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A preliminary study on the benefits of urban parks in Ho Chi Minh City using i-Tree tools

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Abstract. Green spaces in urban areas are essential for improving environmental sustainability and resilience in fast-growing cities such as Ho Chi Minh City. This study utilized i-Tree tools to assess and compare the ecological and economic contributions of two urban parks, Tao Dan Park and 23/9 Park. The results revealed distinct land cover distributions, with Tao Dan Park having greater tree/shrub and herb/grass cover, while 23/9 Park had more impervious surfaces. Key species such as *Dipterocarpus alatus* in Tao Dan Park and *Peltophorum pterocarpum* in 23/9 Park highlighted differences in species importance and ecological contributions. Tao Dan Park's older trees exhibited higher carbon storage, particularly in the largest diameter class, with an estimated storage of 1,337 tons of carbon valued at USD 24,512 using i-Tree Eco, compared to 276.1 tons valued at USD 5,062 in 23/9 Park. Additionally, Tao Dan Park outperformed 23/9 Park in oxygen production, carbon dioxide absorption, avoided runoff, and $PM_{2.5}$ removal. Compared to i-Tree Canopy, the i-Tree Eco model provided more detailed and accurate in terms of ecological and economic values, which were used to estimate the annual financial benefits of the parks at USD 5,121 for 23/9 Park and USD 17,639 for Tao Dan Park. To fully leverage the potential of i-Tree Eco, future research should investigate the integration of this model into urban park management to enhance ecosystem services and support sustainable urban planning strategies.

Keywords: Carbon sequestration, Ecological service, i-Tree, Urban park

1. Introduction

Urban green spaces are crucial for cities, providing essential ecosystem functions like supporting biodiversity and regulating the climate. By incorporating forest plantations, vegetation, and water bodies, urban green spaces help reduce the impact of the heat island effect, which can raise temperatures by as much as 5°C [1-6]. These spaces also reduce air and noise pollution, with parks filtering up to 85% of air pollutants [1, 7-10]. Biodiversity is preserved in urban parks, which support diverse habitats despite their recreational focus [4, 11]. Vegetation in green spaces can lower energy costs through improved air circulation, shading, and evapotranspiration, potentially reducing energy consumption by 5 to 10% in cities like Chicago [12-14]. Green infrastructure elements enhance water management by reducing runoff and improving climatic conditions, which is crucial in cities prone to flooding [15, 16]. Urban parks promote social cohesion and well-being, reducing stress and enhancing physical and psychological health [1, 14, 17].

In Ho Chi Minh City, urban parks provide essential green infrastructure that significantly improves residents' quality of life throughout its history [18]. Publicly owned and managed urban park systems are designed to support both active and passive recreation through their interconnected green spaces. However,

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the availability of parks in Ho Chi Minh City is still extremely limited, with only 0.55 m² of park area per resident [19]. This figure falls well below the national standard for special urban areas (7 m²) [20] and is lower compared to other Southeast Asian cities like Bangkok (1 m²) and Kuala Lumpur (1.25 m²) [21]. Nevertheless, public spaces, particularly parks, are vital for the city's residents, providing areas for relaxation and recreation. Unfortunately, these parks are continuously at risk from unauthorized construction, real estate developments, and the encroachment of commercial activities [21].

As science and technology progress rapidly, the methods for evaluating the ecological services of urban green spaces are continually evolving to keep pace with modern advancements. In Vietnam, the woody tree monitoring in urban setting is adopted from traditional forest inventory methods which focus solidly on biomass and carbon stock investigation. i-Tree is an advanced software package created by Davey Institute and the U.S. Forest Service (USFS). The tools within the i-Tree platform are designed to help diverse stakeholders evaluate and track the benefits provided by trees. Through the selection of suitable tree species for specific locations, i-Tree can measure the benefits of trees using various data sources, including field inventories along with air pollution data [10, 13, 22]. The i-Tree software package includes 11 different tools, such as the i-Tree Eco and i-Tree Canopy models, which were applied in this research. The i-Tree Eco model stands out from other systems by offering comprehensive approaches for creating holistic green space management strategies and sustainable urban policies aimed at reducing air pollution [23]. The i-Tree Canopy tool is commonly employed in scientific research to assess both tree canopy coverage and other types of land cover. Its widespread use is attributed to its capability to simplify land cover evaluations through the use of aerial imagery [24-27]. In Vietnam, i-Tree tools - particularly i-Tree Eco, were introduced by GreenViet in 2021 with support from the USDA Forest Service and got the scientific interest for its powerful model with rich tropical species database. In Vietnam, several publications have investigated urban trees using i-Tree Eco in Ho Chi Minh City [28], Da Nang City [29] and Hung Yen Province [30].

This preliminary study investigates the benefits of two public parks, Tao Dan Park and 23/9 Park, focusing on their contributions to environmental sustainability and urban resilience. By examining aspects such as biodiversity, carbon sequestration, and economic value with different i-Tree tools, we aim to provide a scientific basis for i-Tree application in highlighting the importance of preserving and expanding urban parks in rapidly growing cities.

2. Materials and methods

2.1 Study area

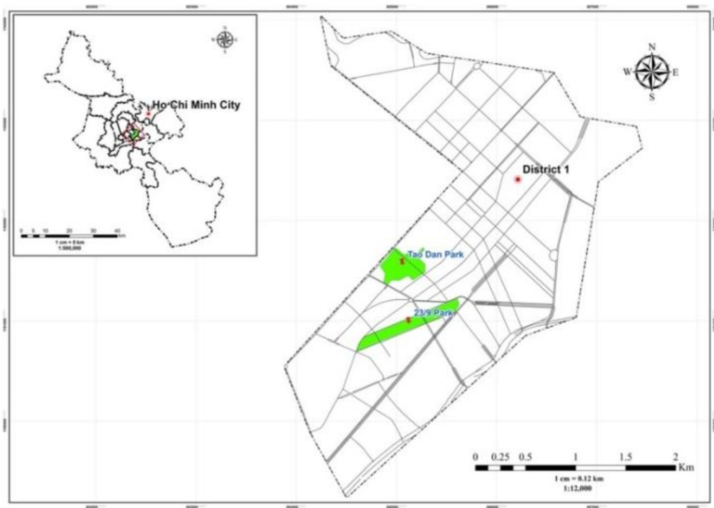

Figure 1. Map of Ho Chi Minh City (HCMC) and sample parks in this study.

The two parks are located in the center of HCMC (Figure 1) and have played a crucial role in the city's historical development. Notably, 23/9 Park (N $10^0$46'10'' - E 106°41′35″) was established in 1985, originating from an old tramway station constructed by the French Governor of Saigon (the former name of HCMC) in 1881 [31]. The park underwent a reduction in size in 2020 when a portion was repurposed for the development of the city's metro system. Meanwhile, Tao Dan Park (N 10°46′29″ - E 106°41′33″), also known as Jardin de la Ville (The Garden of City) or le bois de Boulogne des Saigonnanais (The Boulogne Forest of Saigoneses) is a is a key element in the evolution of the city [31]. The Park inherited the so many old trees which are mainly natives such as *Dipterocarpus alatus*, *Hopea odorata* and *Tectona grandis.*

In the research region, the average annual temperature is 25 - 28°C and the average annual rainfall is 1900 – 2000 mm. On average, there are 159 rainy days per year, with 90% of these occurring during the wet season from May through November. The average humidity is 79,5% during the wet season and 74,5% in the dry season. Essentially, the study area is situated in a region that is not affected by hurricanes (Tan Son Hoa meteorological station: N $10^0$47'47" - E $106^0$39'60").

2.2 Field data collection

The field measurements were conducted from March 2024 to May 2024 in Tao Dan Park and 23/9 Park, located in the center of HCMC, Vietnam. We carried out complete the inventory of each park following the i-Tree Eco field manual. We recorded the attributes of park trees if their diameter at breast height ($D_{1.3}$) exceeded 6 cm. The tree's profiles were collected including tree location coordinates, species name, diameter at breast height ($D_{1.3}$), tree heights (total tree height, live tree height, crown base height), crown width (North-South and East-West distances), crown health (percentage of die-back, percentage of crown missing), and crown light exposure (CLE: 0-5).

2.3 i-Tree Canopy

We generated the 1000-point random sample within each park boundary and carefully defined the land covers utilizing Google Earth imagery. The i-Tree Canopy employs a point-quadrant method, which is frequently used to evaluate tree canopy composition in the city setting. In this study, the land cover classes were determined the category as follows: Herb/grass (H), Imperious Building (IB), Imperious Others (IO), Imperious Road (IR), Tree/shrub (T), and Water (W).

For ecological service calculation, i-Tree Canopy offers a regional setting that can be defined according to the weather similarity between the specified locations. In this study, we use the tree benefit valuations of urban areas in Florida, USA, due to the weather similarity of 97% between HCMC and Florida (https://www.codeminders.com/weather_similarity).

2.4 i-Tree Eco

Leaf Area (LA) refers to the total one-sided surface area of a tree's leaves. This is determined using the equation provided by Nowak (1996) [32]. The Important Values (IV) for each tree species are determined by aggregating their respective contributions to the overall tree population and leaf area. IV = (percentage number of tree species x 100) + (percent of species leaf area x 100).

Air pollution and meteorological data: i-Tree Eco is tailored to analyze urban forest structure and its various impacts by utilizing standardized field data combined with comprehensive hourly air pollution and meteorological data collected over an entire year [22]. The hourly precipitation data for 2022 was obtained from Tan Son Hoa meteorological station (N $10^0$47'47.48"; E $106^0$39'59.75"). In terms of air pollution, hourly measurements for nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2) and particulate matter less than 10 microns (PM_{10}) were not available. The only accessible data in 2022 was for particulate matter less than 2.5 microns ($PM_{2.5}$), which was obtained from the U.S. Consulate General in Ho Chi Minh City (airnow.gov). The rainfall and $PM_{2.5}$ data were submitted via the i-Tree Database Platform and have been available to use since Jan 2024.

Carbon storage and sequestration: to estimate tree carbon storage, tropical biomass equations - which can be used in i-Tree Eco v6 were applied in this study. The calculation of carbon storage involves multiplying the biomass of trees by a factor of 0.5, or by 0.41 specifically for palm trees [33]. To estimate the annual carbon sequestration, the mean increase in diameter for the specific tree genera and size class was added to the measured diameter of the tree (for year x). This estimation was used to project carbon storage for the subsequent year (year x+1).

Air pollution removal: Trees' leaves capture $PM_{2.5}$ and may either be washed away by rain or absorbed into the soil [34]. The i-Tree model calculates the amount of $PM_{2.5}$ removed by urban trees using the Leaf Area Index (LAI) and hourly measurements of $PM_{2.5}$ flux along with the impact of hourly removal rates on atmospheric $PM_{2.5}$ levels.

Oxygen production: The O_2 production is calculated using carbon sequestration data, derived from atomic weight ratios.: O_2 release (ton/yr) = net C sequestration (ton/yr) x 32/12

Avoided runoff (AVRO): using data on leaf area and hourly precipitation, i-Tree Eco calculates the volume of intercepted rainfall and the amount of runoff prevented by the presence of trees. These estimates are first made with the current tree conditions and then with the trees removed, to evaluate their effect on surface runoff [33].

2.5 Economic estimation

We applied the prices of urban tree benefits in Florida (USA) to calculate the economic values of pollutant removal and avoided surface runoff. Particularly, $PM_{2.5}$ removal was 131 USD/kg [35]; avoided runoff was 2.36 USD/m^3 [5]. Carbon values were calculated at 10 USD/ton CO_2e based on The Emissions Reduction Purchase Agreements (ERPAs) between the Vietnamese Government and LEAF/emergent.

3. Results and discussion

3.1 Land covers

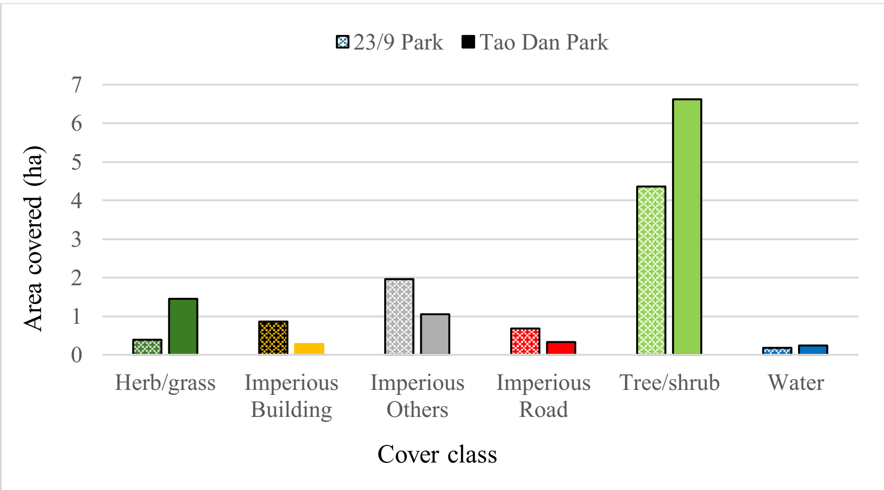

Figure 2. The land cover of 23/9 Park (*pattern-fill bars*) and Tao Dan Park (*solid-fill bars*).

In Figure 2, the land cover data for 23/9 Park and Tao Dan Park in Ho Chi Minh City shows distinct management approaches. Tao Dan Park has a large tree/shrub cover (6.62 ha) and herb/grass cover (1.45 ha), indicating a focus on greenery and biodiversity. In contrast, 23/9 Park has more impervious surfaces (1.96 ha), buildings (0.86 ha), and park roads (0.68 ha), reflecting an emphasis on infrastructure and

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accessibility. Both parks have minimal water features, with Tao Dan Park having slightly more (0.24 ha vs. 0.18 ha).

3.2 Tree characteristics of the Urban Parks

The ten species which are likely prioritized in last decade of each park management regime are presented in Table 1 and Table 2.

Table 1. Most common species in 23/9 Park

No.	Species	N	LA (ha)	% N	% LA	IV (%)
1	*Peltophorum pterocarpum*	91	2.37	15.7	22.7	38.4
2	*Khaya senegalensis*	62	2.73	10.7	26.1	36.8
3	*Dipterocarpus alatus*	25	1.62	4.1	15.5	19.8
4	*Tectona grandis*	61	0.35	10.5	3.3	13.8
5	*Delonix regia*	40	0.48	6.9	4.6	11.4
6	*Elaeis guineensis*	42	0.30	7.2	2.9	10.1
7	*Pterocarpus macrocarpus*	38	0.32	6.6	3.0	9.6
8	*Lagerstroemia speciosa*	38	0.30	6.6	2.9	9.4
9	*Shorea siamensis*	14	0.21	6.0	2.0	8.1
10	*Cassia fistula*	16	0.09	6.0	0.8	6.9

Table 2. Most common species in Tao Dan Park

No.	Species	N	LA (ha)	% N	% LA	IV (%)
1	*Dipterocarpus alatus*	243	26.3	27.9	61.9	89.9
2	*Hopea odorata*	40	3.12	4.6	7.4	12.0
3	*Khaya senegalensis*	40	2.46	4.6	5.8	10.4
4	*Afzelia xylocarpa*	49	0.80	5.6	2.3	7.9
5	*Swietenia macrophylla*	42	0.48	4.8	1.9	6.7
6	*Peltophorum pterocarpum*	33	1.15	2.6	2.7	5.4
7	*Streblus asper*	21	0.57	2.4	1.4	3.8
8	*Ficus microcarpa*	13	0.76	1.5	1.8	3.3
9	*Roystonea regia*	23	0.19	2.6	0.5	3.1
10	*Tamarindus indica*	18	0.43	2.1	1.0	3.1

In 23/9 Park, *Peltophorum pterocarpum* emerges as the most significant species, contributing 15.7% to the tree count and 22.7% to the leaf area, with an importance value (IV) of 38.4% (Table 1). Conversely, in Tao Dan Park, *Dipterocarpus alatus* dominates, accounting for 27.9% of the tree count, 61.9% of the leaf area, and an IV of 89.9% (Table 2). While *Khaya senegalensis* plays a substantial role in both parks, with similar tree counts, it exhibits differences in leaf area contribution and IV. Other notable species like *Tectona grandis* and *Delonix regia* contribute to the diversity in 23/9 Park, whereas *Hopea odorata* and *Afzelia xylocarpa* stand out alongside *Dipterocarpus alatus* in Tao Dan Park. These differences highlight the unique ecological compositions and management approaches of the two parks, with varying species dominance and contributions to the overall biodiversity of each park. Additionally, Tao Dan Park, with its long history of stable management, has preserved native species like *Dipterocarpus alatus* and *Hopea odorata*. In contrast, 23/9 Park is dominated by widely popular urban tree species in Vietnam, such as *Peltophorum pterocarpum* and *Khaya senegalensis*, as noted in other studies such as Tran *et al* (2022) [28] and Duong *et al* (2024) [30].

Table 3. Volume and carbon storage of trees by diameter class (cm)

DBH (cm)	23/9 Park			Tao Dan Park		
	N	V (m^3)	C storage (ton)	N	V (m^3)	C storage (ton)
0-20	114	7,6	3.7	172	5,5	3.8
20-40	216	75,0	37.0	227	103,6	48.3
40-80	224	436,3	179.4	269	677,0	298.7
> 80	26	159,3	56.0	205	2476,5	986.2
Total	580	678,2	276.1	873	3262,5	1337.0

In both 23/9 Park and Tao Dan Park, the distribution of volume and carbon storage of park trees by diameter class varies significantly (Table 3). In the 0-20 cm diameter class, Tao Dan Park has a higher number of trees (172) compared to 23/9 Park (114), although the volume and carbon storage are slightly higher in 23/9 Park (V = 7.6 m^3, C storage = 3.7 tons) compared to Tao Dan Park (V = 5.5 m^3, C storage = 3.8 tons). The 20-40 cm diameter class, both parks show an increase in the number of trees, volume, and carbon storage, with Tao Dan Park exhibiting higher values in all three parameters. The trend continues in the 40-80 cm diameter class, with Tao Dan Park having a larger number of trees, higher volume, and greater carbon storage compared to 23/9 Park. In the diameter class above 80 cm, Tao Dan Park, with 205 trees - many originating from its establishment in the 19th century - exhibits a significantly greater volume and carbon storage (V = 2476.5 m^3, C storage = 986.2 tons) compared to 23/9 Park (V = 159.3 m^3, C storage = 56 tons).

3.3. Tree ecological services and monetary contribution

Table 4. Tree carbon storage and its value estimation in two Parks

Tool	C (ton)	CO_2 (ton)	Value[a] (USD)
	23/9 Park		
i-Tree Canopy	335.0	1,228.4	12,284
i-Tree Eco	276.1	1,012.4	5,062
	Tao Dan Park		
i-Tree Canopy	509.1	1,866.7	9,334
i-Tree Eco	1,337.0	4,902.3	24,512

[a]CO_2e – 10 USD/ton (ERPAs).

The comparison between tree carbon storage and its value estimation in 23/9 Park and Tao Dan Park reveals notable differences between the two parks and the methods used for assessment (Table 4). In 23/9 Park, the i-Tree Canopy method estimates a total carbon storage of 335 tons, with a corresponding CO_2 absorption of 1,228 tons, and a value of USD 12,284. Meanwhile, the i-Tree Eco method yields a lower estimate, with carbon storage at 276.1 tons, carbon dioxide absorption at 1,012.4 tons, and a value of USD 5,062. Conversely, in Tao Dan Park, the i-Tree Canopy method estimates higher carbon storage of 509.1 tons, carbon dioxide absorption of 1,866.7 tons, and a value of USD 9,334. On the other hand, the i-Tree Eco method provides a significantly higher estimate, with carbon storage at 1,337 tons, carbon dioxide absorption at 4,902.3 tons, and a value of USD 24,512.

One of the most frequently mentioned advantages of urban trees is their ability to produce oxygen. The amount of oxygen a tree generates each year is linked to the total of carbon it sequesters, which in turn depends on the tree's biomass growth.

Table 5. The most oxygen production species in 23/9 Park

No.	Species	N	O_2 (ton/year)	CO_2 (ton/year)	Canopy cover (m^2)
1	*Khaya senegalensis*	62	8.37	11.5	3,446
2	*Peltophorum pterocarpum*	91	6.25	8.6	4,148
3	*Elaeis guineensis*	42	4.38	6.0	1,336
4	*Delonix regia*	40	3.2	4.4	1,542
5	*Dipterocarpus alatus*	25	2.95	4.1	1,699
6	*Tectona grandis*	61	2.33	3.2	1,065
7	*Lagerstroemia speciosa*	38	1.25	1.7	1,186
8	*Enterolobium cyclocarpum*	11	1.08	1.5	993
9	*Pterocarpus macrocarpus*	38	1.06	1.5	945
10	*Cassia fistula*	16	0.68	0.9	385

Table 6. The top 10 oxygen production species in Tao Dan Park

No.	Species	N	O_2 (ton/year)	CO_2 (ton/year)	Canopy cover (m^2)
1	*Dipterocarpus alatus*	243	40.49	55.7	19,616
2	*Khaya senegalensis*	40	6.08	8.4	2,320
3	*Afzelia xylocarpa*	49	4.25	5.8	1,894
4	*Swietenia macrophylla*	42	4.06	5.6	1,350
5	*Streblus asper*	21	2.62	3.6	742
6	*Hopea odorata*	40	2.34	3.2	2,241
7	*Roystonea regia*	23	2.22	3.0	462
8	*Peltophorum pterocarpum*	23	1.72	2.3	1,863
9	*Diospyros mollis*	10	1.23	1.7	434
10	*Tamarindus indica*	18	1.20	1.7	675

The comparison between the distribution of the top 10 oxygen production species in 23/9 Park and Tao Dan Park reveals significant differences in species composition and their respective contributions to oxygen production (Table 5, Table 6). In 23/9 Park, *Khaya senegalensis* and *Peltophorum pterocarpum* are prominent oxygen producers, with substantial numbers of trees generating significant oxygen output. Conversely, in Tao Dan Park, *Dipterocarpus alatus* emerges as the dominant oxygen producer, followed by *Khaya senegalensis*. Additionally, while both parks exhibit diverse species contributing to oxygen production, the specific species and their relative contributions differ, highlighting the unique environmental characteristics of each park. These findings are consistent with those of Tran *et al* (2022) [28], who identified *Khaya senegalensis* as the leading contributor to ecological services in university campuses in Ho Chi Minh City, particularly in oxygen production and carbon dioxide (CO_2) absorption.

Furthermore, although both parks support a variety of species that contribute to oxygen production, the specific species and their respective contributions vary, reflecting the distinct environmental attributes of each park. However, the economic value of this oxygen production was not computed in our study. This omission is because the contribution of tree-generated oxygen is minimal compared to the abundant and stable atmospheric oxygen supply and the substantial input from aquatic environments [36].

Table 7. Ecological service provision and its moneytory contribution of two parks

Tool	CO_2 (ton/year)	Value[a] (USD)	AVRO (m^3/year)	Value[b] (USD)	$PM_{2.5}$ (kg/year)	Value[c] (USD)
	23/9 Park					
i-Tree Canopy	75.9	759	12.9	30	13.0	1,704
i-Tree Eco	50.1	250	838.0	1,978	23.5	3,075
	Tao Dan Park					
i-Tree Canopy	115.4	1,154	19.6	46	19.8	2,590
i-Tree Eco	111.3	1,113	2,432.0	5,740	86.6	11,343

[a]CO_2e – 10 USD/ton (ERPAs); [b]avoided runoff - 2.36 USD/m^3; [c]$PM_{2.5}$ – 131 USD/kg.

The comparison of service provision between 23/9 Park and Tao Dan Park using two methods, i-Tree Canopy and i-Tree Eco, reveals significant differences in the estimated values across various environmental indicators (Table 7). In 23/9 Park, the i-Tree Canopy method estimates carbon dioxide absorption at 75.93 tons/year, with a corresponding value of USD 759, whereas Tao Dan Park shows a higher absorption rate of 115.4 tons/year, valued at USD 1,154. However, the i-Tree Eco method provides a contrasting result, with 23/9 Park showing a lower carbon dioxide absorption of 50.1 tons/year (valued at USD 250) compared to Tao Dan Park's 111.3 tons/year (valued at USD 1,113). Similar disparities are observed in other service provisions, such as air volume reduction (AVRO) and $PM_{2.5}$ removal. 23/9 Park demonstrates AVRO of 12.9 m^3/year (valued at USD 30) and $PM_{2.5}$ removal of 13.0 kg/year (valued at USD 1,704) with the i-Tree Canopy method, while Tao Dan Park exhibits a higher AVRO (19.6 m^3/year valued at USD 46) and $PM_{2.5}$ removal (19.8 kg/year valued at USD 2,590). However, with the i-Tree Eco method, 23/9 Park shows a significant increase in AVRO (838 m^3/year valued at USD 1,978) and $PM_{2.5}$ removal (23.5 kg/year valued at USD 3,075), but still lower compared to Tao Dan Park's estimates of 2,432 m^3/year AVRO (valued at USD 5,740) and 86.6 kg/year $PM_{2.5}$ removal (valued at USD 11,343).

Overall, i-Tree Canopy, with its user-friendly interface and satellite imagery integration, offers a broad overview of the ecological and environmental services within the study area. However, i-Tree Eco, by incorporating field-based tree data and specific input values such as climate conditions and air pollution levels, provides a more precise and detailed analysis for individual tree species. As a result, the ecological and economic values calculated and projected by i-Tree Eco were adopted for the outcomes of this study, given its higher accuracy and detail. Accordingly, the annual economic contributions of 23/9 Park and Tao Dan Park are valued at USD 5,121 and USD 17,639, respectively.

4. Conclusions

Urban green spaces are essential for improving the environmental sustainability and resilience of fast-expanding urban areas such as Ho Chi Minh City. This research utilized i-Tree Tools to evaluate both the ecological and economic aspects of two urban parks: Tao Dan Park and 23/9 Park as follows: (1) The study revealed a clear distinction in land cover distribution between the parks, with Tao Dan Park having a higher proportion of tree/shrub and herb/grass cover, while 23/9 Park featured more impervious surfaces. (2) Key species such as *Dipterocarpus alatus* in Tao Dan Park and *Peltophorum pterocarpum* in 23/9 Park highlight differences in species importance and their ecological contributions to the parks. (3) Tao Dan Park, with older and larger trees, exhibited higher carbon storage, particularly in its largest diameter class, storing an estimated 1,337 tons of carbon valued at USD 24,512. In comparison, 23/9 Park stored 276.1 tons, valued at USD 5,062. (4) Tao Dan Park demonstrated higher levels of key environmental services compared to 23/9 Park, including greater oxygen production, carbon dioxide absorption, avoided runoff, and $PM_{2.5}$ removal. (5) The i-Tree Eco model provided more comprehensive and accurate ecological and economic values, estimating the annual financial contributions of the parks at USD 5,121 for 23/9 Park and USD 17,639 for Tao Dan Park.

To fully leverage the potential of i-Tree Eco, future research should investigate the integration of this model into urban park management to enhance ecosystem services and support sustainable urban planning strategies. Additionally, there is a need for high-resolution data on pollutants such as O_3, SO_2, NO_2, and PM_{10}, as well as the development of growth models for native species, to improve the accuracy of the i-Tree database integration in Vietnam.

Conflict of interest

The author declares that there are no conflicts of interest to disclose related to this manuscript.

References

[1] Bolund P, and Sven H 1999 Ecological services in urban areas *Ecol. Econ.* **29** 293-301. https://doi.org/10.1016/S0921-8009(99)00013-0

[2] Haq S M A 2011 Urban green spaces and an integrative approach to sustainable environment *J. Environ. Prot.* **2** 601-608. http://dx.doi.org/10.4236/jep.2011.25069

[3] Byrne J, and Sipe N 2010 Green and open space planning for urban consolidation – A review of the literature and best practice *Griffith University - Urban Research Program - Issues Paper* **11**.

[4] Nowak D J 2010 Urban biodiversity and climate change in *Urban Biodiversity and Design* ed N Müller *el al* (New Jersey, USA: Wiley-Blackwell) pp 101.

[5] Nowak D J, Coville R, Endreny T, Abdi R, and Van Stan II J T 2020 Valuing urban tree impacts on precipitation partitioning in *Precipitation Partitioning by Vegetation: A Global Synthesis* ed J T van Stan *et al* (New York, USA: Springer) pp 253-268.

[6] Chang C R, Li M H, and Chang S-D 2007 A preliminary study on the local cool-island intensity of Taipei city parks *Landsc. Urban Plan* **80** 386-395. https://doi.org/10.1016/j.landurbplan.2006.09.005

[7] Nowak D J, Hirabayashi S, Doyle M, McGovern M, and Pasher J 2018 Air pollution removal by urban forests in Canada and its effect on air quality and human health *Urban For Urban Green* **29** 40-48. https://doi.org/10.1016/j.ufug.2017.10.019

[8] Wu J, Wang Y, Qiu S, and Peng J 2019 Using the modified i-Tree Eco model to quantify air pollution removal by urban vegetation *Sci. Total Environ.* **688** 673-683. https://doi.org/10.1016/j.scitotenv.2019.05.437

[9] Riondato E, Pilla F, Basu A S, and Basu B 2020 Investigating the effect of trees on urban quality in Dublin by combining air monitoring with i-Tree Eco model *Sustain. Cities Soc.* **61** 102356. https://doi.org/10.1016/j.scs.2020.102356

[10] Hirabayashi S 2014 i-Tree Canopy air pollutant removal and monetary value model descriptions *The Davey Institute, Syracuse, New York* **11.**

[11] Cornelis J, and Hermy M 2004 Biodiversity relationships in urban and suburban parks in Flanders *Landsc. Urban Plan.* **69** 385-401. https://doi.org/10.1016/j.landurbplan.2003.10.038

[12] Heidt V, and Neef M 2008 Benefits of urban space for improving urban climate, ecology, planning and management of urban forests: International perspective *J. Environ. Prot.* **2**. Jg., Nr. 5.

[13] Nowak D J 1994 Atmospheric carbon dioxide reduction by Chicago's urban forest *Chicago's urban forest ecosystem: Results of the Chicago urban forest climate project* 83-94.

[14] Sorensen M, Smit J, and Barzetti V 1997 Good practices for urban greening *International Seminar on Urban Greening in Latin America and Caribbean. Inter-American Development Bank (IDB)*

[15] Pauleit S, and Duhme F 2000 Assessing the environmental performance of land cover types for urban planning *Landsc. Urban Plan* **52** 1-20. https://doi.org/10.1016/S0169-2046(00)00109-2

[16] Pataki D E, Carreiro M M, Cherrier J, Grulke N E, Jennings V, Pincetl S, Pouyat R V, Whitlow T H, and Zipperer W C 2011 Coupling biogeochemical cycles in urban environments: Ecosystem services, green solutions, and misconceptions *Front. Ecol. Environ.* **9** 27-36. https://doi.org/10.1890/090220

[17] Maas J, Van Dillen S M, Verheij R A, and Groenewegen P P 2009 Social contacts as a possible mechanism behind the relation between green space and health *Health Place* **15** 586-95. https://doi.org/10.1016/j.healthplace.2008.09.006

[18] Truong V K 1885 Historical memories of Saigon and its surroundings in *Conference given at the College of Interpreters Saigon 1885*. Saigon, Annam: Imprimerie Coloniale.

[19] HCMC-DOC 2020 *The Master Plan of Tree and Urban Park Development of Ho Chi Minh City in the 2020-2030* June 2020.

[20] Vietnam National Technical Regulation 2021 *QCVN 01:2021/BXD: National Technical Regulation on Construction Planning*.

[21] Hoang A T, Apparicio P, and Pham T T H 2019 The provision and accessibility to parks in Ho Chi Minh city: Disparities along the urban core—periphery Axis *Urban Sci.* **3** 37. https://doi.org/10.3390/urbansci3010037

[22] Nowak D J, and Crane D E 2000 The urban forest effects (UFORE) model: Quantifying urban forest structure and functions in *Integrated tools for natural resources inventories in the 21st century* ed Hansen M *el al* (Minnesota, USA: US Department of Agriculture, Forest Service, North Central Forest Experiment Station).

[23] Pace R, Biber P, Pretzsch H, and Grote R 2018 Modeling ecosystem services for park trees: Sensitivity of i-tree eco simulations to light exposure and tree species classification *Forests* **9** 89. https://doi.org/10.3390/f9020089

[24] Oliveira M, Santagata R, Kaiser S, Liu Y, Vassillo C, Ghisellini P, Liu G, and Ulgiati S 2022 Socioeconomic and environmental benefits of expanding urban green areas: A joint application of i-Tree and LCA approaches *Land* **11** 2106. https://doi.org/10.3390/land11122106

[25] Parmehr E G, Amati M, Taylor E J, and Livesley S J 2016 Estimation of urban tree canopy cover using random point sampling and remote sensing methods *Urban For. Urban Green.* **20** 160-71. https://doi.org/10.1016/j.ufug.2016.08.011

[26] Omodior O, Eze P, and Anderson K R 2021 Using i-tree canopy vegetation cover subtype classification to predict peri-domestic tick presence *Ticks Tick Borne Dis.* **12** 101684. https://doi.org/10.1016/j.ttbdis.2021.101684

[27] Lee E, and Kim G 2023 Green space ecosystem services and value evaluation of three-dimensional roads for sustainable cities *Land* **12** 505. https://doi.org/10.3390/land12020505

[28] Tran T T, Nguyen D K, Do M T, and Vu T Q 2022 Evaluation of the role of trees in removing air pollutants at selected universities in Ho Chi Minh City using i-Tree Eco model *TNU J. Sci. Tech.* **227** 15 117-129. https://doi.org/10.34238/tnu-jst.6650

[29] Tran N S, and Doan C C 2024 Above ground biomass and carbon sequestration of urban green spaces in Danang City, Vietnam *A. J. Bio.* **20** 1-8.

[30] Duong T B N, Nguyen T M, Pham H P, Hoang V S, and Nguyen Q V 2024 Assessing environmental services and economic values of urban tree species in open public green spaces at Ecopark, Hung Yen province, Vietnam: An application of i-Tree Eco model *J. For Sci. Tech.* **9** 86-95.

[31] Tran H Q 2023 *The Early Urban Infrastructure of Saigon (in Vietnamese)* (Ho Chi Minh City, Vietnam: General Publishing House).

[32] Nowak D J 1996 Estimating leaf area and leaf biomass of open-grown deciduous urban trees *For Sci* **42** 504-507. https://doi.org/10.1093/forestscience/42.4.504

[33] Nowak D J 2021 *Understanding i-Tree: 2021 summary of programs and methods* (Minnesota, USA: US Department of Agriculture, Forest Service, Northern Research Station).

[34] Nowak D J, Hirabayashi S, Bodine A, and Hoehn R 2013 Modeled PM2.5 removal by trees in ten US cities and associated health effects *Environ. Pollut.* **178** 395-402. https://doi.org/10.1016/j.envpol.2013.03.050

[35] Nowak D J, Hirabayashi S, Bodine A, and Greenfield E 2014 Tree and forest effects on air quality and human health in the United States *Environ. Pollut.* **193** 119-29. https://doi.org/10.1016/j.envpol.2014.05.028

[36] Broecker W S 1970 A boundary condition on the evolution of atmospheric oxygen *J. Geophys. Res.* **75** 3553-7. https://doi.org/10.1029/JC075i018p03553