate change, one to mitigate the greenhouse gas (GHG) emission or to adapt to changing climate patterns. Deforestation and other forms of land-use/cover change are major contributors to climate change. (Tian et al., 2021) found that deforestation in the Amazon rainforest could lead to changes in precipitation patterns, with potential impacts on regional water resources and agriculture. On the other hand, forests play an important role in protecting against the impacts of climate change, such as sea level rise, floods, and droughts (Prakash and Srivastava, 2019; Segaran et al., 2023). According to an (FAO, 2020) study, global forest cover acts as a sink, absorbing approximately 2.4 Gt of carbon annually, which is equivalent to nearly one-third of annual fossil fuel emissions, highlighting their vital role in mitigating climate change by storing carbon dioxide from the atmosphere. Carbon sequestration through the forestry sector has been given much importance to offset the carbon emission, as part of the clean development mechanism (CDM) during the post-Kyoto Protocol in the year 1997.

The Paris Agreement, 2015, reinforced the importance of forests in the global response to climate change and reaffirms the importance of "negative emissions" through sinks such as forests, which can be used to offset a country's emissions. Sustainable Development Goals (SDGs) adopted by the United Nations in the same year target to provide universal access to safe, inclusive, accessible, green, and public spaces, in particular for women and children, older persons, and persons with disabilities by 2030. Target 15.2 of SDG 15 aims to promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests, and substantially increase afforestation and reforestation globally by 2020, which is yet to be realized in the field.

As an action-oriented plan, the 27th Conference of Parties (CoP27) held in Egypt combined the efforts of the Paris Agreement and the SDG (New York SDG Agreement) and urged the international community to reduce the emission by up to 45% by 2030 compared to the 2010 levels to limit temperature rise to 1.5℃ by the end of the century besides signing an agreement to provide “loss and damage” funding to vulnerable countries. The CoP 27 encouraged nature-based solutions, to halt and reverse forest loss and degradation by 2030 (United Nations, 2022). In such a situation it is imperative to increase the capacity building to audit the carbon stock in the forest sector to offset the emission reduction activity in the country.

India is committed to reducing the emission intensity of its GDP by 45 percent by 2030, from the 2005 level focusing on the utility of non-fossil fuel and enhancing carbon sinks to 2.5 to 3.5 billion tonnes of carbon dioxide equivalent in the forestry sector (Government of India, 2022).

Studies in India assessed the impact of urbanization on the green cover, the benefits, barriers, and opportunities of green infrastructure, urban green cover, and its relationship to the heat island phenomenon and management of storm water (Garg and Anand, 2022; Ghosh et al., 2022; Khan et al., 2022; Rahman and Szabó, 2021). The studies in Tamil Nadu have primarily focussed on the identification of heat islands, observation of the thermal discomfort level, spatiotemporal dynamics of urban and peri-urban land transitions in Chennai Metropolitan Area its relationship to the urban sprawl; effect of urbanisation and UHI in Chennai (Chinnappa et al., 2021; Jeganathan et al., 2019, 2016; Mathivanan and Muthaiah, 2020; Muthiah et al., 2022; Padmanaban et al., 2017).

The aforementioned studies are city specific, therefore the present study assess the green cover in all the cities (municipal corporations) of Tamil Nadu including the newly formed one. Further, there are research gaps in terms of lack of long-term monitoring and data collection about green cover in the cities of Tamil Nadu. In the above situation, it is imperative to mention that urgent action is required to increase the green cover by assessing the current scenario of green cover in all 21 cities, estimating the carbon sequestration, and identifying potential areas for restoring it in Tamil Nadu. The outcome of this assessment will accelerate several ongoing schemes at the state level, such as the Tamil Nadu Climate Change Mission, the Green Tamil Nadu Mission, the Tamil Nadu Wetland Mission to enhance the green cover of the State of Tamil Nadu (GoTN, 2023)

2. Methodology

2. 1. Study Area

The 21 Municipal Corporation of Tamil Nadu was selected as the study area for the assessment of urban green cover. Based on their geographical positions, the 21 cities can be grouped under the six agro-climatic zones (Figure 1).

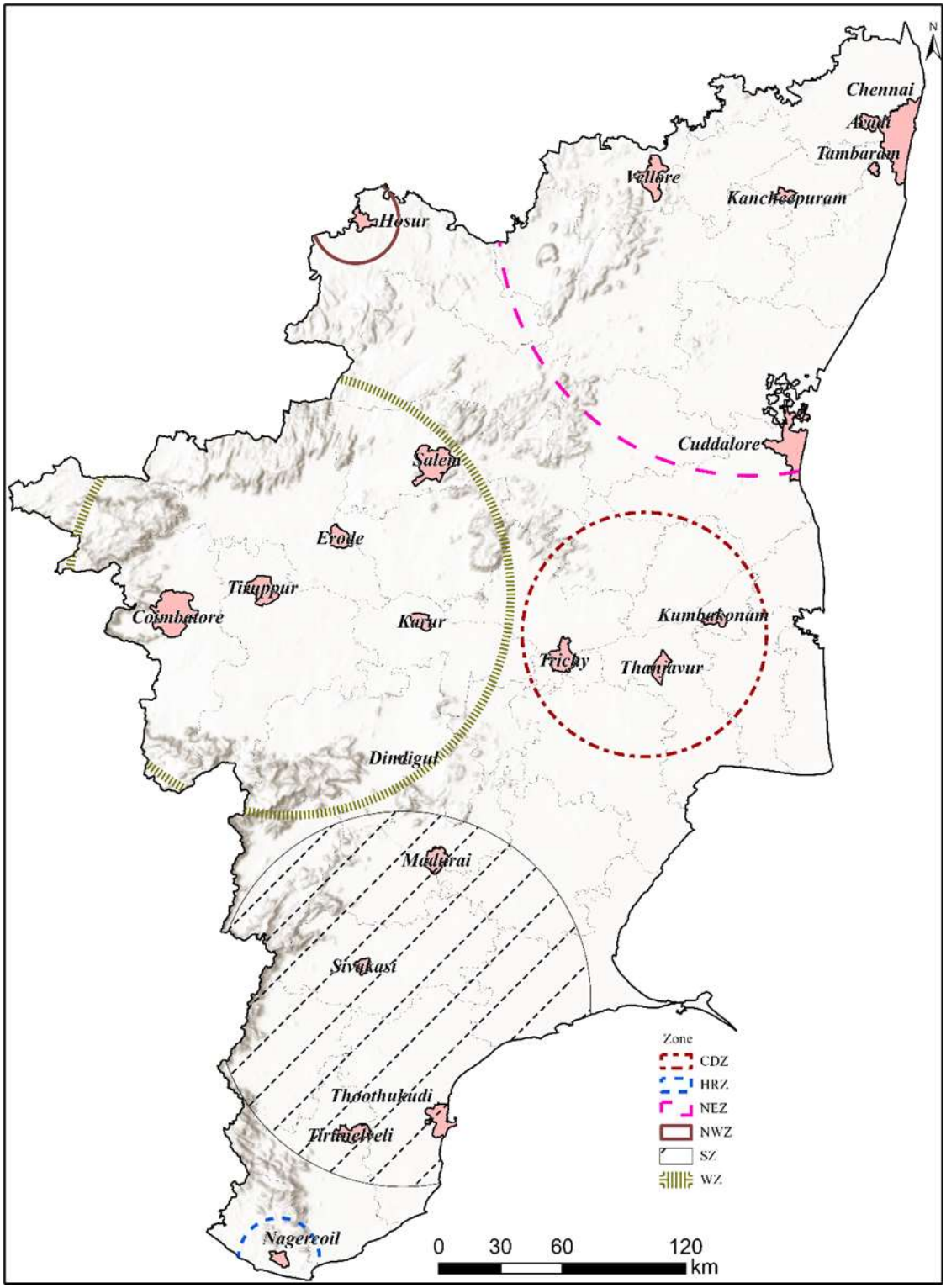

Figure 1. Study Area – Agro-climatic zone wise grouping of 21 cities of Tamil Nadu

Among the 21 cities, some cities are older like the Greater Chennai Corporation was formed in the year 1688, which is the capital city of Tamil Nadu, while other cities are very newly formed Cuddalore, Kancheepuram, Karur, Kumbakonam, Sivakasi, and Tambaram are the newly formed cities in the year 2021 (MAWS, 2023).

2.2. Green cover Assessment using NDVI component and ground truth verification

The overall methodology to assess the green cover in 21 cities of Tamil Nadu is portrayed in Figure 2. For conducting the green cover assessment, the Normalised Difference Vegetation Index (NDVI) is employed. Landsat 8 (OLI) satellite images of 30m resolution are collected from Earth Explorer (https://code.earthengine.google.com//) for the year 2021 across all the 21 municipal corporations of Tamil Nadu. Landsat images have been registered and geo-corrected from the source. The reclassification of NDVI maps has been implemented through the value of NDVI range from -1 to + 1 which refers to vegetation rates based on spectral reflections (Mathivanan and Muthaiah, 2020). The certified maps of land cover and use, which were generated, classified, and validated by using the ground control points, (GPS) method and Google Maps, were used to measure the accuracy assessment.

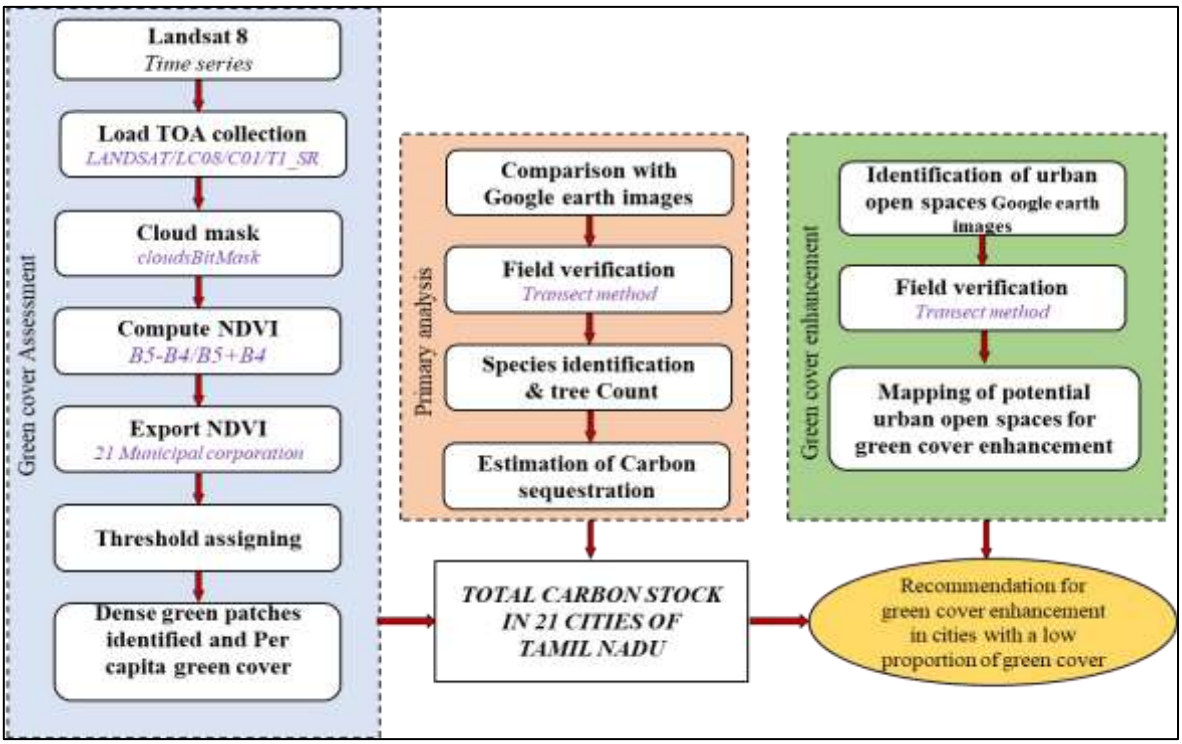

Figure 2. Methodology Framework for Green Cover Assessment in 21 cities of Tamil Nadu

Land Cover Analysis: This study conducted a land cover analysis by using the NDVI index. The negative value of an NDVI index refers to a lack of vegetation and other types of land uses such as built-up areas. Furthermore, a zero value indicates bodies of water, whereas positive values refer to different types of vegetation rates. The computation for NDVI is depicted in equation (1).

$$NDVI = (NIR - RED)/(NIR + RED) \quad (1)$$

The operation to generate land cover maps with the use of an NDVI index is carried out using Remote Sensing (RS) and Geographical Information System (GIS) techniques.

2.3. Estimating current carbon sequestration potential

Ground truth verification was conducted in the 21 municipal corporations of Tamil Nadu which reported dense vegetation. The NDVI maps along with Google Earth images were first used to demarcate at least 10 locations with dense vegetation indicating the presence of tree species. These locations were then surveyed in person by the predetermined traversing method at random in different cities to cover 10% of the total study area combining all 21 cities using geospatial technology. Around the 21 cities, 120 species were found and the list of tree species in the cities categorized based on the agro-climatic zonation were enumerated as in Appendix 1. It was found that on average there were 90 trees per hectare area in the 21 cities of Tamil Nadu. The Above Ground Biomass (AGB) and the Below Ground Biomass (BGB) were calculated by weighing the actual weight of the wind-thrown trees during the Gaja cyclone in the year 2018. The green biomass of a 40-50 years old tree was found to be 3.8 tonnes on an average. This value is used to enumerate the green biomass of trees in the 21 cities. The average wood density of different tree species found in the 21 cities was 0.64, which is used to calculate the dry biomass. It is known that the 50% of the dry biomass of trees is carbon (Ramachandran et al., 2007) and thus the total carbon in the tree biomass is calculated.

Soil samples were randomly collected in all 21 cities. All soil samples were shade-dried, pulverised with an agate mortar, and then sieved (0.2 mm). The samples were analysed for carbon using the C/N Analyser (Ramachandran et al., 2016, 2007).

3. Results and Discussion

3.1. Status of the Present Green Cover

The proportion of urban green cover in 21 municipal corporations of Tamil Nadu is depicted in Figure. 3. It is observed that most of the cities in Tamil Nadu have very less green cover, with Chennai city recording the least extent of green cover of 8.050 sq. km. Nagercoil city has the highest proportion of urban green cover.

The area of urban green cover is 9.171 sq. km. out of the total city area of 46.95 sq. km as also recorded by (Castro J et al., 2022). The green cover of the Chennai Metropolitan Area in the year 2012 was 69 sq. km (Chinnappa et al., 2021). The spatial spread of green cover for the cities with the highest green cover proportion and least green cover proportion are portrayed in Figure. 4 (a) and (b) respectively.

As per the urban greening guidelines 2014, the Ministry of Urban Development recommends that the proportion of recreational areas (including parks, spaces, water bodies, etc.) to the total developed area in medium towns and large cities should be from 18 to 20% in medium towns and large cities; and 20-25% in

metropolitan cities (Ministry of Urban Development, 2014). From the analysis of the proportion of urban green cover, it is observed that only Nagercoil has 19% of urban green cover, while all the other cities are below it. This could be attributed to the location of the city in the high rainfall zone, which receives rainfall during two monsoon seasons that is the South West Monsoon during the June, July, August and September (JJAS) and the North East monsoon during the October, November and December (OND). Out of 21 cities, the majority of the cities (16 cities) have less extent of green cover which don't meet the minimal requirement of the Ministry of Urban Development.

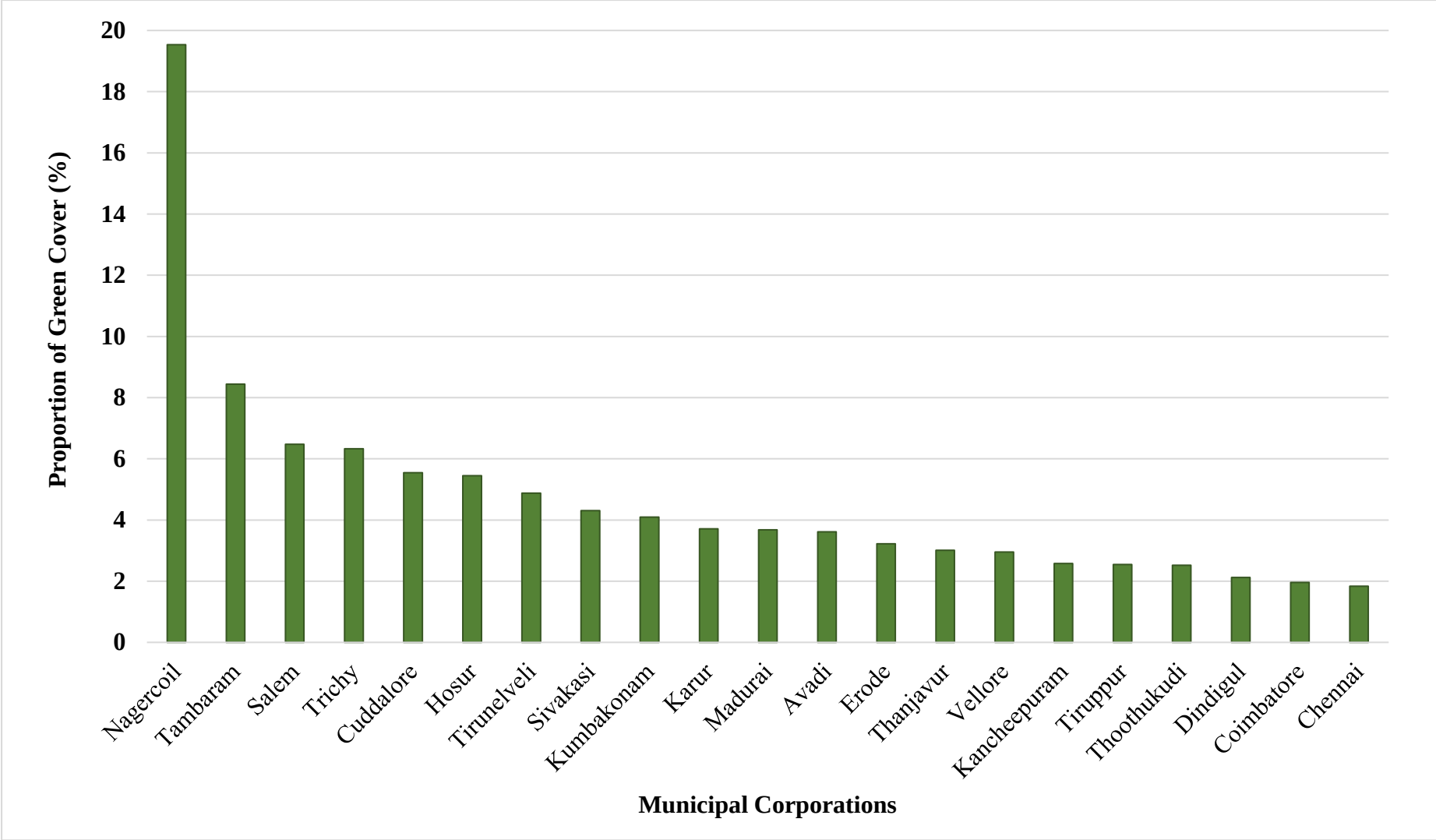

Figure 3. Proportion of Green Cover in 21 Cities of Tamil Nadu in decreasing order

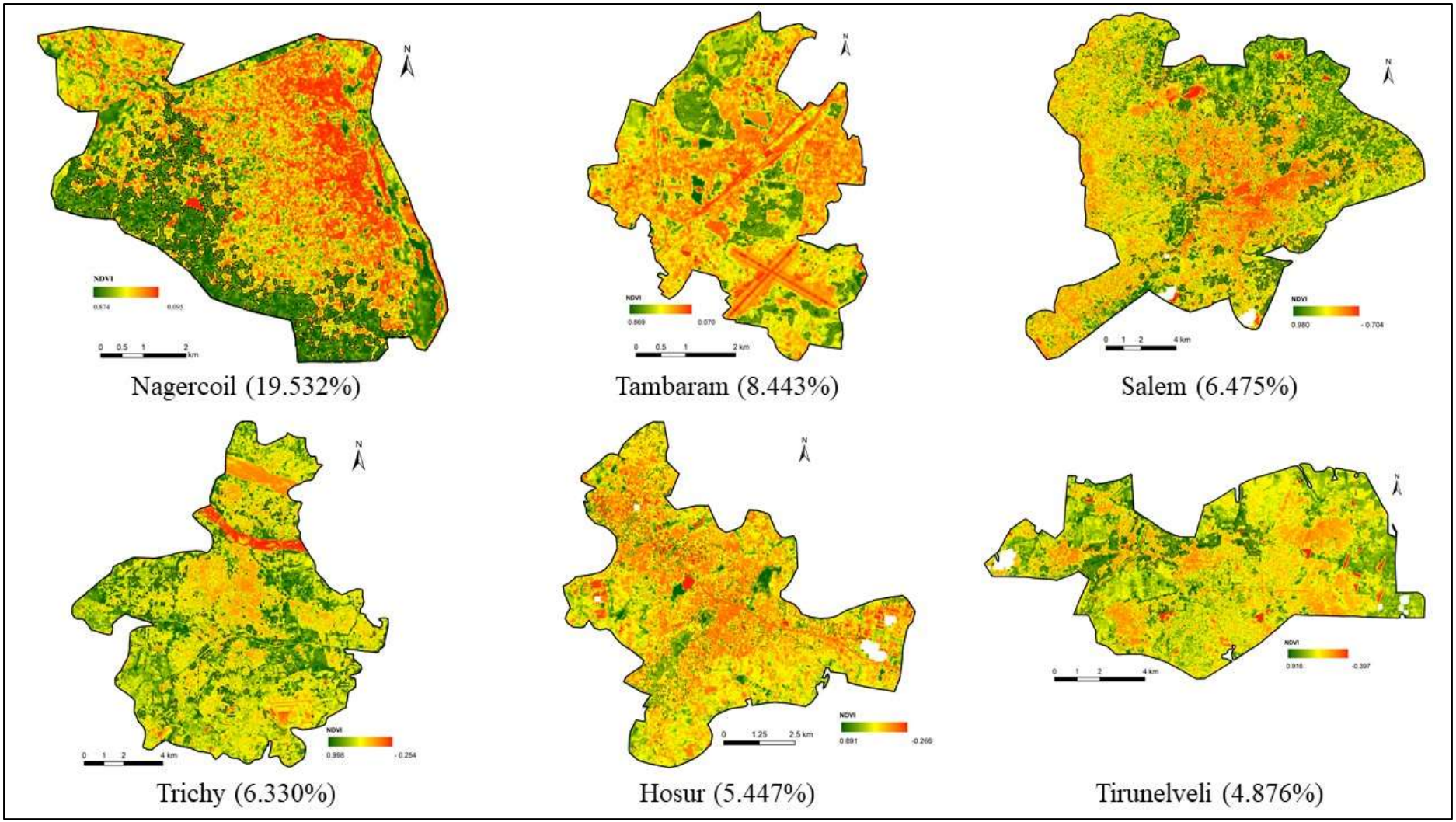

Figure 4 (a). Tamil Nadu cities with the highest proportion of Urban Green Cover

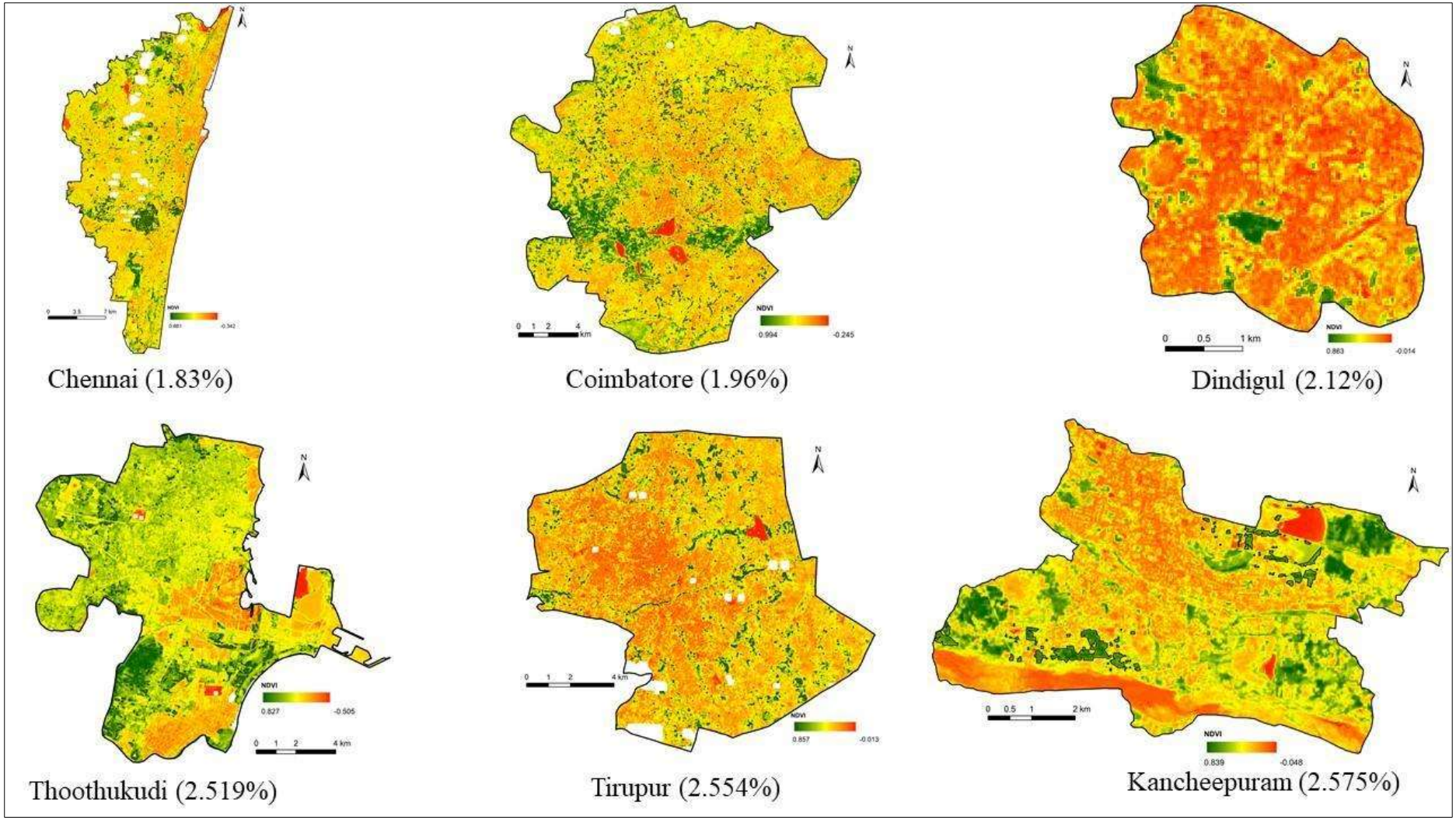

Figure 4 (b). Tamil Nadu cities with the least proportion of Urban Green Cover

The World Health Organisation (WHO) recommends a minimum of 9 sqm of green space per capita in urban areas and also suggests that an ideal amount of 50 sqm per person of urban green space may be provided (Panwar, 2022). The per capita green space availability was evaluated based on the population projection in urban Tamil Nadu (Ministry of Helath and Family Welfare, 2019) . It is projected that the population of urban areas of Tamil Nadu will increase by 18% by 2023 from 2011. This percentage increase is applied to project the city population. The evaluation of the per capita green space based on the projected population in 21 cities of Tamil Nadu is depicted in Table 1. It is observed that 11 cities (Avadi, Chennai, Coimbatore, Dindigul, Kancheepuram, Madurai, Tambaram, Thanjavur, Tirunelveli, and Tiruppur) out of the 21 cities do not meet the minimum recommendation of the World Health Organisation of 9 sq m per person, and is a critical point of consideration. Cities that have more than 9 sq m per person of urban green cover are Cuddalore, Nagercoil, Erode, Hosur, Karur, Kumbakonam, Salem, Sivakasi, Thoothukudi, and Vellore.

In this situation it is vital to enhance the green cover in the cities with the lowest per capita green spaces. The cities with more than the recommended green cover must be preserved without further degradation owing to the ever-growing population in urban areas in the future. Though urban forestry is man-made, the results inferred that more attention must be given to urban forestry management. (Nagendra, 2013) pointed out that trend of development in Indian cities are observed by their distinctive culture, geography, planning and administration. For example, Pune and Bangalore maintain major green space in the core of the city in spite of rapid development and growth owing to the occurrence of military and public sector companies, which safeguard expansive green patches.

Table 1. Green cover assessment and carbon sequestration in cities of Tamil Nadu

Name of the city	City Area (sq.km.)	Total City Population (Census 2011)	Area of Urban Green Cover (sq. km.)	Proportion of Urban Green Cover (%)	Per capita Urban Green Space (sq.m.per person)	Biomass Carbon (in Tonnes)	Soil Organic Carbon (in Tonnes)	Total Carbon Stock (in Tonnes)
1. Avadi	60.035	345996	2.17	3.62	5	23748.48	121.21	23870
2. Chennai	438.945	4646732	8.05	1.83	1	88099.20	2409.68	90509
3. Coimbatore	332.248	1050721	6.50	1.96	5	71136.00	1157.07	72293
4. Cuddalore	303.680	173636	16.85	5.55	50	184427.95	17014.99	201443
5. Dindigul	12.312	207327	0.26	2.12	1	2857.35	2.78	2860
6. Erode	85.380	157101	2.75	3.23	15	30141.20	291.61	30433
7. Hosur	67.432	116821	3.67	5.45	27	40196.22	309.83	40506
8. Kancheepuram	47.006	164384	1.21	2.58	6	13247.03	38.64	13286
9. Karur	59.918	70980	2.22	3.71	27	24329.27	142.79	24472
10. Kumbakonam	50.227	140156	2.06	4.10	12	22512.48	223.82	22736
11. Madurai	96.049	1017865	3.54	3.68	3	38701.06	418.45	39120
12. Nagercoil	46.953	224849	9.17	19.53	35	100366.25	6508.85	106875

Name of the city	City Area (sq.km.)	Total City Population (Census 2011)	Area of Urban Green Cover (sq. km.)	Proportion of Urban Green Cover (%)	Per capita Urban Green Space (sq.m.per person)	Biomass Carbon (in Tonnes)	Soil Organic Carbon (in Tonnes)	Total Carbon Stock (in Tonnes)
13. Salem	243.874	829267	15.79	6.48	16	172805.76	15251.62	188057
14. Sivakasi	39.075	71040	1.68	4.31	20	18411.73	59.54	18471
15. Tambaram	22.431	174787	1.89	8.44	9	20725.86	91.99	20818
16. Thanjavur	79.635	222943	2.40	3.01	9	26252.88	303.44	26556
17. Thoothukudi	140.719	237830	3.54	2.52	13	38788.76	659.65	39448
18. Tirunelveli	101.711	473637	4.96	4.88	9	54270.61	664.70	54935
19. Tiruppur	143.216	444352	3.63	2.54	7	39868.99	420.44	40289
20. Trichy	143.377	847387	9.08	6.33	9	99329.99	1316.16	100646
21. Vellore	160.699	185803	4.75	2.96	22	51969.21	539.54	52509

3.2. Carbon Sequestration in Urban Areas of Tamil Nadu

From the rapid assessment of the tree species, it was found that there are more than 120 species commonly present in 21 cities of Tamil Nadu (refer Appendix 1). The results of the carbon sequestration by the trees (biomass carbon and soil organic carbon) across the 21 cities of Tamil Nadu are shown in Table 2. The amount of carbon sequestered as carbon dioxide equivalent in the cities is depicted in Figure 5.

Table 2. The extent of additional green space needed to meet the Urban Greening Guidelines, 2014

CITY	Recommended Green Cover (sq.km)	Existing green cover (sq.km)	Additional Green Cover Needed (sq.km)	Potential area for additional green cover (sq. km.)	Deficiency in open space (sq.km.)
1. Nagercoil	8	9	-1	1	**0**
2. Kancheepuram	8	1	7	8	**0**
3. Tambaram	4	2	2	2	**0**
4. Dindigul	2	0	2	0	**2**
5. Thanjavur	14	2	12	10	**2**
6. Karur	11	2	9	4	**4**
7. Sivakasi	7	2	5	1	**5**
8. Hosur	12	4	8	4	**5**
9. Avadi	11	2	9	4	**5**
10. Tirunelveli	18	5	13	8	**6**
11. Thoothukudi	24	4	21	14	**7**
12. Kumbakonam	9	2	7	0	**7**
13. Salem	44	16	28	18	**10**
14. Erode	15	3	13	2	**10**
15. Madurai	17	4	14	2	**12**
16. Vellore	29	5	24	12	**13**
17. Trichy	26	9	17	4	**13**
18. Cuddalore	55	17	38	22	**16**
19. Tiruppur	26	4	22	2	**20**
20. Coimbatore	60	7	53	13	**40**
21. Chennai	79	8	71	9	**62**

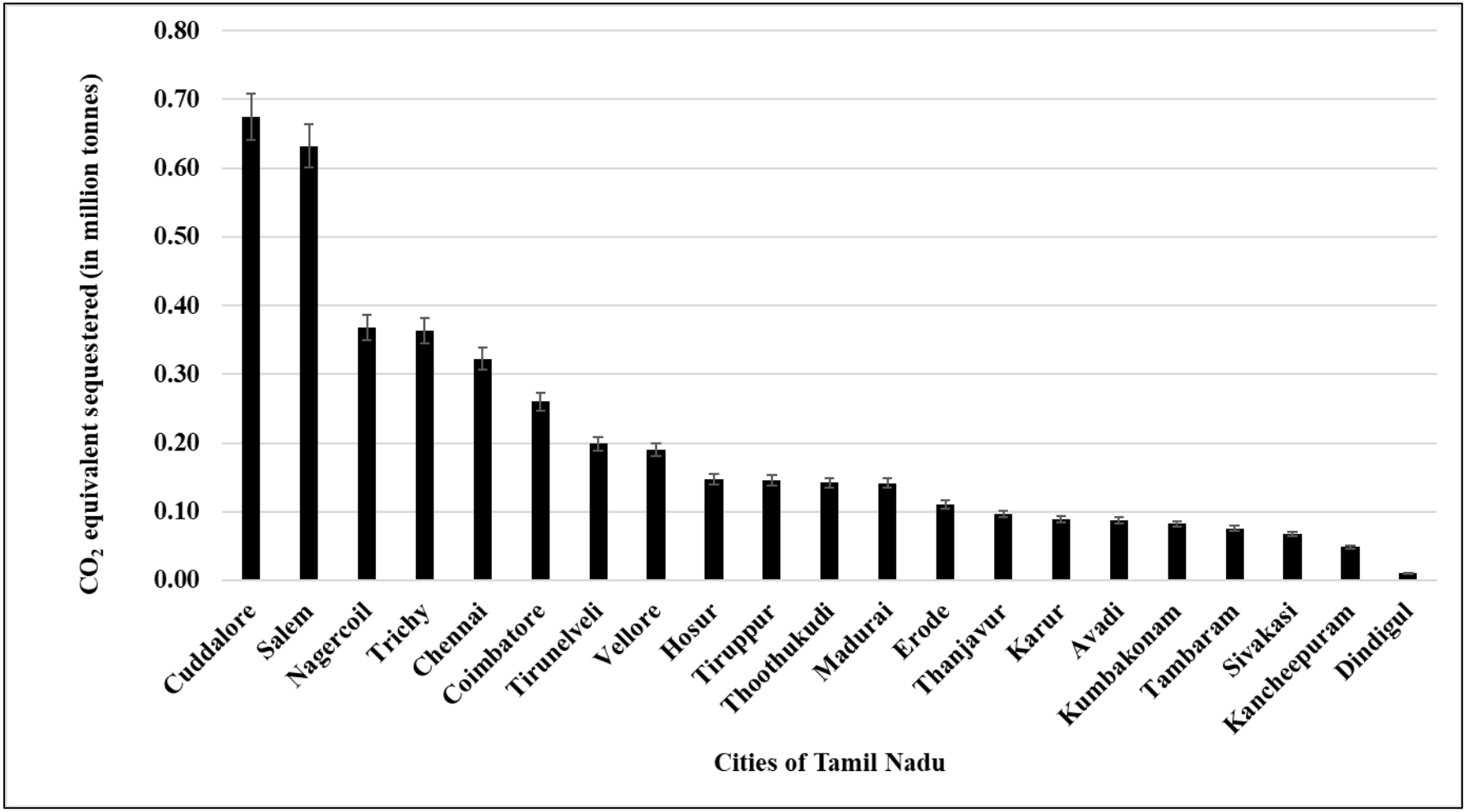

Figure 5. Carbon sequestered as CO_2 equivalent in cities of Tamil Nadu

It is observed that the total amount of carbon dioxide sequestered by the urban green cover in 21 cities of Tamil Nadu is 4.25 Tg CO2-eq**.** The highest carbon is sequestered in Cuddalore city while the least carbon sequestration is in Dindigul city.

The amount of carbon sequestered by urban green cover varies depending on the city and the extent of its green cover. Total tree carbon storage in U.S. urban areas in the year 2005 is estimated at 643 million tonnes with an annual sequestration estimated at 25.6 million tonnes (Nowak et al., 2013). In India the urban green cover has deteriorated in many cities (Raj et al., 2021; Das et al., 2022a; Ramaiah and Avtar, 2019), resulting in lesser carbon sequestration.

A study estimated that 90.51 Mg ha−1 biomass and 63.49 Mg C ha−1 carbon is present in the semi-arid forest of Delhi, India (Meena et al., 2019). A specific study at National Zoological Park, Delhi by (Snehlata et al., 2021) showed that the carbon stock of the National Zoological Park (NZP) was 168.83 Tonnes ha^{-1}. According to a 2022 study conducted in five Indian cities Bengaluru showed highest carbon sequestration (141.83 MT), and carbon sequestration in the city of Leh was comparatively very low (1.51 MT) (Bherwani et al., 2022). This study highlights the need of developing region-specific allo-metric relationships to understand the potential of urban trees as carbon sinks. (Behera et al., 2022) assessed the carbon sequestration potential of tropical tree species for urban forestry in India and enumerated that the Maximum Above Ground Biomass (AGB) of 71.94 Tonnes/ha and carbon stock of 25.54 Tonnes/ha was observed in *Tectona grandis* plantations.

The results of the present study are in line with the above observations, with varying carbon sequestration dependent upon the extent of green cover present in the respective cities. The carbon sequestration potential in cities is indicative of the significant role played by the green cover in offsetting carbon emissions.

3.3. Cadastral level assessment for policymakers

The IPCC, 2022 underpins that nature-based solutions should be included alongside customary ‘grey’ or engineered infrastructure. Vegetation corridors, greenspace, wetlands, and other green infrastructure can be merged into the built-up areas with the city to reduce heat and flood risks, which also provides other benefits such as health and biodiversity. Green cover enhancement is widely identified as a low-regret measure for disaster risk reduction and climate change adaptation, as they provide a nature-based solution across scales to reduce temperature shocks and provide natural defences from flooding, and enhances the coping capacity as well as

to control environmental pollution (Andersson et al., 2018; Nowak et al., 2006; Frantzeskaki, 2019; Geneletti and Zardo, 2016; McPhearson et al., 2016; Nowak et al., 2018; van den Berg et al., 2015)

Various studies have documented that public parks, urban forests, street trees, and green roofs, as well as lakes, ponds, and streams, provide local cooling (Štrbac et al., 2023; Gunawardena et al., 2017; Das et al., 2022; Gratani et al., 2016). Though there is increasing knowledge about the benefits of nature-based solutions, recent studies show that nature-based methods of adaptation and resilience are still under-represented in urban planning and development (Buzási and Csizovszky, 2023; Frantzeskaki, 2019; Geneletti and Zardo, 2016).

From the assessment of the open spaces, it is found that there is very less extent of urban open spaces (Table 2) for promoting new afforestation projects. Most of the cities need additional green cover for meeting the minimum requirement of 18% of area as designated by the Ministry of Urban Development Guidelines, 2014. Even if all the available open spaces space is afforested, only Kancheepuram and Tambaram can achieve the minimum requirement of 18%, while other cities need additional open space ranging from 2 sq.km to 62 sq.km.in order to support new afforestation actions. In light of fewer available open spaces for new green projects, alternate initiatives like roadside and avenue plantations, tot-lots (play areas for children), and green strips in the periphery of the peri-urban area expansion may be considered.

It is further observed that in highly concretised built up area of the cities, it is not possible to increase the green cover. Further, the litter in urban areas are not stocked but are partially burnt by the local people. Litter is necessary to create muck. The decayed muck in turn provides soil organic carbon, which helps improve the fertility of the soil and water holding capacity. The heavy concretisation of the urban areas provides less scope for the natural decay of the litter and leaf fall. Proper conservation of litter is therefore mandatory. Larger perception is needed to understand the carbon sink, wherein leaf and litter material are foremost to enrich the soil organic carbon. This could be achieved only by creating awareness to the community in regard to the importance of green cover and enhancing carbon sink by meticulous conservation of organic litter.

Due to the heavy demand for organic manure in the agriculture sector, enhancing SOC in urban forestry is a challenge. This situation can be tide over by utilising the bio-mined soil which is also rich in organic carbon. The results of the present study can be a significant input for revisiting the guidelines for various implementation entities for promoting development activities

such as the smart cities initiatives. Such cross-cutting strategies and actions are therefore the need of the hour.

Conclusion

Overall it is observed that the green cover in cities of Tamil Nadu ranges from on an average 5.5 sq.km. ranging from 0.26 sq.km to 17 sq km. In most of the cities the per capita availability of urban green cover is lesser than the WHO recommended value of 9 sq.m. per person, which needs to be addressed in detail. The existing green cover of the cities have the potential to sequester 4.25 Tg of CO_2-eq by its biomass and sink around 1.2 Tg of carbon in the soil. Therefore, the available dense green cover must be conserved with utmost care and requires non-sectoral participation of greening facilities. The remaining sparse green cover need to be enhanced with adequate afforestation programme employing good forestry practices to enhance the soil sequestration and carbon sink.

The open spaces available for new afforestation activities are very deficient in most of the urban areas of Tamil Nadu, which demands the need to promote avenue plantations, roadside plantation etc. Further concrete structure has less scope for the litter conservation, which must also be given importance.

To address these challenges and maximize the carbon sequestration potential of urban trees, it is important to prioritize urban forestry in urban planning and development. This can include planting and maintaining more trees, protecting existing green spaces, and incorporating green infrastructure such as green roofs and walls. Policy interventions such as carbon taxes and carbon offset programs can also incentivize the maintenance and expansion of urban forests.

Hence, municipal authorities may consider the results of the present study in preparing city climate action plan as a seamless effort involving the Forest Department, Urban Development Departments, and Non-Governmental Organisations.

The way forward is to provide site-specific afforestation techniques on the line of soil quality to enhance the carbon stock and climate-proof green cover in the Urban areas of Tamil Nadu.

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Appendix 1: List of Tree Species in cities of Tamil Nadu in respective agro-climatic zone

Agro-climatic zone	Cities covered	List of Tree species
North Eastern Zone	Avadi, Chennai, Tambaram, Kancheepuram, Vellore	*Albizia lebbeck, Atalantia monophylla, Azadiracta indica, Cascia siamea, Casscia fistula, Cassia auriculata, Cassia glauca, Delonix regia,, Ficus benghalensis, Ficus glabrata, Gauzuma tomentosa, Grewia tiliaefolia, Mangifera indica, Mayurantha flora, Mimosa elangii, Morinda tinctoria, Palmyra borassusflabellifer, Parkia biglandulosa, Peltophorum feruginiuni, Phoenix slyvestris, Polyalthia longifolia, Pongamia pinnata, Samanea saman, Spathodea campanulata, Sterculia foetida, Streblus teliofolia, Syzygium cumini, Tabubia rosea,Tamarindus indica, Terminalia catappa, Wrightia tinctoria,*
North Western Zone	Hosur	*Albizia lebbeck, Albizia saman, Annona cherimola, Annona squamosa, Bauhinia purpurea, Bauhinia racemosa, Bougainvillea spectabilis, Butea monosperma, Caesalpinia pulcherrima, Casuarina equisetifolia, Citrus media,Citrus medica, Delonix regia, Eucalyptus globulus, Ficus benghalensis, Ficus hispida, Ficus racemosa, Ficus religiosa Holoptelia integrifolia, Jacaranda mimosifolia, Lawsonia inermis, Madhuca longifolia, Nyctanthes arbortristis, Phyllanthus emblica, Saraca asoca, Sesbania grandiflora, Syzygium cuminii, Tamarindus indica, Tectona grandis, Terminalia arjuna,*

Agro-climatic zone	Cities covered	List of Tree species
Western Zone	Coimbatore, Salem, Erode, Tiruppur, Karur, Dindigul	*Aegle marmelos, Albizia lebbeck, Albizia saman,Annona cherimola, Annona squamosa, Araucaria cunninghamii, Azadirachta indica,* *Bauhinia purpurea, Bauhinia racemosa, Bombax ceiba, Borassus flabellifer, Bougainvillea spectabilis,* *Butea monosperma,* *Caesalpinia pulcherrima, Callistemon citrinus, Carica papaya,Caryota urens,Cassia fistula, Cassia siamea, Casuarina equisetifolia, Citrus media,Citrus medica, Cocos nucifera, Cordia sebestena,* *Delonix regia, Eucalyptus globulus,* *Feronia limonia, Ficus benghalensis, Ficus hispida, Ficus racemosa, Ficus religiosa* *Holoptelia integrifolia, Jacaranda mimosifolia, Lawsonia inermis,* *Madhuca longifolia, Magnolia champaca, Mangifera indica, Melia dubia, Millingtonia hortensis,* *Mimusops elingi,Murraya koenigii,* *Nyctanthes arbor-tristis, Phyllanthus emblica, Phyllanthus polyphyllus, Pithecellobium dulce,* *Plumeria pudica, Plumeria rubra, Polyalthia longifolia,Pongamia pinnata, Psidium guajava,* *Pterocarpus marsupium,* *Saraca asoca, Sesbania grandiflora, Simarouba amara, Spathodea campanulata, Sterculia foetida,* *Swietenia mahagoni,Syzygium cuminii,* *Tamarindus indica, Tecoma stansTectona grandis, Terminalia arjuna, Thespesia populnea,* *Vitex negundo, Ziziphus Jujuba, Ziziphus mauritiana,*

Agro-climatic zone	Cities covered	List of Tree species
Cauvery Delta Zone	Kumbakonam, Trichy, Thanjavur	*Aegle marmelos, Ailanthus excels, Albizia amara, Albizia lebbeck, Alstonia scholaris, Anacardium occidentale, Anthocepalus cadamba, Anthocepalus cadamba, Atrocarpus heterophyllus, Azadirachra indica* *Bauhinia purpurea, Bauhinia racemosa, Bauhinia variegate, Bomba ceiba, Butea monosperma,* *Caesalpinia sappan, Calophyllum inophyllum, Cassia fistula,* *Dalbergia latifolia, Dalbergia sissoo,* *Delonix regia, Diospyros ebenum, Erythirina indica,* *Ficus benghalensis, Ficus racemose, Ficus religious,* *Gmelina arborea, Haldina cordifolia, Hardwickia pinnata,* *Khaya sengalensis, Madhuca indica, Mangifera indica*
Southern Zone	Madurai, Sivakasi, Thoothukudi, Tirunelveli	*Acacia nilotica, Acacia planifrons, Adinia cordifolia, Aegle marmelos, Albezzia lebbeck,* *Albizia lebbeck, Azadirachta indica,* *Bauhinia racemose, Borassus flaballifer, Cassia fistula,* *Dalbergia sissoo, Delonix regia, Derris indica,* *Ficus bengalensis, Ficus racemose, Ficus religiosa, Ficus religiosa,* *Gmelina arborea, Inga dulce* *Maduca indica, Mangifera indica, Melia dubia, Mellingtonia hortensis* *Mimusops elengi, Morinda tinctoria*

Agro-climatic zone	Cities covered	List of Tree species
		Peltophorum pterocarpum, Pithecellobium dulce, Pongamia pinnata *Samanea saman, Strychnos vomica, Swietenia macrophylla, Syzygium cumini,* *Tamarindus indica, Tamarindus indicus, Terminalia arjuna, Thespesia populnea, Thespesia populnea,* *Wrightia tinctoria*
High Rainfall Zone	Nagercoil	*Azadirachra indica, Pongamia pinnata, Calophyllum inophyllum, Artocarpus incises, Albizia lebbeck, Albizia fulcata, Ficus bengalensis, Ficus religiosa*