High carbon storage and oxygen (O₂) release potential of Mahagony (Swietenia macrophylla) woodlot plantation in Bangladesh

Md. Najmus Sayadat Pitol a,⇑, Md. Bachchu Mian b

a Mangrove Silviculture Division, Bangladesh Forest Research Institute, Khulna 9000, Bangladesh
b Forest Ranger, Bangladesh Forest Department, Ministry of Environment, Forest and Climate Change, Bangladesh

Abstract

Woodlot plantation takes our attention nowadays because of having high wood value, biomass and carbon stock. It also has considerable potential for regulating climate change by sinking CO₂. This study investigated the market value of Swietenia macrophylla woodlots concerning the current carbon trade mechanism, local timber and oxygen value. The carbon-di-oxide equivalence (CO₂e) and release oxygen (O₂ release) ranged from 125.5 to 1004.5 Mg/ha (mean 436.3 Mg/ha) and 91.25–730.26 Mg/ha (mean 317.2 Mg/ha), respectively. Form carbon trade, the Swietenia macrophylla woodlots owner will earn 4,285–34,470 BDT/ha (mean 14,900 BDT/ha). It also seemed that the present market value of release oxygen (O₂ release) ranged from 3.2 to 25.5 million BDT/ha (average 11.1 million BDT/ha). However, the study area’s average DBH, height, density, and basal area were 18.9 cm, 12.6 m, 1233 stem/ha, and 36.6 m²/ha, respectively. The above-ground biomass, below-ground biomass, and total biomass ranged from 45.9 to 389.7 Mg/ha (mean 166.5 Mg/ha), 22.5–157.7 Mg/ha (mean 71.2 Mg/ha), and 68.4–547.4 Mg/ha (mean 237.7 Mg/ha) correspondingly. Besides, the produced wood volume ranged from 64.95-1225.19 m³/ha (average 481.48 m³/ha). While the price of wood ranged from 0.8 to 15.14 million BDT/ha (mean 5.95 million BDT/ha). However, the above-ground, below-ground, and total carbon ranged 22.97–194.85 Mg/ha (mean 87.27 Mg/ha), 11.23–78.85 Mg/ha (35.61 Mg/ha), and 34.2–273.7 Mg/ha (118.89 Mg/ha) independently. Moreover, our three developed basal area-based allometric models are fit for calculating the carbon stock of Swietenia macrophylla woodlots. This study explores the potentiality of woodlots in Bangladesh. Policymakers should encourage the farmers to create more woodlots that actively participate in climate change mitigation.

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1. Introduction

Plantation forest (woodlot plantation) with fast-growing species takes our attention nowadays. It has enormous ecosystem services with timber and non-timber products. It seizes the atmospheric CO₂ for photosynthesis, stores biomass, and produces a huge amount of oxygen (Lukito and Rohmatiah, 2013). The stored carbon curbs the increase of atmospheric CO₂ and mitigates global warming with the economic return and environmental paybacks it offers (Birdsey and Pan 2015, Calfapietra et al. 2015, Pandey et al. 2019, Zeng et al. 2018). Though forest plays a very important role in carbon sequestration (Tesfaye et al. 2016), the world faces the rapid destruction of natural forests due to anthropogenic activities like deforestation, industrialization, urbanization, etc. As a consequence, the last century ended with 0.74 °C global temperature and 379 ppm atmospheric CO₂ (UNFCCC, 2007; IPCC, 2013). The rate will be doubled by 2050 and raised to 2–4 °C by 2100, responsible for a 28–98 cm sea-level rise due to the melting of polar ice (IPCC, 2013). It will severely change the existence and livelihoods of low-lying countries like Bangladesh, Maldives, Sri Lanka, etc. (IPCC, 2013). The present world has approximately 187,086 (000 ha) plantation forests with a new planting rate of 4493 (000 ha) per year, whereas 115,847 (000 ha) plantation forests with a new plantation rate of 31,556 (000 ha) per year in Asia (FAO 2010). However, 5 million ha plantations were raised globally every year between 2005 and 2010. Planted forests covered 7 % (264 million ha) of the total forest area of the world in 2010 and...
supplied 35 % of total wood demand (FAO, 2010) with a projected increase to 44 % by 2020 (ABARE & Jaakkko Pöryy, 1999). In Bangladesh, the natural forest reduced from 643.61(000 ha) to 593.24 (000 ha), whereas the plantation forests increased from 238.81 (000 ha) to 278.11(000 ha) from 1990 to 2005 (FAO, 2010).

In Bangladesh, Mahagony (Swietenia macrophylla) woodlots become familiar as a fast-growing species. It is the first choice of woodlot owners because of its high-quality timber and widespread uses. It is commonly planted in homesteads, roadsides, river embankments, and fallow lands all over the country. Biomass and carbon stock are now considered for creating any woodlot (Ekholm 2016; Gren and Zeleke 2016; Riutta et al. 2018; Nonini and Fiala 2019; Rinnamang et al. 2020) which is the main concern of the present carbon trade program. But, the contribution of plantation forests to carbon trade and ecosystem services is not well documented (Nair, 2012). Clear evidence of the input of woodlots is a prerequisite to improving the country’s negotiations for REDD + and carbon trade mechanisms (Nair, 2012; Bashamuddin and Inoue, 2012). For measuring the carbon stock of woodlot the diameter at breast height (DBH) based and basal area-based biomass carbon calculation allometric models are becoming popular and used widely (Pandey et al., 2014; Rahman et al. 2015a, 2015b; Torres and Lovett, 2012). This study was designed to develop generalized basal-area-based allometric equations to the approximation of tree biomass carbon stock of Mahagony (Swietenia macrophylla) woodlot in Bangladesh. It also aimed to calculate the value of timber, carbon storage and release oxygen (O2) for understanding the feasibility and proper management of woodlots in Bangladesh.

2. Materials and methods

2.1. Study area

The study was conducted in the south-western zone of Bangladesh, lying between 23.10° and 23.33° north latitude and 88.40° and 89.10° east-longitude (Fig. 1). Floodplain landmass zone with excessive siltation and sedimentation caused notable floods during the monsoon and severe drought during the dry season. The soils are calcareous to non-calcareous types with peat. The major crops are Oryza sativa, Corchorus capsularis, Hibiscus cannabinus, Gossypium herbaceum, Saccharum officinarum, Triticum aestivum, Lens esculenta, Phaseolus mungo, Phaseolus radiates, Oryza sativa, Solanum miltiorrhiza, Brassica oleracea var botrytis, Brassica oleracea var gongylodes, etc. fruits (such as Carica papaya, Musa spp, Mangifera indica, Litchi chinensis, Cocos nucifera, etc.) and nuts are also important cultivated crops in the study area (BBS, 2019). The zone observed three distinct seasons such as summer (March-May), rainy (June-October), and winter (November-February) (Kabir and Webb, 2008). The annual temperature ranged from 12 to 32°C with a mean of 24°C. The temperature goes down to 8.1°C in the winter and up to 40°C in the summer (BBS, 2019). In the study area, about 90 % of the total annual rainfall occurs during the monsoon (June-September) with an average of 1800 ± 268 mm, ranging from 1400 to 2600 mm (Kabir and Webb, 2008). The relative humidity is 78 %, where possible evaporotranspiration is 65–129 mm (Kabir and Webb, 2008).

2.2. Sample size and sampling design

For collecting the data, three upazilla (Mohespur, Kotchandpur, Chaugachha) from two districts (Jhenaidah and Jessore) were selected purposively. The selection rationale was that having many Mahagony (Swietenia macrophylla) woodlots in these three upazilla. And also the climatic and edaphic conditions were similar in these two districts. However, the size and shape of Mahagony (Swietenia macrophylla) woodlots were analogous in the study area. Purposive sampling was used for the data collection because of the uneven and discrete distribution of woodlot plantations in these regions. A reconnaissance survey was done in 48 villages of 16 unions in 3 upazilla. Based on the preliminary survey, six unions of three upazilla (two unions in each upazilla) were selected. The selected unions were Fulsara, Jagodispur, Elangi, Kusna, Azompur, and SBK. Overall, 30 villages of 6 unions (3–5 villages in each union) were selected for data collection. A total of 90 plots (2–5 plots per village) with a size of 0.01 hectare were considered for survey. The DBH (cm) and height (m) of all trees within the plot were recorded by using Diameter tape, measuring tape, and Spigel Relaskop.

2.3. Data calculation

Diameter at breast height (DBH) is frequently used for biomass calculation as an effective and easily available tool in the forest sector (Haygreen and Bowler, 1989; Jackson, 1992; Malimbwi, 1994; Munishi et al., 2000, Munishi and Shear, 2004). Chave et al. (2005) developed a set of allometric equations for tropical trees used for a wide geographical range. But, DBH and biomass may differ among species in a similar functional group that can differ greatly in various geographic locations (Pearson et al., 2007). Considering this, we used semi-destructive biomass models for the village zone of Bangladesh recommended by Mahmood et al. (2020) for above-ground biomass calculation in our study. However, Cairns et al. (1997) recommended the most cost-effective method was applied for below-ground biomass calculation. The wood density (kg/m3) of Mahagony (Swietenia macrophylla) was derived by Satter et al. (1999). The calculated biomass was multiplied by the carbon content (50 %) used in most tropical forests (Chave et al. 2005). It found that the tree tissues like wood, leaves and roots contain 50 % carbon on a dry mass basis (Chave et al. 2005, Haygreen and Bowler, 1989; Munishi and Shear, 2004). The total biomass carbon was multiplied by 3.67 for calculating carbon-di-oxide equivalence (CO2e) suggested by Kauffman and Donato (2012). Moreover, 1 ton (Mg) carbon-di-oxide equivalence (CO2e) is equal to 1 Certified Emission Reduction (CER). According to the present carbon trading mechanism, the value of 1 Certified Emission Reduction (CER) was 50.4 (UNFCCC, 2017) where 1 US Dollar ($) = 85.34 BDT (Date: 29/08/2021). Also, the O2 release was calculated by using the photosynthesis equation. According to the photosynthesis equation, $1 \text{CO}_2$ may release 0.727 $\text{O}_2$ into the atmosphere and the value of 1 kg Oxygen ($\text{O}_2$) is equal to BDT 35 in the local market. The density and basal area were calculated for relationship assessment using Moore and Chapman’s (1986) and Shukla and Chandel’s (1980) suggested equations. The tree volume was estimated by using Huber’s formula, \[ V = (A \times H) \text{ m}^3 \] where \( V = \text{volume of tree in m}^3, A (\text{m}^2) = 3.1416 \times (\text{radius})^2 \] and \( H = \text{height in meter} \) (Patterson et al. 1993; Waddell 1989) and the average local price of Mahogany (Swietenia macrophylla) wood was 12,360 BDT/m3.

(a) \( \ln (\text{AGB}) = -6.0325 + 1.9715 \times \ln (D) + 0.8193 \times \ln (W) \) (Mahmood et al. 2020)

(b) \( \ln (\text{BGB}) = -1.0587 + 0.8836 \times \ln (\text{TAGB}) \) (Cairns et al. 1997)
Where, AGB = above-ground biomass, BGB = below-ground biomass, D = Diameter at breast height (cm), W = Wood Density (kg/m³).

2.4. Statistical analysis

Data analysis was done using Microsoft Office Excel 2019. Descriptive analysis was performed including mean and standard deviation for the variables DBH, height, density, basal area, wood volume, biomass, and carbon stock, etc. Regression analysis was executed to estimate the relationship among the mean DBH, mean height, mean density, and mean basal area with total carbon stock. Moreover, the regression analysis was applied for finding the best fit basal area-based carbon measurement model and their validation. Those models showed significantly (p < 0.01) strong relationships ($R^2 > 0.99$) were retained according to GLRM.

3. Result

3.1. Biomass and wood value of Mahagony (Swietenia macrophylla) plantations

It was found that the mean DBH (cm) and mean height (m) in the Mahagony (Swietenia macrophylla) plantation of Mohespur (18.4 cm, 11.8 m) and Kotchandpur (18.3 cm, 12.2 m) Upazilla comparatively lower to Chaugachha (19.9 cm, 14 m) Upazilla (Table 1). The highest and lowest mean value of DBH and Height in the study area were 33.47 cm, 10.9 cm, 16.5 m, and 6.5 m separately. However, the density (stem/ha) and basal area (m²/ha) were higher in Mohespur (1323 stem/ha, 37.8 m²/ha) and Kotchandpur (1356 stem/ha, 38.2 m²/ha) upazilla than Chaugachha (1020 stem/ha, 33.8 m²/ha) upazilla (Table 1). The mean density of the study area ranged from 800 to 2400 stem/ha, and the basal area ranged from 9.9-86.2 m²/ha. The study area’s average DBH, height, density, and basal area were 18.9 cm, 12.6 m, 1233 stem/ha and 36.6 m²/ha, respectively (Table 1). Moreover, it was found that the Mahagony (Swietenia
Mahogany (Swietenia macrophylla) plantations produced a huge amount of wood volume ranging 64.95–1225.19 m³/ha with an average of 481.48 m³/ha. The price of wood ranged from 0.8 to 15.14 million BDT/ha. The Mahagony (Swietenia macrophylla) plantations earned a huge amount of money with an average of 5.95 million BDT/ha.

3.2. Carbon stock, Carbon-di-oxide equivalence (CO₂e), Release oxygen (O₂ Release) of Mahagony (Swietenia macrophylla) plantations

Photosynthesis is an ongoing process in plants, which continues every second. And at every moment, carbon-di-oxide is taken from the atmosphere, and oxygen is released into the atmosphere. We used the accumulated carbon to evaluate carbon-di-oxide equivalence (CO₂e) in the trees. We also calculated the amount and value of the release oxygen based on the accumulated carbon so far. Total carbon stock (TC), carbon-di-oxide equivalence (CO₂e) and release oxygen (O₂ Release) ranged from 34.2 to 273.7 Mg/ha, 125.5–1004.5 Mg/ha, and 91.25–730.26 Mg/ha respectively, where the mean carbon stock (TC) were 182.65 ± 11.2 Mg/ha; and 401.86 ± 21.98 Mg/ha, respectively (Table 2).

3.4. Mean basal area-based carbon biomass measurement equations development and their validation

Three mean basal area-based carbon biomass measurement models were developed (Fig. 3: e, f, g). All three models showed a strong relationship between mean carbon stock (Mg/ha) and mean basal area (m²/ha) for Mahagony (Swietenia macrophylla) woodlots. The R² value for linear, power and polynomial models were 0.9986, 0.9986 and 0.9987, respectively and significant (p < 0.01) (Fig. 3: e, f, g). All the equations tested 90 plots with Mahmood et al. (2020) and Cairns et al. (1997) models (Fig. 4: h, i, j) and three basal area-based models with Pitol et al. (2019) (Fig. 4: k, l, m). According to GLRM, all models showed significant (p < 0.01) and strong relationship (R² = 0.9986, 0.9986, 0.9987, 1.0, 0.9916 and 0.9971) (Fig. 4: h, i, j, k, l and m). These three developed basal area-based allometric models are similarly fit for calculating the carbon stock of Mahagony (Swietenia macrophylla) woodlots.

\[(a)\] Biomass Carbon (Mg/ha) = 3.1051 \times (BA)^0.5269
\[(b)\] Biomass Carbon (Mg/ha) = 3.8702 \times (BA)^{0.9524}
\[(c)\] Biomass Carbon (Mg/ha) = -0.0008 \times (BA)^2 + 3.1765

4. Discussion

It was found that the mean DBH (cm) and mean height (m) in the Mahagony (Swietenia macrophylla) plantation of Chaugachha (19.9 cm, 14 m) Upazilla were comparatively higher than Mohespur (18.4 cm, 11.8 m) and Kotchandpur (18.3 cm, 12.2 m) Upazilla (Table 1). Table 1. Other hand, the density (stem/ha) and basal area (m²/ha) were higher in Mohespur (1323 stem/ha, 37.8 m²/ha) and Kotchandpur (1356 stem/ha, 38.2 m²/ha) upazilla than Chaugachha (1020 stem/ha, 33.8 m²/ha) upazilla (Table 1). It happened because most of the plantations in the Chaugachha Upazilla were old and had big trees. The plantations of Mohespur and Kotchandpur upazilla were newly established and had small trees with high

| Upazilla | AGC (Mg/ha) | BGC (Mg/ha) | Total Carbon (Mg/ha) | CO₂e (Mg/ha) | Price of CO₂e BDT/ha | O₂ Release (Mg/ha) | Price of O₂ Release (Million BDT/ha) |
|----------|-------------|-------------|----------------------|--------------|----------------------|-------------------|-------------------------------------|
| Mohespur | 85.95 ± 8.15 | 36.71 ± 3.06 | 122.65 ± 11.2        | 450.13 ± 41.09 | 15365 ± 1402         | 327.24 ± 30.0     | 11.5 ± 1.0                          |
| Kotchandpur | 87.01 ± 6.26 | 37.5 ± 2.46  | 124.51 ± 8.71        | 456.94 ± 31.57 | 15611 ± 1096         | 332.19 ± 23.24    | 11.6 ± 0.8                          |
| Chaugachha | 76.86 ± 4.31 | 32.63 ± 2.46 | 109.50 ± 5.99        | 401.86 ± 21.98 | 13724 ± 750          | 292.15 ± 15.98    | 10.2 ± 0.6                          |
| Average  | 83.27 ± 3.75 | 35.61 ± 1.44 | 118.89 ± 5.18        | 436.31 ± 19.01 | 14900 ± 650          | 317.2 ± 13.82     | 11.1 ± 0.5                          |
Fig. 2. Relationship between total carbon stock with mean DBH (a), mean height (b), mean density (c) and mean basal area (d).

Fig. 3. Developed basal-area based models (e, f, g).
numbers. Same DBH and height pattern was found for Mohespur (18.39 cm, 12.01 m) and Kotchandpur (19.52 cm, 12.57 m) upazilla (Pitol et al. 2019). In addition, the similar density and basal area were found for Mohespur (1340 stem/ha, 37.98 m²/ha) and Kotchandpur (1305 stem/ha, 42.01 m²/ha) upazilla (Pitol et al. 2019). However, it observed that the Mahagony (Swietenia macrophylla) woodlots show very high mean density (1233 stem/ha) and basal area (36.6 m²/ha). The mean DBH (18.9 cm) and mean height (12.6 m) was also adequate (Table 1). The found density and basal area was much greater (620 stem/ha and 16 m²/ha) than the Mahagony (Swietenia macrophylla) woodlots in the Philippines (Racelis et al. 2008). While the mean DBH and mean height was lesser (28.5 cm and 23.6 m) than the Mahagony (Swietenia macrophylla) woodlots in the Philippines (Racelis et al. 2008). It occurred because the age of the plantations in the Philippines was superior to our study sites. Conversely, the density (1233 stem/ha) was inferior to the roadside plantations (3668 stem/ha) under participatory management in Bangladesh (Rahman et al. 2015a, 2015b), Sundarbans mangroves (2701 stem/ha) (Siddiqui et al. 2021) and natural sal forest (2218 stem/ha) in northern Bangladesh (Rahman et al. 2020). Moreover, this study’s density (1233 stem/ha) was better than recorded natural and restored forests from other Asian countries and Bangladesh. For example, Taiwanese highway plantations (705 stem/ha) (Wang, 2011), urban roadside forests (279 stem/ha) in Shenyang, China (Liu and Li, 2012), Chittagong (South) Forest Division (381 stem/ha) (Nath et al. 1998), Cox’s Bazar Chunati Wildlife Sanctuary (459 stem/ha) (Rahman and Hossain, 2003), Dudpukuria-Dhopachori Wildlife Sanctuary (464 stem/ha) of Chittagong (Hossain et al., 2013), National park of Madhupur track (200 stem/ha) (Uddin et al. 2021), and Ukhiya natural forests (257 stem/ha).
ha) of Cox’s Bazar (Ahmed and Haque, 1993). Besides, the basal area (36.6 m²/ha) was poorer than roadside plantations (52.6 m²/ha) under participatory management in Bangladesh (Rahman et al. 2015a, 2015b), Chittagong (South) Forest Division (53.5 m²/ha) (Nath et al. 1998), National Park of Madhupur track (43.55 m²/ha) (Uddin et al. 2021) and higher than Chunati Wildlife Sanctuary (16.88 m²/ha) (Rahman and Hossain, 2003) and Dudupukuria-Dhopachori Wildlife Sanctuary (27.07 m²/ha) (Hossain et al., 2013). It was concluded that Mahagony (Swietenia macrophylla) woodlots have great potential in terms of showing higher DBH, height, stem density and basal area than many natural forests and artificial plantations around the world. This high density is caused due to maintaining a specific tree spacing (2 m × 2 m) and the high survival rate of Mahagony (Swietenia macrophylla). Because of the potential, the farmers of Bangladesh choose the Mahagony (Swietenia macrophylla) for woodlot creation.

Moheshpur (245.3 Mg/ha) and Kotchandpur (249.01 Mg/ha) upazilla had higher total biomass than the Chaugachha Upazilla (219 Mg/ha). The low density (1052 stem/ha) may be the cause of low biomass in the Chaugachha Upazilla. The above-ground, below-ground and total biomass of Swietenia macrophylla woodlots were 166.5 Mg/ha, 71.2 Mg/ha and 237.8 Mg/ha respectively (Table 1). The value was higher compared to mixed Swietenia macrophylla (60.12 Mg/ha) and pure Swietenia macrophylla stands (16.28 Mg/ha) from Luzon (Lasco and Pulhin 2006), the Visayas region (67 Mg/ha) and the Mindanao Swietenia macrophylla plantation (261 Mg/ha) (Lasco and Pulhin 2000). Mahagony (Swietenia macrophylla) woodlots grabbed more biomass and carbon than other natural and restored forests in Bangladesh and other countries. The high biomass and carbon stock happened due to the high stem density and basal area of Swietenia macrophylla (Table 1). It also appeared that the average value of wood of Swietenia macrophylla woodlots was 5.95 million BDT/ha (Table 1). The value was better than the value of Keora coastal plantation in Hatia (Mamun et al., 2021). The farmers may earn huge amount of money by selling the wood of Swietenia macrophylla. Moreover, the above-ground, below-ground and total carbon biomass of Swietenia macrophylla woodlots were 83.27 Mg/ha, 35.61 Mg/ha and 118.89 Mg/ha correspondingly. In addition, the mean biomass carbon (118.9 Mg/ha) in our study fulfilled the reported range (65–158 Mg/ha) of tree biomass carbon for Bangladesh (Gibbs et al., 2007). The average biomass carbon of Moheshpur (122.65 Mg/ha), Kotchandpur (124.51 Mg/ha) and Chaugachha (109.50 Mg/ha) upazilla also satisfied the stated range. The mean carbon biomass (118.9 Mg/ha) was higher than the reported mean biomass carbon of 83.72 Mg/ha (Shin et al., 2007), 110.94 Mg/ha (Ullah and Al-Amin, 2012), and 93.77 Mg/ha (Azad et al. 2021) in hill forests and rubber plantations of Bangladesh. However, the carbon stock (118.9 Mg/ha) was also more than the roadsides plantations (11.71 Mg/ha) of Eastern Australia (Eldridge and Wilson, 2002), plantations of Buter Street (45.49 Mg/ha), and Penn Street (22.29 Mg/ha) in the USA (Keating et al., 2005), national urban forest (22.83 Mg/ha) of USA (Nowak and Crane, 2002) and 34.95 Mg/ha of Shenyang, China (Liu and Li, 2012). Moreover, the carbon stock (118.9 Mg/ha) was smaller than 192.8 Mg/ha (Rahman et al. 2015a, 2015b), 143.93 Mg/ha (Pitol et al. 2019), and 605.24 Mg/ha (Racelis et al. 2008). Studies documented carbon stock ranged from 295 to 340 Mg/ha in Indonesia, Malaysia, and Thailand (Hairaiah and Sitompul, 2000, Noordwijk et al., 2000, Abu Bakar 2000, Boopragob 1998).

The scientists and policymakers are concerned about checking the atmospheric carbon-di-oxide emission by lessening deforestation and outspreading afforestation and reforestation (Kanowski et al. 2011, Pandey et al. 2014). Participating in the REDD + mechanism is essential for developing countries (Pandey et al. 2014), where afforestation and reforestation are two practical tools for minimizing climate change effect (Bonacci 2008, Wang et al. 2011). Mahagony (Swietenia macrophylla) woodlots stored high carbon-di-oxide (CO₂) (436.6 Mg/ha) that may earn an average of 14,900 BDT/ha according to the present carbon trade system. However, the present market value of release oxygen (O₂ Release) ranged 3.2–25.5 million BDT/ha with an average of 11.1 million BDT/ha. Moreover, the woodlots of Moheshpur and Kotchandpur Upazilla stored more carbon (450.13 Mg/ha and 456.94 Mg/ha) and released more oxygen (327.24 Mg/ha and 332.19 Mg/ha) than Chaugachha Upazilla (401.86 Mg/ha and 292.15 Mg/ha) respectively. As a result, the woodlot owners of Moheshpur and Kotchandpur Upazilla made large amount of money than the woodlot owners of Chaugachha Upazilla. It seemed that the price of carbon-di-oxide equivalence (CO₂e) and release oxygen (O₂ Release) was huge, and the value was more with the increase of age of the plantations. It is crucial to obtain more precise biomass estimations for plantation forests, especially woodlots, to improve understanding of the role of woodlots in Bangladesh and the global carbon trade. The established three basal area-based carbon stock calculation, allometric models, in this study, can be convenient for stand carbon calculation of Mahagony (Swietenia macrophylla) woodlots. According to GLRM analysis, three models showed significant (p < 0.01) and strong relationship (R² = 0.99).

Government should formulate a new policy considering the owner of Mahagony (Swietenia macrophylla) woodlots in the study area as an active stakeholder of carbon trade. Finally, this single study is not necessarily representative of all woodlots in Bangladesh. This study did not consider the soil carbon, biomass of litter fall and other ecological services of woodlots. The woodlots may vary greatly in composition, the intensity of use, trends of ecological services over time, and location. More study is required to get a clear view of woodlots and carbon stock potential in Bangladesh. Moreover, this study provides valuable inputs in estimating the potentiality of woodlots in Bangladesh to sequester carbon, release oxygen and mitigate global warming.

5. Conclusion

Swietenia macrophylla woodlots in the study area show extraordinary growth performance (DBH, height, density, basal area, biomass) and diversified ecological services (carbon-di-oxide storage and release oxygen). Farmers can earn a huge financial return by selling wood and involving them in the carbon trade program. It also releases a huge amount of oxygen into the atmosphere. It could bring extra benefits and new hope to the landless and marginal people if the government considers creating woodlots in government fallow lands. Woodlots are suitable for ensuring the proper use of fallow lands in Bangladesh. It is high time for the government to adopt new policies to improve the living standards of marginal farmers considering the financial returns of Woodlots. The outcomes of our research will help to evaluate and expand the Woodlots in Bangladesh and elsewhere in Asia that will enhance climate change mitigation activities.

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7. Author’s contribution

MNSP and MBM perceived the study and participated in field survey, MNSP analysed data and wrote the first draft, and both authors revised the manuscript.
Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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