Aassessment of ecosystem services based on i-Tree Eco model in the 29/3 Park, Danang City

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Abstract: *Park trees serve an important role in giving environmental advantages to humans. The i-Tree Eco model is used in this study to analyze the value of trees planted in 29/3 Park in terms of carbon storage capacity, carbon dioxide sequestration, and runoff avoidance. A total of 2,331 trees calculated in the 29/3 Park are estimated to store about 122,540 kg of carbon, sequester roughly 24,490kg of carbon dioxide, and prevent 518.4m³ of runoff. The findings may be utilized to choose appropriate trees for future parks in Danang City to optimize environmental benefits.*

Keywords: *i-Tree Eco; urban tree; environmental benefits; carbon storage; Danang City.*
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1. INTRODUCTION

Green spaces play an important role in the urban ecosystem, providing people with a wide range of recreational, aesthetic, and environmental advantages. Trees, in particular, serve an important role in environmental preservation by improving air quality, removing pollutants and noise, protecting water and soil, and regulating microclimates. Assessing the environmental and ecological worth of each tree and green space is vital for providing critical information that improves public awareness, aids urban planning, and decision-making processes for local management (Bautista and Peña-Guzmán, 2019; Bertram and Rehdanz, 2015; Song et al., 2020).

Cities all across the globe have conducted quantitative studies to estimate the ecological merits of trees and green areas. The i-Tree Eco model, created by the USDA Forest Service and the Davey Institute, has grown in popularity, with more than 90 cities in 130 nations utilizing it to collect data on trees and air spaces in urban and woodland regions. The i-Tree is a free software package that includes i-Tree Eco, i-Tree Canopy, i-Tree Design, and i-Tree Landscape, all of which are particularly intended to assess the many advantages and values generated from trees. Since its initial release in 2006, the i-Tree Eco, particularly its i-Tree Eco tool, has grown in popularity due to its intuitive design, ease of use, and ability to provide critical insights about trees, such as carbon storage capacity, CO_2 sequestration, oxygen generation and the elimination or absorption of air pollutants such as VOCs, SO_2, NO_2, CO, PM2.5, and PM10 (Nowak et al., 2018). Several studies have used the i-Tree Eco model to calculate the ecological and economic benefits of trees and green spaces. For example, a research done in the Luohe City, China resulted in 54,329 tons of carbon storage, 92 tons of air pollutants removal, and 122,637m³ of runoff reduction. Another study in Dublin, Ireland, used the i-Tree Eco model to analyze urban air quality and discovered that trees in the City eliminated around 3 kg of PM2.5 dust each year (Riondato et al., 2020).

Danang is rapidly urbanizing, industrializing, and modernizing in order to become a centre of trade and education, as well as a vital gateway to Vietnam's Central highlands. This progression has resulted in tremendous socioeconomic growth achievements. However, as mentioned in the Environmental City Plan, the City needs aid in meeting its stated environmental goals. Despite a population of approximately 1.134 million people in 2020, Danang has a low green tree index of 7.51m² per person. To meet its 2030 aim of 9.6m² per person for green urban, the City must create green areas and carefully pick appropriate trees. This is an important phase in the planning and development of the City.

Previous research on trees and green spaces in Vietnamese cities has provided managers with vital information on the species composition and variety of planted trees (Hanh, 2015; Sang, 2018; Tan, 2019). In this study, we used the i-Tree Eco model to analyze the 29/3 Park in Danang City, with the goal of offering insights into the urban tree structure, as well as assessing the environmental protection and ecological benefits of the park's trees. This knowledge is critical for managers to successfully plan and develop green spaces in cities, making this a significant addition to the field of study.

2. MATERIALS AND METHODS

2.1. Study site

The 29/3 Park is located in Danang's Thanh Khe District (16°03'46.8"N 108°12'20.6" E) (Figure 1). It covers an area of 19.4ha, of which approximately 10ha is covered by water. This Park serves as a venue for relaxation, entertainment, and cultural events.

2.2. Data collection

The study's data were gathered using the grid technique in accordance with the standard i-Tree plot procedure (i-Tree Eco Field Guide Manual v. 6.0). Each standard plot has a circle with a radius of 11.3m and an area of 404.7m^2 measured including the percentage tree. This study collected data on 372 trees from 36 plots, including tree location, species name, diameter at breast height (DBH) at 1.3m above ground level, total tree height, crown size (height) to live top, height to crown base, crown width, crown width, percent crown missing), crown health (dieback), and crown light exposure. Garmin GPSMAP 65 was used to locate trees; trunk diameter was measured at 1.3m ground level, canopy width was measured above using a tape measure, and tree height values were estimated using a Sndway Sw - 600A laser rangefinder (USDA, 2021). The research was conducted atthe 29/3 Park in Thanh Khe District, Danang City, from October to December 2021.

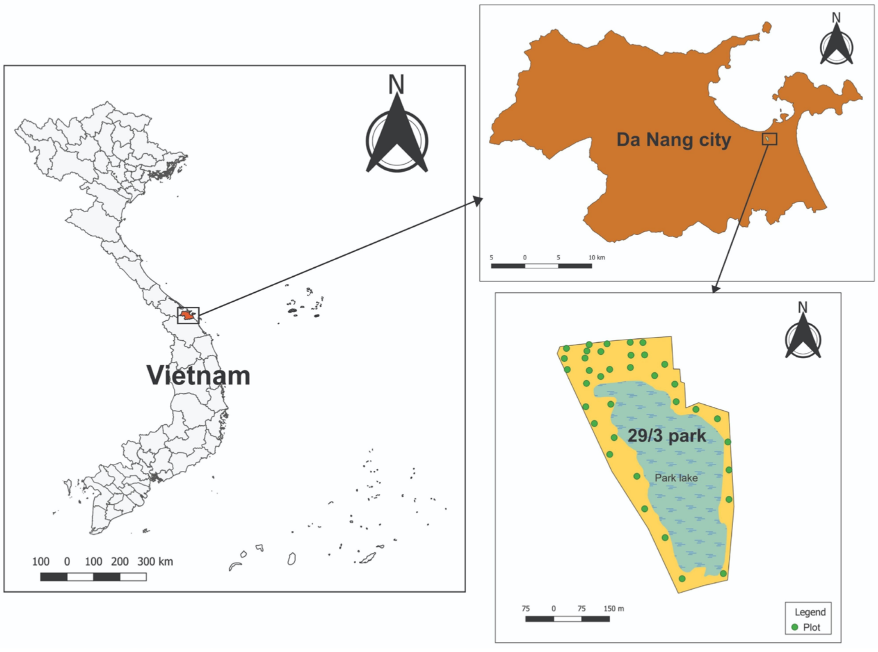
2.3. Data analysis

The i-tree Eco model v6.0.32 was used to import and compute data on trees at plots. Furthermore, data on precipitation, air quality, and local location were obtained from the i-Tree Database (https://database.itreetools.org). The i-Tree Eco model then will assess the value of 29/3 Park including tree structure and ecosystem services (Nowak, 2021; USDA Forest, 2021).

3. RESULTS AND DISCUSSION

3.1. The Park urban tree structure

The i-Tree Eco model indicates that there were around 2,331 trees at the 29/3 Park, with a total of 30 species belonging to 14 families and 10 orders. *Roystonea regia* (46.5%), *Cyrtostachys renda* (9.4%), and *Dracontomen duperreanum* (7.0%) were the most common species. These three dominant species accounted for 62.9% of all tree counts. In terms of leaf area, *Dalbergia tonkinensis* was ocupied with an average of 377m^2, followed by Samanea saman with 157m^2 (Table 1).



▲ *Figure 1. Map shows sampling plots in the 29/3 Park*

The distribution of tree sizes, as measured by diameter at breast height (DBH), was critical to the survival of a tree population. It has an impact on both present and future costs, as well as the flow of ecological benefits (McPherson, 1989). The stem diameter distribution for the ten most dominant species was primarily in the range of DBH less than 20cm. Only *Samanea saman* had a lower rate than 50%. This indicates that there are a lot of young trees, which might represent an increase in urban ecosystem services in the future.

Table 1. The dominant species and the value of tree-shading in the 29/3 Park

Species	Number of trees	Percent of population (%)	Leaf area (m^2)		
			Average	Total	% of Total
Roystonea regia	1,084	46.5	21	22,980	16.0
Cyrtostachys renda	219	9.4	5	1,150	0.8
Dracontomelon duperreanum	163	7.0	57	9,360	6.5
Samanea saman	132	5.6	157	20,670	14.4
Lagerstroemia speciosa	119	5.1	43	5,110	3.6
Hopea odorata	88	3.8	21	1,840	1.3
Dalbergia tonkinensis	75	3.2	377	28,240	19.6
Dipterocarpus alatus	75	3.2	44	3,330	2.3
Cocos nucifera	50	2.2	12	580	0.4
Delonix regia	50	2.2	89	4,460	3.1
Other species	276	15		46,180	
Total	**2,331**			**143,900**	

3.2. Carbon storage and carbon dioxide sequestration

The trees in the 29/3 Park were predicted to store 112,540kg of carbon, with a total value of stored carbon benefits of US$ 23,015. The yearly value of the carbon dioxide sequestration was US$ 4,601. *Roystonea regia* has the greatest carbon storage capacity of 68,480kg, with a yearly accumulation of 16,820kg. Meanwhile, *Samanea saman* exhibited the highest average carbon storage and sequestration of 123.4kg and 17.3kg, respectively (Table 2).

3.3. Hydrological effects of trees

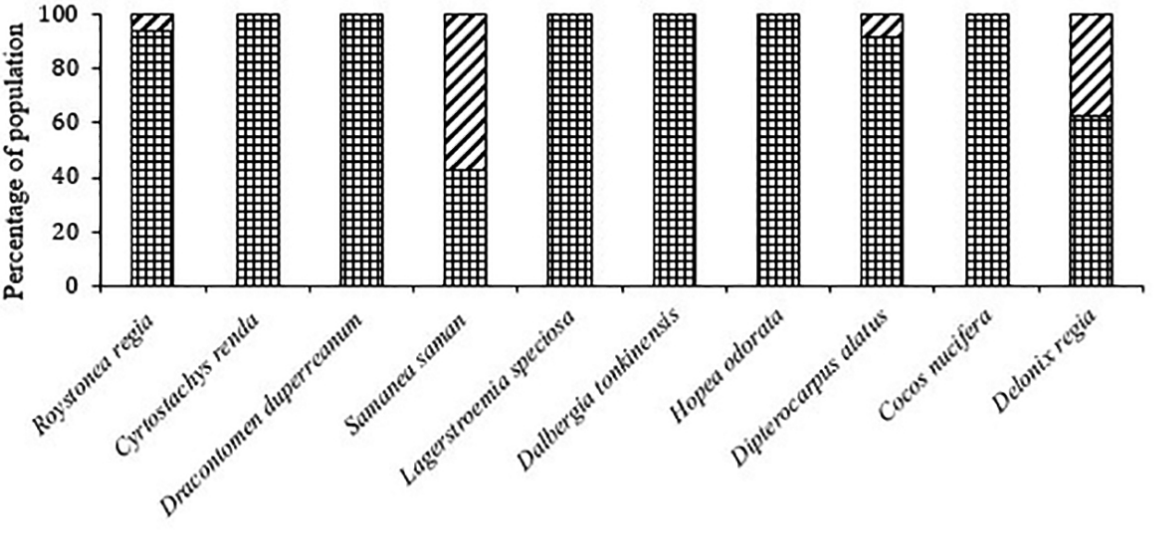
The total yearly value of water captured and runoff from trees in the Park increased by 2603.7m^3 and 518.4m^3 respectively. Despite having just 75 trees, *Dalbergia tonkinensis* achieved the greatest annual value for water interception and runoff prevention, with 510.8 m^3 and 101.7m^3, respectively (Table 3).

Table 2. Carbon storage and carbon sequestration

Species	Number of trees	Carbon storage			Carbon dioxide sequestration		
		Average (kg)	Total (kg)	Values ($)	Average	Total (kg/year)	Values ($)
R. regia	1,084	63.2	68,480	12,863	15.5	16,820	3,159
C. renda	219	2.6	580	108	1.5	330	62
D. duperreanum	163	7.7	1,250	235	2.8	450	85
S. saman	132	123.4	16,290	3,059	17.3	2,280	427
L. speciosa	119	15.2	1,810	340	6.2	740	138
H. odorata	88	12.4	1,090	205	5.6	490	93
D. tonkinensis	75	8.3	620	116	3.9	290	54
D. alatus	75	27.7	2,080	391	6.7	500	93
C. nucifera	50	30.2	1,510	283	7.6	380	71
D. regia	50	63.0	3,150	591	13.0	650	123
Other species	276	-	25,680	4824	-	1,560	296
Total	**2,331**		**122,540**	**23,015**		**24,490**	**4,601**

Table 3. The values of urban trees on hydrology rhythm

Species	Number of trees	Evaporation (m^3/year)	Water captured (m^3/year)	Prevented runoff (m^3/year)	Prevented Runoff Value ($)
R. regia	1084	411.1	415.7	82.8	195.2
C. renda	219	20.6	20.9	4.2	9.8
D. duperreanum	163	167.5	169.3	33.7	79.5
S. saman	132	369.9	374.0	74.5	175.6
L. speciosa	119	91.5	92.5	18.4	43.4
H. odorata	88	33.0	33.4	6.6	15.7
D. tonkinensis	75	505.2	510.8	101.7	239.8
D. alatus	75	59.6	60.3	12.0	28.3
C. nucifera	50	10.4	10.5	2.1	4.9
D. regia	50	79.9	80.8	16.1	37.9
Other species	276	826.6	835.7	166.4	392.4
Total	**2331**	**2575.2**	**2603.7**	**518.4**	**1222.5**



▲ *Figure 2. The age structure of ten dominant species*

3.4. Prediction of upcoming benefits

The i - Tree Eco model was used to forecast the benefits of trees in the 29/3 Park or the next 30 years (Table 4). The results reveal that all values increase, with carbon dioxide sequestration rising roughly five times and water interception increasing around 2.2 times. This means that the Park's environmental value will increase in the future.

Table 4. The prediction of tree values in the next 30 years

Year	Environmental values			
	Carbon storage (ton)	Carbon dioxide sequestration (ton/year)	Prevented run off (m^3/year)	Water interception (m^3/year)
2022	1,225	25	518	2,604
2052	1,854	125	1,100	5,852

4. CONCLUSIONS

The research examined the value of 2,331 trees in the 29/3 Park that provided environmental advantages in terms of leaf area, carbon storage, carbon dioxide sequestration, prevented runoff, and water interception. The study discovered that *Samanea saman* had the highest average carbon storage and sequestration, while *Dalbergia tonkinensis* had the highest yearly value for water interception and runoff prevention ▪

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