

Aboveground Biomass Stockpile and Carbon Sequestration Potential of *Albizia saman* in Chennai Metropolitan City, India

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Abstract: *Albizia saman* (Jacquin) F. Mueller belongs to the family Fabaceae (sub family: Mimosoideae) is a native to Northern South America. Commonly known as rain tree and locally known as *Thoongu-moonchi maram* (Tamil). The species' introduced during Colonial period as an ornamental tree in Chennai metropolitan city (CMC). Though *A. saman* represent as a dominant tree species' in CMC, there are voids in baseline data such as density, biomass stockpile, and annual C sequestration potential hence this study was conducted to fill these voids. A total of 2522 individuals which cover 1672.14 m² basal area (mean = 9.61 ± 4.95 m² ha⁻¹; range = 0-24.96 m² ha⁻¹) was recorded from study plots. During study period *A. saman* stocked a sum of 6403.51 Mg aboveground biomass (AGB) (mean = 36.8 ± 18.9 Mg ha⁻¹; range = 0-95.4 Mg ha⁻¹) and 3201.76 Mg C (mean = 18.9 ± 9.45 Mg ha⁻¹; range = 0-47.7 Mg ha⁻¹). C storage of individual tree ranged from 3.74 to 4598.18 kg with a mean value of 1269.53 ± 1082.25 kg. On an average, each tree achieved 1.04 ± 0.27 cm horizontal growth yr⁻¹. In a year *A. saman* population sequestered 111.23 Mg biomass in aboveground (in 174 ha). The mean C sequestration of study area was 319.62 ± 184.0 kg ha⁻¹ year⁻¹. In total, the study area sequestered 55.62 Mg C year⁻¹. Overall, in a year *A. saman* absorbed 204.13 Mg CO₂ for C sequestration in study area. CO₂ absorption ranged from 385.46 to 3009.29 kg ha⁻¹ yr⁻¹. The monetary value of C storage and annual sequestration of *A. saman* is also investigated. Though introduced from tropical Northern South America *A. saman* provides a considerable ecosystem services to CMC through C storage and sequestration. This study estimated monetary values of just two ecosystem services of *A. saman*, study that concentrates on all ecosystem services is essential to assess total actual ecosystem service values.

Keywords: Ecosystem Service, Exotic Tree Species, Stem Horizontal Growth, Tamil Nadu, Tropical City

1. Introduction

Urban areas are home for about half of the global human population [1]. An estimation shows that urban human population will increase up to 5 billion by 2030. Approximately, 1.2 million km² area (three times larger compared to the year 2000) would come under cities in 2030, ultimately, this would lead to loss of biodiversity and forest cover around the world including India [2]. Thus, in-depth scientific studies are essential to understand the importance of urban forests and ecosystem services they provide. Tireless efforts and decades of continuous research work has

advanced our understanding of urban forests and green spaces [3]. Urban forests and their biotic components play vital roles in reducing energy budgets of building and urban heat islands [4, 5], augmenting water and air quality [6], decreasing the impacts of flooding [7], improving human health and reducing sound pollution [8]. Among lifeforms, trees are important constituent of urban ecosystems. Besides, urban trees do array of ecosystem services including biomass and carbon storage [9].

Urban forests are either rich in native species [10] or introduced species [11]. McKinney [12] named the introduced species as urban exploiters, found extensively

from urban areas around the world. Introduced trees can also provide considerable quantum of ecosystem services [13]. *Albizia saman* (Jacquin) F. Mueller belongs to the family Fabaceae (sub family: Mimosoideae) is a native to Northern South America. Commonly known as rain tree and monkey pod, locally known as *Thoongu-moonchi maram* (Tamil). Now extensively grows throughout the tropics. It reaches up to 25 m tall and 30 m crown diameter, highly suitable for large homesteads, parks, roadsides and school play grounds [14]. The tree has good qualities, grows well at sea level to 300 m amsl, adapts to a broad array of soil types and pH ranges, growth rate is relatively high ($2.5\text{--}5\text{ ft yr}^{-1}$), produces fodder and timber, generates 1700-4200 kg biomass in 5 years [14]. Besides that the tree also has economic importance as fuel wood [15], food and fodder [16], timber [17], gum and resin [18], nitrogen fixer and green manure [19], and medicine [20, 21].

The species was introduced during Colonial period as an ornamental tree in Chennai metropolitan city (CMC) [22]. Now it grows extensively in parks, roadsides, playgrounds of academic institutions, and avenues in CMC [23]. The urban forest division of Chennai district prefers this tree for its fast-growing nature, handsome dome-shaped crown and shade. Though *A. saman* represent as a dominant species in CMC there are voids in baseline data such as density, sequestered biomass, C stockpile and sequestration potential hence this study was conducted to fill these voids.

2. Methods

2.1. Study Area

Chennai Metropolitan city is 34th largest city in the world with the human population ~ 5 million [24]. CMC is one among the four mega-cities of the Indian subcontinent, and the capital city of Tamil Nadu state. The city is experiencing a tropical dissymmetric climate and receiving bulk of the rainfall during north-east monsoon (September-December). Mean temperature and rainfall were 30°C and 1300 mm [25]. East-side of the city is bounded with the Bay of Bengal and remaining three sides are bordered with Thiruvallur and Kanchipuram districts. CMC is endowed with rich plant diversity (1039 species) [24] which include both native as well as introduced species.

2.2. Field Survey

The entire geographical area of CMC (174 km^2) was divided into the regular rectangular grids ($1\text{ km}^2 \times 1\text{ km}^2$) by fishnet tool of ArcGIS software (version 9.3). The sample sites were selected randomly inside of the each grid. A total of 174 one-hectare sample plots were laid to record density and diameter at breast height (dbh) of *Albizia saman* ($> 5\text{ cm dbh}$). Diameter of all trees $> 5\text{ cm dbh}$ was measured at the height of 137 cm above the ground and recorded in field data sheet. In order to record DBH value for consecutive years, trees were tagged with consecutively numbered aluminium tags. Field survey was conducted during January-March on

2011 and 2012. Data on trees was recorded with the help of students of Botany departments across the Chennai city. Rainfall and temperature recorded in the year 2011 and 2012 were more or less equal to the mean rainfall and temperature of the study area, hence the study period represented Chennai's usual climatic and environmental conditions.

2.3. Estimation of Aboveground Biomass

A region-cum-species specific allometric formula developed by destructive sampling method was employed to estimate AGB of *Albizia saman* in study area [26, 27]. $\text{AGB}_{\text{dry}} = \exp(1.9724 \cdot \text{LN}(\text{DBH}) - 1.0717)$; where, AGB_{dry} is aboveground dry biomass of tree (kg); DBH is stem diameter at breast height (cm); LN is natural logarithm; 1.9724 and 1.0717 are constants. The allometric formula developed with the destructively sampled healthy individuals of *A. saman* (DBH range 4.45 to 178.7 cm). Due to hetero-scedasticity nature of field data, the error variance was not constant. The problem was dealt with the transformation of variables. But the de-transformed predicted values are biased [28]. To overcome those bias, the back transformed results from logarithmic unit was multiplied by a conversion factor ($\text{CF} = 1.016$) [29]. DBH of trees ranged from 5 to 176 cm in the present study. The coefficient of determination of allometric equation is high (r^2) i. e. 0.98. Standard error of the estimate is 0.76.

2.4. Assessment of Carbon Storage and Sequestration

To get carbon storage values of trees aboveground biomass multiplied by 0.50 [30]. The annual increase of stem diameter and biomass sequestration of trees were calculated by the difference in estimates of dbh and biomass stockpile between year x and $x+1$. Carbon storage and sequestration values were converted to CO_2 equivalent by multiplying with 3.67, the ratio of molecular weights of CO_2 to C [31].

2.5. Monetary Value of Ecosystem Services

The money value of ecosystem services provided by *A. saman*, namely C storage and sequestration was calculated based on international C price. International price for one tonne C is 41 US\$ [32].

3. Results

3.1. Tree Density and Basal Area

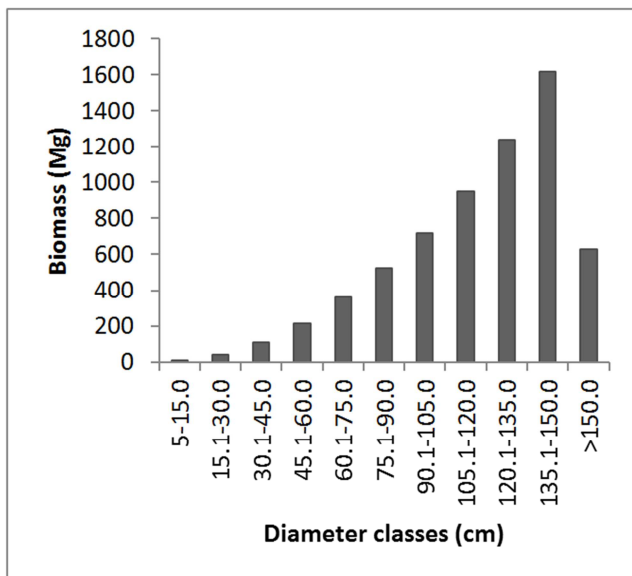
A total of 2522 individuals ($> 5\text{ cm dbh}$) was recorded in 174 ha. Density of trees ranged from $0\text{--}30\text{ ha}^{-1}$. The mean tree density of *A. saman* was $14.49 \pm 8.52\text{ ha}^{-1}$. Likewise, the basal area of trees varied from $0\text{--}24.96\text{ m}^2\text{ ha}^{-1}$. The average basal area of *A. saman* was $9.61 \pm 4.95\text{ m}^2\text{ ha}^{-1}$. Few sample plots completely fell on water bodies where density, basal area and AGB were recorded as '0'. DBH of trees differed from 5-176 cm, while the mean dbh in study area recorded as $80.95 \pm 43.53\text{ cm}$ (Table 1).

Table 1. Information on *A. saman* recorded from Chennai metropolitan city, India.

Variable	Value (Mean \pm S.D.; range)
Density (trees ha ⁻¹)	14.49 \pm 8.52; 0-30
Basal Area (m ² ha ⁻¹)	9.61 \pm 4.95; 0-24.96
DBH (cm)	80.95 \pm 43.53; 5-176
AGB (Mg ha ⁻¹)	36.8 \pm 18.9; 0-95.4
AGB of single tree (kg tree ⁻¹)	2539.1 \pm 2164.5; 7.48-9196.35
Carbon storage (Mg ha ⁻¹)	18.4 \pm 9.45; 0-47.7
C storage of single tree (kg tree ⁻¹)	1269.55 \pm 1082.25; 3.74-4598.18

3.2. Aboveground Biomass

As on March 2011, *A. saman* stores a sum of 6403.51 Mg AGB in 174 ha study plots. The mean AGB of study area was 36.8 ± 18.9 Mg ha⁻¹ (range, 0 to 95.4 Mg ha⁻¹). The mean AGB of an individual tree was recorded as 2539.1 ± 2164.5 kg (range, 7.48 to 9196.35 kg) (Table 1). DBH of tree is positively linked with AGB ($r^2=0.94$, $p < 0.01$). The larger is the tree the more is the sequestered biomass. The largest tree holds nearly 1200 times more AGB than the smallest one in study area. AGB storage of diameter classes varied considerably in the study area, DBH class 135.1-150.0 cm stored a largest quantity (1615.25 Mg; 25.22%) followed by 120.1-135.0 cm (1236.97 Mg; 19.32%) and 105.1-120.0 cm (949.62 Mg; 14.83), while the least quantity was stocked by the smallest DBH class (5-15.0 cm; 5.67 Mg; 0.09%), (Figure 1).

**Figure 1.** Aboveground biomass stored in diameter classes in Chennai metropolitan city, India.

3.3. Carbon Storage

In total *A. saman* stored 3201.76 Mg C in study area. The average C storage of study area was 18.9 ± 9.45 Mg ha⁻¹ (range, 0-47.7 Mg ha⁻¹), while each tree stored 1269.53 ± 1082.25 kg C (range, 3.74-4598.18 kg) (Table 2).

Table 2. Carbon storage and sequestration potential of tree diameter classes.

Diameter class (cm)	Carbon storage (kg tree ⁻¹ \pm S.D.)	Carbon sequestration (kg tree ⁻¹ year ⁻¹ \pm S.D.)
5.0-15.0	16.68 \pm 9.74	4.66 \pm 1.30
15.1-30.0	83.13 \pm 30.43	10.10 \pm 1.83
30.1-45.0	222.5 \pm 49.02	14.37 \pm 1.40
45.1-60.0	430.94 \pm 69.34	19.11 \pm 1.26
60.1-75.0	694.39 \pm 87.35	22.49 \pm 1.50
75.1-90.0	1029.31 \pm 104.89	27.43 \pm 1.28
90.1-105.0	1433.42 \pm 125.17	29.74 \pm 1.30
105.1-120.0	1899.23 \pm 146.31	31.46 \pm 1.17
120.1-135.0	2425.43 \pm 162.66	30.25 \pm 4.33
135.1-150.0	3040.54 \pm 182.04	23.75 \pm 2.53
>150.0	3601.93 \pm 389.85	22.45 \pm 7.35
Mean	1269.53 \pm 1082.26	22.05 \pm 8.47

3.4. Annual Horizontal Stem Growth

On an average, each tree achieved 1.04 ± 0.27 cm horizontal growth yr⁻¹. There is a negative relationship exists between tree dbh and tree horizontal growth ($r^2=0.87$, $p < 0.01$). The smaller is the tree the larger is the annual stem horizontal growth (Table 3).

Table 3. Stem horizontal growth and aboveground biomass increment of *Albizia saman*.

Diameter class (cm)	Diameter increment (cm tree ⁻¹ year ⁻¹ \pm S.D.)	AGB increment (kg tree ⁻¹ year ⁻¹ \pm S.D.)
5.0-15.0	1.42 \pm 0.14	9.31 \pm 2.60
15.1-30.0	1.40 \pm 0.90	20.20 \pm 3.65
30.1-45.0	1.23 \pm 0.07	28.74 \pm 2.79
45.1-60.0	1.18 \pm 0.04	38.21 \pm 2.52
60.1-75.0	1.10 \pm 0.04	44.97 \pm 2.99
75.1-90.0	1.09 \pm 0.06	54.85 \pm 3.55
90.1-105.0	1.02 \pm 0.05	59.48 \pm 2.59
105.1-120.0	0.95 \pm 0.07	63.41 \pm 3.34
120.1-135.0	0.80 \pm 0.12	60.49 \pm 8.66
135.1-150.0	0.57 \pm 0.07	47.50 \pm 5.03
>150.0	0.49 \pm 0.13	44.90 \pm 14.69
Mean	1.04 \pm 0.27	44.10 \pm 16.94

3.5. Sequestration of Biomass and Carbon

In a year *A. saman* population sequestered 111.23 Mg biomass in aboveground parts (174 ha). AGB sequestration varied from 210.05 to 1639.94 kg ha⁻¹ year⁻¹. The mean AGB sequestration of study area was estimated as 639.24 ± 367.99 kg ha⁻¹ year⁻¹. Carbon sequestration of *A. saman* differed from 105.03 to 819.97 kg ha⁻¹ year⁻¹ among study plots. The mean C sequestration of study area was 319.62 ± 184.0 kg ha⁻¹ year⁻¹. In total, the study area sequestered 55.62 Mg C year⁻¹.

3.6. Absorption of CO₂ for C Sequestration

Overall, in a year *A. saman* absorbed 204.13 Mg CO₂ for C sequestration in study area. CO₂ absorption ranged from 385.46 to 3009.29 kg ha⁻¹ yr⁻¹. On an average, each one-hectare plot absorbed 1173.0 ± 675.28 kg CO₂ to sequester C.

3.7. Monetary Values of Carbon Storage and Sequestration

The monetary value of C storage and sequestration of *A. saman* in study area (174 ha) is 131,272 and 2,280 US\$,

respectively. The money value of these kind of ecosystem services of *A. saman* for entire CMC (17400 ha) could be estimated as 13.12 and 0.23 million US\$, respectively. On an average, the monetary values of C storage and sequestration of each hectare could be valued as 754 and 13.11 US\$, correspondingly.

4. Discussion

4.1. Tree Density and Basal Area

In an earlier tree diversity study conducted across different land uses of CMC *A. saman* constituted 6% tree community and topped in the list of important value index (IVI) among 45 species [10]. Likewise, *A. saman* constituted a considerable proportion of tree communities in urban forests of Bangalore and West Bengal, India [33, 34]; Bangkok, Thailand [35, 36]; Chittagong, Bangladesh [15] and USA [37].

The mean basal area recorded for *A. saman* ($9.61 \pm 4.95 \text{ m}^2 \text{ ha}^{-1}$) is not in agreement with previous study [23]. Earlier a study recorded $22.33 \text{ m}^2 \text{ BA ha}^{-1}$ for *A. saman*. However, the

previous study concentrated only on a hectare area of CMC, present study concentrated on large area i.e. 174 ha. The mean basal area recorded for species' under study is larger than the mean stand basal area (of all species) of urban forests in Ohio, USA ($4.8 \text{ m}^2 \text{ BA ha}^{-1}$) [38], and more or less equal to urban forests of Miami-Dade County, USA ($10.0 \text{ m}^2 \text{ BA ha}^{-1}$) [39]. It is apparent that the occurrence of good proportion of well-grown large trees in the CMC ($>60 \text{ DBH}$, 61.14%) contributed to larger tree stand basal' areas.

4.2. Population Structure

Albizia saman is showing a non-expanding population structure in CMC (Figure 2). Among 11 diameter classes, nine (except smallest and largest DBH classes) had more or less similar number (230-249) of individuals. Ongoing developmental activities such as construction of buildings and bridges, widening of roads etc. are contributing to the destruction of trees. Non-expanding population structure of *A. saman* indicates that the individuals of all girth classes are under disturbances.

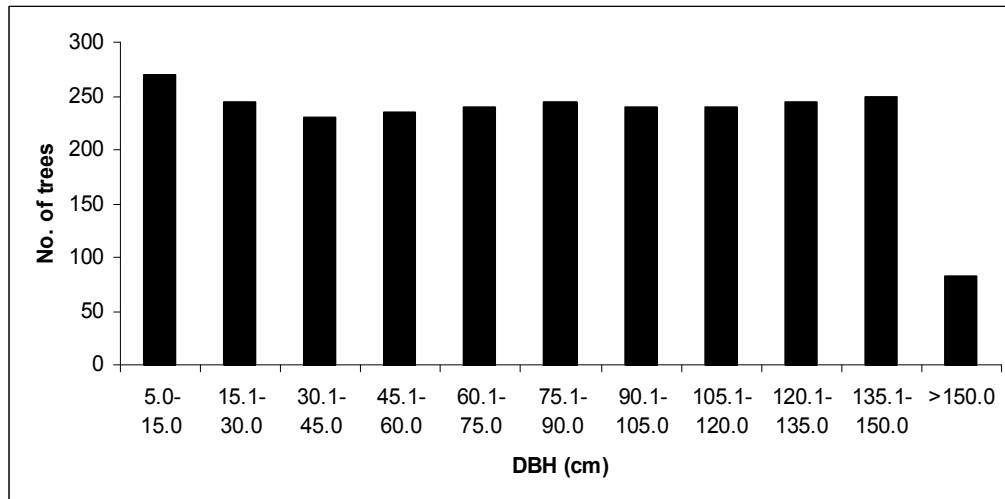


Figure 2. Population structure of *A. saman* ($\geq 5 \text{ cm dbh}$) based on diameter class frequency in Chennai metropolitan city, India.

4.3. Aboveground Biomass and Carbon Storage

The results obtained on mean AGB and C storage of *A. saman* ($\text{AGB}=36.8 \pm 18.9 \text{ Mg ha}^{-1}$; $\text{C}=18.4 \pm 9.45 \text{ Mg ha}^{-1}$) is higher than in urban forest of Tripura university campus, Northeast India ($\text{AGB}=11.81 \text{ Mg ha}^{-1}$; $\text{C}=5.91 \text{ Mg ha}^{-1}$) [40]. The recorded values of current study are greater than what has been reported for all species together from Liepig, Germany (22 Mg ha^{-1} , 11 Mg ha^{-1}) [41]; Korea (23.8 Mg ha^{-1} ; 11.9 Mg ha^{-1}) [42]; Chiayi, Taiwan (27 Mg ha^{-1} ; 13.5 Mg ha^{-1}) [43]; Beijing, China (14.82 Mg ha^{-1} ; 7.42 Mg ha^{-1}) [44]; Shenyang, China (26.34 Mg ha^{-1} ; 13.17 Mg ha^{-1}) [32]; Los Angeles, USA (20.76 Mg ha^{-1} ; 10.38 Mg ha^{-1}) [45]; five cities of USA ($5.02\text{--}15.33 \text{ Mg ha}^{-1}$; $10.4\text{--}30.66 \text{ Mg ha}^{-1}$) [30]; and, Oakland, USA (22 Mg ha^{-1} ; 11 Mg ha^{-1}) [46]. The population of *A. saman* composed of relatively larger trees (mean $\text{DBH}=80.95 \text{ cm}$) hence stored good amount of biomass and C in its aboveground parts. Quantitative studies

should be conducted to estimate biomass and C storage of all tree species in Chennai city. The absence of region-specific multi-species tree allometric models is the primary lacking for these studies hence research on these lines could be valuable.

Each tree stored $1269.53 \pm 1082.25 \text{ kg C}$ (range, $3.74\text{--}4598.18 \text{ kg}$) in study area. This value is higher than in Tshwane, South Africa (474.22 kg C) [47]; Beijing, China (98.87 kg C) [41]; Shenyang, China (58.51 kg C) [32]; and cities of USA (mean = 227.01 kg C ; range = $91.81\text{--}638.95 \text{ kg C}$) [30]. On the other hand, the present study concentrated only on single species' thus studies that consider all tree species in CMC are essential to confirm the dominance.

4.4. Stem Horizontal Growth

The findings pertaining to mean stem horizontal growth

(1.04 ± 0.27 cm tree⁻¹ year⁻¹) is agreed with the result of Jo and McPherson [48] who reported 1.1 cm stem horizontal growth tree⁻¹ year⁻¹ for urban trees of USA. While the result of current study is not in line with that of deVries [49], Nowak [50] and Smith and Shifley [51] recorded 0.61, 0.90 and 0.38 cm horizontal stem growth tree⁻¹ yr⁻¹ respectively for trees of central park, New Jersey, three USA cities, and Indiana and Illinois, USA. Fast growth nature of *A. saman* in CMC contributed to a high dbh growth tree⁻¹ yr⁻¹ in this study.

A negative relationship as obtained between stem horizontal growth yr⁻¹ and diameter class is chiefly linked to the age of trees. Young trees show faster growth than larger trees. Age-related decreases in aboveground C sequestration were extensively recorded and reported around the world [52-54].

4.5. Carbon Sequestration

Carbon sequestration potential recorded for an individual tree (22.05 ± 8.47 kg yr⁻¹) in CMC is higher than in urban trees of Canberra, Australia (3.52 kg yr⁻¹) [55]; Beijing, China (4.78 kg yr⁻¹) [44]; seven cities of USA (mean=4.83, range=3.41 to 7.75 kg yr⁻¹) [30]; and Shenyang, China (5.01 kg yr⁻¹) [32].

The per hectare C sequestration potential recorded for *A. saman* (319.62 ± 184.0 kg ha⁻¹ year⁻¹) is extremely lower than in urban forests of Pungol Eco-town, Singapore (3.61 Mg ha⁻¹ yr⁻¹) [43] and lower than in seven USA cities (458.57 kg ha⁻¹ yr⁻¹) [30]. Present study concentrated on single species, if all species taken in to consideration for C sequestration then the value may exceeds than in USA. Further studies are necessary to validate these lines. However, the per hectare C sequestration potential of *A. saman* is relatively higher than the cumulative C sequestration potential (individuals belongs to all species in a hectare) of urban trees in California (300 kg ha⁻¹ year⁻¹), Texas (300 kg ha⁻¹ year⁻¹), Arizona (300 kg ha⁻¹ year⁻¹), Rhode Island (300 kg ha⁻¹ year⁻¹), North Dakota (200 kg ha⁻¹ year⁻¹), and Wyoming (100 kg ha⁻¹ year⁻¹) of USA [47, 48].

4.6. Monetary Value of two Ecosystem Services

The monetary value of two ecosystem services namely, C storage and sequestration of *A. saman* for entire CMC is 13.12 and 0.23 million US\$, respectively (Table 4). The monetary value estimated in this study is higher as well as lower than in urban forests elsewhere. Stoffberg *et al.* [44] reported 3 million US\$ for Tshwane, South Africa; Liu and Li [32] found 13.88 million US\$ for Shenyang, China; Brack [55] calculated 20-67 million US\$ for Canberra, Australia. On an average the monetary value of C storage and sequestration of each hectare could be valued as 754 and 13.11 US\$, correspondingly.

This study calculates monetary value of just two ecosystem services. Urban trees offer many ecosystem services [see 55, 59 for details]. Valuation studies on ecosystem services of urban trees and forests are plenty in USA and other developed nations but very limited for developing countries like Brazil, Russia, India, China and South Africa. Urban forests of India can be considered as a place for ecosystem service valuation studies.

Table 4. Monetary value of two ecosystem services of *Albizia saman* in Chennai metropolitan city, India.

Ecosystem service	Value (US\$)	
	Study area	Entire Chennai city
Carbon storage	131272.16	13127216.0
Carbon sequestration (per year)	2280.42	228042.0
Total (as on March, 2012)	133552.58	13355258.0

4.7. CO₂ Emission Reduction

In a day Chennai needs 1300 kilolitres petrol and 2000 kilolitres diesel. Use of petrol, diesel emits 3003, 5360 Mg CO₂ in to the atmosphere, respectively. In all, fossil fuel use in CMC releases about 8363 Mg CO₂ into the atmosphere per day. C stockpile and sequestration of *A. saman* is equal to 1175, 204.13 Mg CO₂, correspondingly. The average effects of tree diameter classes listed in Table 5. In total, *A. saman* population in CMC provide C storage and sequestration equivalent to 16.49% of a day's CO₂ emissions by fossil fuels.

Table 5. Mean tree effects by tree diameter.

DBH class (cm)	C storage			C sequestration		
	(kg)	(\$)	(Petrol) ^a	(kg)	(\$)	(Petrol) ^a
5.0-15.0	16.68	0.68	26.52	4.66	0.19	7.41
15.1-30.0	83.13	3.40	132.16	10.10	0.41	16.06
30.1-45.0	222.5	9.12	353.74	14.37	0.59	22.84
45.1-60.0	430.94	17.67	685.12	19.11	0.78	30.38
60.1-75.0	694.39	28.47	1103.96	22.49	0.92	35.76
75.1-90.0	1029.31	42.20	1636.42	27.43	1.12	43.61
90.1-105.0	1433.42	58.77	2278.88	29.74	1.22	47.28
105.1-120.0	1899.23	77.87	3019.44	31.46	1.29	50.02
120.1-135.0	2425.43	99.44	3856.01	30.25	1.24	48.09
135.1-150.0	3040.54	124.66	4833.93	23.75	0.97	37.76
>150.0	3601.93	147.68	5726.44	22.45	0.92	35.69

^a Petrol = number of litres that produces emissions equivalent to tree effect

5. Conclusion

Though introduced from tropical Northern South America *A. saman* provides a considerable quantity of ecosystem services to CMC through C storage and sequestration. This study estimated monetary values of just two ecosystem services of *A. saman*, study that concentrates on all ecosystem services is essential to assess total actual ecosystem service values.

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