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ABOVEGROUND CARBON STOCK OF THE WOODLOT PLANTATION IN CHOWGACHA UPAZILA OF JESSORE DISTRICT

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Dedicated To...

My Beloved Parents and

Younger Brother

ABSTRACT

Carbon exists as carbon dioxide in the atmosphere and constitutes about 0.04% of the atmosphere. In the recent past, it has gained a lot of attention as a greenhouse gas, as it has potential to influence the climate pattern of the world. Anthropogenic activities like industrialization, deforestation, forest degradation and burning of fossil fuel, has caused an increase in the level of carbon in the atmosphere and disrupted the global carbon cycle. However, nature has its own mechanism of sequestering and storing the carbon in its "reservoirs" or "sinks''. Forest has great potential for carbon sequestration particularly under changing environment. The role of plantation forest is increasing in carbon sequestration due to rapidly destroying natural forest. Woodlot plantation is also playing crucial role in carbon sequestration which is the most important of plantation forest. Among all the carbon pools, the above-ground biomass constitutes the major portion of the carbon pool. In this research aboveground carbon stocks of woodlot plantation is studied. Estimating the amount of forest biomass is very crucial for monitoring and estimating the amount of carbon that is lost or emitted during deforestation, and it will also give us an idea of the forest's potential to sequester and store carbon in the forest ecosystem. Estimations of forest carbon stocks are based upon the estimation of forest biomass. Each sample plot's area is (10m*10m) and forty sample plots are selected from ten villages of study area purposively. The most woodlot plantations of the study area are composed of switenia macrophylla and the present study is conducted on the woodlots of switenia macrophylla. The above ground biomass in woodlot plantations ranges between 74.65 and 544.16 Mgha^{-1} with lowest and highest value in Mahagony(*Switenia macrophylla*) plantation. In this study area, the average carbon stock in Mahagony (*Switenia Macrophylla*) plantation is estimated to 118.5Mg ha^{-1}. The carbon stocks in Mahagony plantation ranges between 37.32 Mg/ha and 272.08 Mgha^{-1} with lowest and highest in Mahagony plantation in this study area. This paper, aims to estimate the above-ground biomass of the woodlot plantation by using universal chave's allometric equation.

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Md. Bachchu Mian

APPROVAL

Project Thesis submitted to the Forestry and Wood Technology Discipline, Khulna University, Khulna, Bangladesh, for the partial fulfillment of 1 year professional B.Sc. (Masters.) degree in Forestry. I have approved the style and format of the project thesis.

24.6.15

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DECLARATION

I, Md. Bachchu Mian, declare that this thesis is submitted for the M.Sc. degree in Forestry at Forestry and Wood Technology Discipline, Khulna University, Khulna, Bangladesh, is my own original work and have not previously been submitted or it has not been accepted to any other institution.

I give my consent for my thesis, if accepted, to be available for photocopying and for interlibrary loan, for the title and summary to be made available for other organizations.

24.06.15

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CHAPTER: ONE

1.1 Introduction

Bangladesh lies in the north-eastern part of the South Asia between 20^0 $34'$ and 26^0 $38'$ north latitude and 88^0 $01'$ and 92^0 $41'$ east longitude. The area of the country is 14.757 million hectares (ha). Here tropical climate prevails throughout the year with distinct rainfall and dry period. Bangladesh is one of the most densely populated countries of the world. According to Bangladesh Bureau of Statistics (BBS 2010) population is 145.8 million of which 77% live in the rural areas. Overall per capital availability of land and forest are about 0.12 ha and 0.02 ha respectively. The total forest area in Bangladesh, according to Forest Department, is estimated to be 2.52 million ha corresponding to 17.4% of the surface area of the country. This includes 1.52 Million ha Forest Department controlled land, 0.73 million ha Unclassified State Forests (USF) under the control of District Administration and 0.27 million ha village forest land (mostly homesteads). However, National forest and tree resources assessment 2005-2007 found forest cover of the country as 9.8% as per definition of FAO.

During the last two decades, forest plantations have been gaining importance due to their key role in mitigating atmospheric carbon dioxide (CO2) in the global context of climate change. As CO2 drastically enhances greenhouse effect and global warming, which in turn trigger climate change, forests prove to be promising means of combating this undesirable phenomenon by their unique ability to store large volumes of carbon (C) in their biomass. However, a rapid rise in the rate of deforestation especially in the tropics reduces the CO2 mitigation potential of tropics posing a possible peril of converting them from being a global carbon sink to a net carbon source. In this crucial scenario, plantation forestry has turned out to be a preferential option for climate change mitigation .The total C storage potential of the forest plantations has been recently estimated to be around 11.8 Pg C (Sundarapandian et al., Forest Res 2013).

Now, natural forest is decreasing very rapidly due to anthropogenic activities (such as deforestation, industrialization etc.). In 1990 to 2005, total amount of natural forest was decreased 643.61(000 ha) to 593.24 (000ha) in Bangladesh. Now, the deforestation rate is more than before. On the other hands, the plantation forest was increased 238.81(000ha) to 278.11(000ha) in 1990 to 2005. The total amount of plantation forest in the world was estimated to 187086 (000ha) and annual planting rate of new plantation 4493(000ha) per year and total amount of plantation forest in Asia 115847 (000ha) and planting rate of new plantation 31556 (000ha) per year (CRA, Bangladesh 2010). Globally, an average of 5 million ha of tree plantations have been established per year between 2005 and 2010 (FAO 2010). In 2010, planted forests made up an estimated 7 % of the total forest area or 264 million ha (FAO2010). As an indication only, forest plantations were estimated in the year 2000 to supply about 35% of global round wood, with anticipated increase to 44% by 2020. So, it is said that plantation forest is playing vital role in mitigating global warming through carbon sequestration.

At the same time, Bangladesh is a low carbon dioxide emitting country. For instance, the per capita carbon dioxide emission is estimated at 0.2 ton/year, while the average for developing countries is 1.6 ton/year. In USA the per capita emission is 20 ton/year. The low GHG emission status however provides no relief from the effects of Global Warming because 1.5 meter rise in sea level would inundate an area of 22,000 sq.km of Bangladesh, affecting 17 million people. Obviously Bangladesh is likely to be one of the worst suffers of Global Warming but she is not liable for this rather she is playing crucial role in carbon sequestration (Waste concern, UNDP, 2012).

Now carbon trading is well discussed issue in the world. Carbon trading referred to as emission reduction trading is a relatively simple concept. Carbon trading is an economic tool which, in essence, allows for several parties to meet total emission reduction requirements at lower costs by working together. Carbon trading allows surplus emission reduction to required limits to be traded to other parties needing to meet emission limits. In theory, if one party can reduce emissions at a lower cost than a second party, then first party could maximize emission reductions and sell any surplus reductions to the second party to help meet its reduction requirements. The aim is to improve the overall flexibility and economic efficiency of obtaining emission reduction (Waste concern, UNDP, 2012).

Bangladesh as already ratified the Kyoto protocol may apply for emission permit for trading and if permitted may exchange the amount Bangladesh does not emit with other countries Carbon trading compels to keep the emissions of carbon dioxide within a certain limit. It encourages uses green technology. It helps in increasing forestation. It is an alternative means to recover global warming through taking part with the activities global environmental organization. As a whole it is a reward to who are emitting less carbon dioxide and a charge on who are liable for global warming. So it is not far behind that when small holder farmer will get money in exchange of planting trees. So, it is very much necessary for Bangladesh to assess the biomass or carbon stock of the woodlot plantation for getting the carbon trading facilities.

Considering the above background and justifications, this present study aims to know carbon stocks of the woodlots plantation in Chowgacha Upazilla of Jessore district, Bangladesh.

1.2 Objective

i. To estimate the amount of aboveground carbon stock of the woodlot plantation in Chowgacha Upazilla of Jessore District.

CHAPTER: TWO

LITERATURE REVIEW

2.1 Concept of Woodlot

A woodlot is a term used in North America to refer to a segment of a woodland or forest capable of small-scale production of forest products such as wood fuel, sap for maple syrup, saw logs, as well as recreational uses like bird watching, bushwalking, and wildflower appreciation. In Britain a woodlot would be called a wood, woodland or coppice. Many woodlots occur as part of a larger farm or as buffers and undevelopable land between these and other property types such as housing subdivisions, industrial forests, or public properties (highways, parks, watersheds, etc.). Very small woodlots can occur where a subdivision has not met its development potential, or where terrain does not easily permit other uses. Very large woodlots (hundreds of acres) might emerge where profitable wood species have been depleted by commercial logging practices or compromised by diseases, leaving little choice but to divide and liquidate the real estate for other purposes. One distinguishing characteristic of a woodlot is that the parcel size or quality of wood on the parcel does not generally justify full-scale commercial harvesting, leaving many woodlots as private investments by individuals. On the other hand, good forest management practices, even on a small scale, may create a sustainable source of products, which can significantly contribute to the aggregate inventory available to forest-product consumers. (Wikipedia 2007)

2.1.1Benefits of woodlots

The value of the woodlots is often and only measured by the dollar value from timber sales. Many farmers don't know that there are so many others values that indirectly might be worth more than the dollars from timber sales. The woodlots enhance protection and conservation of soil quality which is a key component of a sustainable agriculture production system and ecosystems as well. The value of woodlots on soils quality includes reduces soil erosion and it is known that the effect of soil erosion on crop yields and soil productivity are substantial. Loss of nutrients and minerals in the soil from erosion and reduction on yield and productivity are considerable costs to farmers, trees absorb chemicals from fertilizers, heavy metals and other pollutants through their root systems and store it in the wood, some shrub and tree species might reduce salinity in the soil (Agroforestry &Woodlot Extension Society, 6547 Sparrow Drive Leduc, AB T9E 7C7).

2.2 Mahogany (Swietenia macrophylla King)

Swietenia macrophylla King, also known as big leaf mahogany, is a tropical tree species native to Central and South America. Swietenia macrophylla has a wide natural distribution, extending from Mexico to Bolivia and central Brazil (Lamb 1966). However, large areas of former S. macrophylla forests have been converted to other uses, or the remaining forests are few (Shono and Snook 2006). The depletion of S. macrophylla populations has lead to concern for the future of the species and its commercial trade. In 2002, S. macrophylla was listed in Appendix II (species that may face extinction if trade is not controlled) of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Grogan and Barreto 2005). The largest plantations of S. macrophylla have been reported in South and Southeast Asia and the Pacific region. A significant proportion of the total area, most remarkably in Indonesia and the Philippines, was intended for protection of slopes and water catchments and may not be productive. In addition, S. macrophyllais widely used for avenue planting in some Asian countries including Indonesia, India and Sri Lanka. According to Mayhew and Newton (1998), the earliest recorded introduction of S. macrophylla into any country is to Indonesia in 1870 with seeds from India. It was then planted as an ornamental and cultivated in plantations in Java between 1897 and 1902.

2.3 Description of the species

2.3.1 Taxonomy

Botanical name: Swietenia macrophyllaKing

Family: Meliaceae

Subfamily: Swietenoideae

Synonyms: Swietenia belizensis Lundell, Swietenia candollei Pittier, Swietenia krukovii Gleason, Swietenia macrophylla King var.marabaensis Ledoux et Lobato, Swietenia tessmannii Harms.

2.3.2 Distribution

Swietenia macrophylla grows naturally in Belize, Bolivia, Brazil, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Peru and Venezuela. However, it is nearly extinct in Ecuador, Colombia, Panama and Costa Rica; close to commercial extinction in Bolivia; declining in Mexico, Belize and Brazil; and in severe decline in Guatemala, Peru, Nicaragua and Honduras

2.3.3 Wood characteristics

Swietenia macrophylla is a rather soft, medium weight timber. The heartwood is reddish or pinkish, the color darkening with age to a deep red or brown; the sapwood is usually yellowish. It has an attractive appearance, can be worked easily with hand tools and has excellent finishing qualities and dimensional stability (Martawijaya et al. 2005)

2.4 Concept of Plantation

A plantation is a large piece of land (or water) usually in a tropical or semitropical area where one crop is intentionally planted for widespread commercial sale and usually tended by resident laborers. The crops grown include fast-growing trees (often conifers), cotton, coffee, tobacco, sugarcane, sisal, oil seeds (e.g. oil palms), rubber trees, and various fruits. Protectionist policies and natural comparative advantage have sometimes contributed to determining where plantations were located. Among the earliest examples of plantations were the latifundia of the Roman Empire, which produced large quantities of wine and olive oil for export. Plantation agriculture grew rapidly with the increase in international trade and the development of a worldwide economy that followed the expansion of European colonial empires. Like every economic activity, it has changed over time. Earlier forms of plantation agriculture were associated with large disparities of wealth and income, foreign ownership and political influence, and exploitative social systems such as indentured labor and slavery (Wikipedia 2007).

2.5 Forest as a climate mitigation tool

Forest has an important role in the global carbon cycle (Pan et al. 2011) and forestry can contribute to climate change mitigation (TFD 2008). There are two ways to reduce CO_2 concentrations in the air: (1) do not allowing CO_2 to enter the atmosphere (i.e., control emission or carbon conservation) and (2) removing some of the excess CO_2 already in the atmosphere and sequestering it where it does less harm (Brown 2010).

2.6 Global Warming and Kyoto Protocol

Increasing scientific evidence reveals that the earth is getting warmer due to various human activities resulting in sea level rise and occurrence of extreme events such as cyclones, floods and droughts. In order to tackle Global Warming, United Nations General Assembly took up this issue of Climate Change and adopted the resolution "Protection of Global Climate for Present and Future Generations of Mankind". The United Nations Framework Convention on Climate Change (UNFCCC), adopted in 1992 which came into force in 1994 established an international framework to address global climate change. Parties to the Convention agreed to stabilize green house gas (GHG) concentrations in the earth's atmosphere. In December 1997, Bangladesh along with 160 other countries, completed negotiations at the third session of Conference of Parties (COP3) at Kyoto Japan to finalize a protocol subsequently known as the Kyoto Protocol. This protocol includes reduction targets and time table for six green house gases. The most important aspect of the Kyoto Protocol is its legally binding commitments for 39 developed countries to reduce their GHG emissions by an average of 5.2% relative to 1990 level. These emission reductions must be achieved by 2008 -2012: the so called first commitment period (Waste concern, UNDP, 2012).

2.7 Impact of global warming in Bangladesh

Bangladesh is a low carbon dioxide emitting country. For instance, the per capita carbon dioxide emission is estimated at 0.2 ton/year, while the average for developing countries is 1.6 ton/year. In USA the per capita emission is 20 ton/year. The low GHG emission status however provides no relief from the effects of Global Warming because 1.5 meter rise in sea level would inundate an area of 22,000 sq.km of Bangladesh, affecting 17 million people. Obviously Bangladesh is likely to be one of the worst suffers of Global Warming. The other impacts of global warming would be on:

- Agriculture
- Bio diversity and Forestry
- Human Health
- Fisheries
- Drainage
- Fresh water (Waste concern, UNDP, 2012).

2.8 Clean Development Mechanism (CDM)

The Kyoto Protocol allows Annex-B countries to reach their emission reduction targets in different ways through Flexibility Mechanisms. These include Emission Trading (trading of emission between developed countries); Joint Implementation (transferring emission allowances between developed nations linked to a specific emission reduction project); and Clean Development Mechanism (CDM). CDM is the only flexibility mechanism that involves developing countries (Non-Annex B). It allows developed countries (Annex-B) to achieve part of their reduction obligations through investment in projects in developing countries that reduce GHG emissions or fix or sequester carbon dioxide from the atmosphere (Waste concern, UNDP, 2012).

2.8.1 Salient Features of CDM

Industrialized (Annex-B) countries' state or private companies can invest in projects in developing (Non-Annex B) countries that contribute to reduction of GHG emission. Developing (Non-Annex B) countries' state or private companies are allowed to implement such projects. Through CDM projects industries in developing countries can be technologically upgraded and made environment friendly thus contributing to global climate protection as well as promoting sustainable development in the host country. The industrialized countries' investing entities can earn credit for emission reductions achieved through its investment in developing country towards its own emission commitment. (Waste concern, UNDP, 2012)

2.9 Carbon sequestration

Carbon sequestration refers to the capture and long term storage of carbon in forests and soils, so that the build-up of CO_2 (one of the principle greenhouse gases) in the atmosphere will reduce or slow (Carbon venture 2011). The United Nations Framework Convention on Climate Change (UNFCCC) defines carbon sequestration as the process of removing carbon from the atmosphere and depositing it in a reservoir. Carbon sequestration can be defined as the amount of carbon that can be additionally stored in an agro-ecosystem (Bernoux et al. 2006). At present, carbon sequestration is valued as a function of credit emission reductions (CERs), based on the difference between the amount of carbon stored in scenario projects and the baseline, current amount of carbon stored in the system (UNFCCC 2004). According to USDA Forest Service (2009), "Carbon sequestration is the process by which atmospheric CO_2 is taken up by trees, grass and other plants through photosynthesis and stored as carbon in biomass (trunks, branches, foliages and roots) and soils.

2.10 Types of carbon sequestration

- According to IPCC (2005), CO_2 sequestration can be done by the following three ways.

- Terrestrial sequestration or vegetative sequestration: Terrestrial sequestration is the natural intake of CO_2 by plants, which incorporate it in their wood, leaves, and roots and also bind it to the underlying soil and much of this CO_2 is not released into the atmosphere until the plant is destroyed (by decay or burning) or the soil is tilled and exposed to the atmosphere (Brown 2010. This can be enhanced by increasing the growth of land plants through planting trees, mitigating deforestation or adjusting forest management practices. It is the easiest and most immediate option for carbon sequestration at the present time.

- Geologic sequestration: Geo-sequestration is burying the CO_2 deep within the earth. It can be done by the mechanical capture of CO_2 from an emissions source (e.g., a power plant) and the captured CO_2 is injected and sealed into deep rock units (Brown 2010). The most suitable sites are deep geological formations, such as depleted oil and natural gas fields or deep natural reservoirs filled with saline water (saline aquifers).

- Oceanic sequestration: Oceanic sequestration is dumping the CO_2 into the oceans depths. Pumping CO_2 into the deep ocean basins (350-3000 meters), where it is anticipated it may form lakes of liquid, supercritical or solid hydrates.

2.11 Carbon stocks

'Terrestrial carbon stocks' is the term used for the C stored in terrestrial ecosystems, as living or dead plant biomass (aboveground and belowground) and in the soil, along with usually negligible quantities as animal biomass. Aboveground plant biomass comprises all woody stems, branches and leaves of living trees, creepers, climbers and epiphytes as well as understory plants and herbaceous growth. For agricultural lands, this includes trees (if any), crops and weed biomass. The dead organic matter pool (necromass) includes dead fallen trees and stumps, other coarse woody debris, the litter layer and charcoal (or partially charred organic matter) above the soil surface. The belowground biomass comprises living and dead roots, soil fauna and the microbial community. There also is a large pool of organic C in various forms of humus and other soil organic C pools. Other forms of soil C are charcoal from fires and consolidated C in the form of iron humus pans and concretions. For peat land, the largest C pool is found in soil.

2.12 Concept of Carbon Trading

Carbon trading also referred to as emission reduction trading is a relatively simple concept. Carbon trading is an economic tool which, in essence, allows for several parties to meet total emission reduction requirements at lower costs by working together. Carbon trading allows surplus emission reduction to required limits to be traded to other parties needing to meet emission limits. In theory, if one party can reduce emissions at a lower cost than a second party, then first party could maximize emission reductions and sell any surplus reductions to the second party to help meet its reduction requirements. The aim is to improve the overall flexibility and economic efficiency of obtaining emission reduction (Waste concern, UNDP, 2012).

2.13 Carbon Trading: Bangladesh Perspective

Farmers are not eager to plant trees because trees usually don't earn them money for many years. Now a carbon broker came and offers them to plant trees and keep it alive for a definite period, in exchange he will pay them money. This is the dream of some environmental organizations, economist states and entrepreneurs. They believe a system of carbon trading that allows the buying and selling carbon credit simultaneously help prevent global warning and promote planting of trees. Carbon trading of carbon dioxide emissions by exchanging it from one's limit fixed according to Kyoto Protocol by the state. This earth when created carbon dioxide was used to keep the earth warm for friendly living environment. And it was in a balance amount. But now a day's carbon dioxide exists over the balance amount and causing different problems like global warming and green house effect. United Nations Frame work convention on climate change (UNFCCC) and different organizations are trying to protect global warming by decreasing carbon dioxide emission. Kyoto Protocol is the first step towards decreasing global emissions of carbon dioxide. By 2012, UNFCCC wants to decrease5.2% global emission of Carbon dioxide .Article 17 of the Kyoto Protocol regulates emission trading. Parties who have ratified Kyoto Protocol shall not exceed this carbon dioxide emission from the limit fixed by the UNFCCC. Carbon trading may be in different ways. There is no single format which is internationally recognized. Different formats are given below:

2.13.1 Exchanging From one's Permit

UNFCCC sets a limit on the amount of carbon dioxide that can be emitted by the state. And the state is bound as she has ratified the Kyoto Protocol. The limit is allocated in the form of emissions permits by the state to the bodies that need to emit carbon dioxide. The total number of permit cannot exceed the limit. Firms who need to emit more than the permit, they can buy it from others who are emitting less than the amount permitted. The transfer of this extra amount in exchange of money is an example of carbon trading.

2.13.2 Planting Trees and Forestation

Suppose I have a company. I need to emit 200 metric tons of carbon dioxide. But the state has permitted me of 100 metric tons. Then I plant some trees somewhere of the country that can absorb100 in tones of carbon dioxide annually. Then I showed the authority that through I am directly emitting 200 metric tons of carbon dioxide but 100 metric tons of carbon dioxide is being absorbed by those trees. So, my actual emission of carbon dioxide is 100 metric tons.

2.13.3 Allowance to Non-Profit Organization:

Someone who is emitting carbon dioxide is directly and indirectly harming the environment. So it is the corporate social responsibility to take part for the recovery of environment. If he directly can to do so he can take help from others who are working for the protection of global warming. That means, payment of a good amount of money to that nonprofit organization which will be reasonable to recover the amount you are harming through emitting carbon dioxide. It is the alternative way to keep balance the environment.

2.13.4 Individual Limit

Some persons are leading luxurious life in the whole world .Whenever they are using more electricity than the usual; they are taking part to emit more carbon dioxide. At the same way adding fuels to their vehicles, using air conditioner etc. They are taking part in global warming. State can fix a limit of emitting carbon dioxide for every individual. Where ever someone needs more amounts to emit then he has to buy it from the extra amount of others who are emitting less than their limit.

2.13.5 Market Size

According to the World Bank's Carbon Finance Unit, 374 million metric tons of carbon dioxide equivalent were exchanged through projects in 2005. In terms of dollars, the World Bank has estimated that the size of carbon market was 11 billion USD in 2005, 30 billion USD in 2006 and 64 billion USD in 2007.

2.13.6 Opportunity for Bangladesh

Bangladesh as already ratified the Kyoto Protocol may apply for emission permit for trading and if permitted may exchange the amount Bangladesh does not emit with other countries. Carbon trading compels to keep the emissions of carbon dioxide within a certain limit. It encourages using green technology. It helps increasing forestation. It is an alternative means to recover global warming through taking part with the activities of global environmental organization. As a whole it is a reward to who are emitting less carbon dioxide and a charge on who are liable for global warming.

2.14 Carbon conservation

The most expeditious way to mitigate climate change in forest is to reduce deforestation and forest degradation, thereby reducing GHG emission. In climate change negotiation, this strategy is usually referred to as "reducing emission from deforestation and degradation" (REDD) (IPCC 2007, Canadell and Raupach 2008, TFD 2008).

2.14.1 Carbon sequestration

As they grow, trees absorb CO_2 and through photosynthesis, sequester carbon to produce wood. Newly established forests (on reforested or afforested sites) and forest re-growth can sequester carbon quickly and will store it for the life of the forest. When trees are harvested efficiently, a large part of the sequestered carbon can be used to produce wood products such as house frames and thus stored over the medium to long term (IPCC 2007, TFD 2008).

2.14.2 Carbon cycle in forest

Carbon is the major component of all cellular life forms. Trees utilize carbon as a building material with which to form trunks, roots, stems, branches, and leaves. Trees remove (sequester) carbon from the atmosphere through photosynthesis (Ferrini 2011), extracting CO_2 from the air, separating the carbon atom from the oxygen atoms and returning oxygen to the atmosphere. In doing so, trees store a tremendous amount of carbon in their structures and annual growth increases the carbon stored within the structure. Photosynthesis is the chemical process by which plants use sunlight to convert nutrients into sugars and carbohydrates. Although individual plants die and decompose, forests eventually reach steady states in which the amount of CO_2 released by dying plants is offset by new plants.

CHAPTER: THREE

MATERIAL AND METHOD

3.1 Site Description

The study was conducted in two unions (Fulsara and Jagodispur) of Chowgacha upazila in Jessore district. Chowgacha is located at latitude 23°01'00"N to 23.0167°N and longitude 89°23'33"E to 89°14'00"E. About 90% of the total annual rainfall occurs during June-September. The average daily temperature ranges from 12° C during December-January to about 31° C during May-August. The annual average temperature is 24° C, with the extreme lowest 8.1° C in January and the highest 40° C in May. Annual average maximum temperature is 37.1° C and minimum 11.2° C. Four main seasons namely the dry or winter season (December to February), the pre-monsoon hot season (March -May), the monsoon or rainy season (June-September) and the post monsoon or autumn season (October -November) are recognized.(Banglapedia 2012).

3.2 Sample Size and Sampling Design

The most woodlot plantations of the study area are composed of switenia macrophylla and the present study was conducted on woodlots of switenia macrophylla. Purposive sampling was used for the data collection because of the uneven and discrete distribution of woodlots plantation in this region. During the reconnaissance survey, the study areas where woodlots plantation are dominant were selected through snow-ball methods. Ten villages were selected purposely from study area (Chowgacha Upazilla in Jessore district). Four sample plots were selected from each village and total forty sample plots from ten villages were selected. Sampling plots were selected purposively. The size of the each sampling plot was 10 m × 10m ($100m^2$). The plantation plot whose individual's diameter is less than 8 cm was discarded purposively.

3.3 Tools

Diameter tape, Measuring tape and Spigel Relaskop were used for collecting primary data for the study.

3.4 Data collection process

3.4.1 Primary data

Primary data were collected from the study area by using measuring tape, Spigel Relaskop and diameter tape for further analysis. The sample plot (10m*10m) was alienated by using measuring tape. Diameters at breast height of individual species of the sample plot were measured by using diameter tape and heights of individuals were measured by using spigel Relaskop.

3.4.2 Secondary data

Secondary data and related information were collected from the following sources:

- Khulna university library
- Seminar library, Forestry and Wood Technology Discipline, Khulna University
- Published and Unpublished reports, journals, books.
- Newspapers.
- Regional center, BBS, Jessore.
- Agriculture Information Services, Jessore.
- Internet.

3.5 Data analysis

3.5.1 Allometric computations for aboveground biomass

Biomass equations relate DBH to biomass and biomass may differ among species as trees in a similar functional group can differ greatly in their growth form between geographic areas (Pearson et al. 2007). Considering these factors Chave et al. (2005) developed allometric equation for tropical trees that was used for wide graphical and diameter range. By using Chave's allometric equation no (1), biomass of the switenia macrophylla woodlots was estimated. The following Chave's universal allometric equation is-

$$AGB = \rho \times \exp(-1.499 + 2.148 \times \ln(DBH) + 0.207\times (\ln(DBH))^2 - 0.0281(\ln(DBH))^3)$$ ....(1).

AGB = Aboveground biomass

ρ = Wood density (gcm^{-3}), DBH = Diameter at breast height , ln = Natural logarithm

1.499 = Constant, 2.148 = Constant, 0.207 = Constant, 0.0281= Constant

3.5.2 Conversion of aboveground biomass to carbon

Estimated biomass was multiplied by the wood carbon content (50%). As almost all carbon measurement projects in the tropical forest assume that all tissues (i.e. wood, leaves and roots) consist of 50% carbon on a dry mass basis (Chave et al. 2005, Prichard et al. 2000, Smith and Heath 2002).

Carbon (Mg) =Biomass estimated by allometric equation × Wood Carbon Content %

= Biomass estimated by allometric equation × 0.5

3.5.3 Density and basal area

Aboveground carbon pools was computed using international standard common tree allometries combined with local tables of wood density by tree species. Statistical analysis was done in Microsoft Excel 2007 and SPSS-16 software. Basal area and density were measured to determine the correlation with the biomass of the woodlot.

The basal area/ha was calculated according to the formula (Equation no: 2) (Shukla and Chandel 1980):

$$Ba/ha = \frac{\sum \frac{\Pi}{4} D^2}{\sum area \quad of \quad all \quad quadrats} X \quad 10000 \qquad \text{..........................} (2)$$

Basal area = $\Pi D^2/4$.

Where, Ba = Basal area in m^2ha^{-1}

D = Diameter at breast height in meter

$\Pi = 3.14$

Following the formulas of Moore and Chapman 1986, Shukla and Chandel 1980 and Dallmeier et al. 1992 quantitative structure parameters of investigated trees were calculated:

$$\text{Density (stem/ha)} = \frac{\text{Total no. of individuals of one species in all the plots}}{\text{Plot area} \times \text{Total no. of plots studied}} \quad \ldots\ldots\ldots\ldots (3)$$

$$\text{Relative density (\%)} = \frac{\text{Total no. of individuals of one species in all the plots}}{\text{Total no. of plots studied}} \times 100 \quad \ldots\ldots\ldots\ldots (4)$$

$$\text{Basal area } (m^2/ha) = \frac{\text{Total basal area of individual species } (m^2)}{\text{Sample plot area (ha)} \times \text{Total no. of plots studied}} \quad \ldots\ldots\ldots\ldots (5)$$

$$\text{Relative basal area (\%)} = \frac{\text{Total basal area of one species in all plots}}{\text{Total basal area of all species in all plots}} \times 100 \quad \ldots\ldots\ldots (6)$$

CHAPTER: FOUR

RESULT AND DISCUSSION

4.1 Carbon stocks of the woodlot

The above ground biomass in woodlot plantations ranged between 74.65 and 544.16 Mg ha^{-1} with lowest and highest value and the basal area in woodlot plantations ranged between 13.68 m^2ha^{-1} and 62.030 $m^2ha^{-1}$with lowest and highest value in Mahagony (*Switenia macrophylla*) plantation (Table no: 4.1). In this study area, the average carbon stock in Mahagony (*Switenia Macrophylla*) plantation was estimated to 118.5Mg ha^{-1} (Table no: 4. 1). The standard deviation of carbon stock in Mahagony plantation was also estimated to 47.85 Mg ha^{-1} (table no: 4.1). The carbon stocks in Mahagony plantation ranged between 37.32 Mg ha^{-1} and 272.08 $Mgha^{-1}$ with lowest and highest in Mahagony plantation in this study area. The minimum and maximum tree density was recorded from Mahagony Plantation 600 stems ha^{-1} and 1400 stems ha^{-1} (Table no: 4.1). In the plantation forest site, a significant positive correlation was observed among the following variables: number of individuals with BA, DBH, biomass, mean tree height and total C and also basal area with AGB and total C.

Table no: 4.1 five most important attributes list

Contents	Minimum	Maximum	Average	
4. Biomass (Mg ha^{-1})	74.65	544.16		
1. Carbon stock (Mg ha^{-1})	37.32	272.08	118.5	
2. Basal Area (m^2ha^{-1})	13.68	62.030		
3. Stem density ha^{-1}	600	1400		
5. Standard deviation ($Mgha^{-1}$)				47.85

4.2 Diameter at brest height

It was found that DBH/individual had a strong relationship with total aboveground carbon and the relationship was significant where R^2 is 0.91 (Figure 4.1).

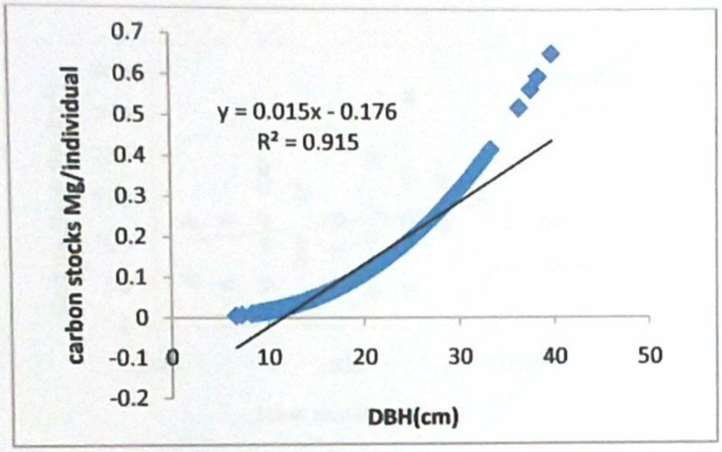

Figure 4.1 Relationship between DBH and total aboveground carbon stock

4.3 Mean tree height

There was a weak relation between mean tree height and total aboveground carbon stock and the relationship was not significant where R^2 is 0.20 (Figure 4.2).

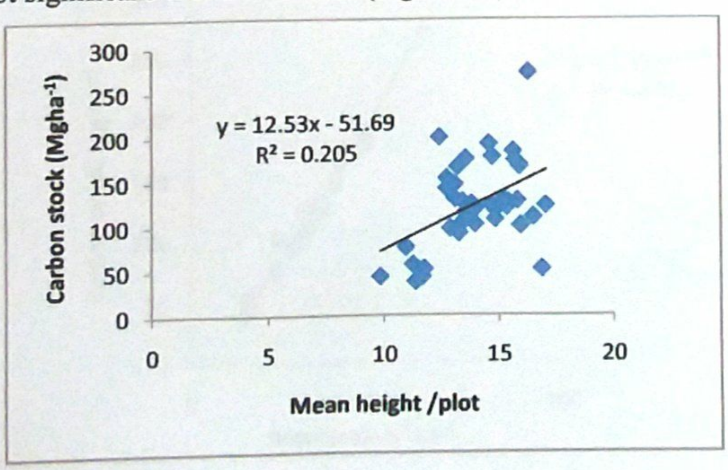

Figure 4.2 Relationship between mean tree height and total aboveground carbon stock

4.4 Stem density

There was a poor relation between stem density/ha and total aboveground carbon stock and relationship was not significant ($p < 0.01$). The value of r is 0.23 and R^2 is 0.056 (Figure 4.3).

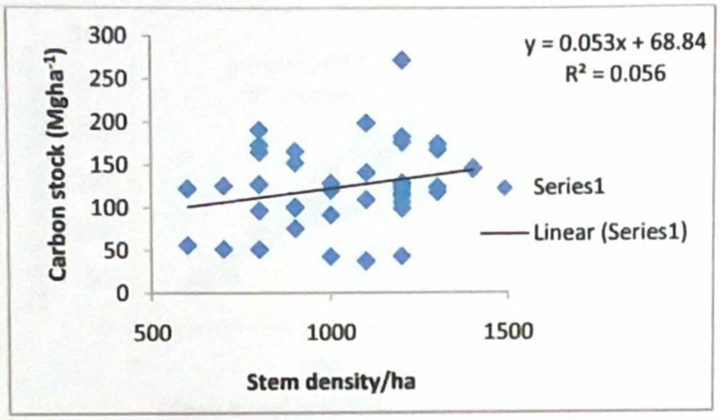

Figure 4.3 Relationship between stem density/ha and total aboveground carbon stock

4.5 Basal area

It was found that basal area ha^{-1} had a very strong relationship with total aboveground carbon stock and the relationship was significant where R^2 is 0.96 (Figure 4.4).

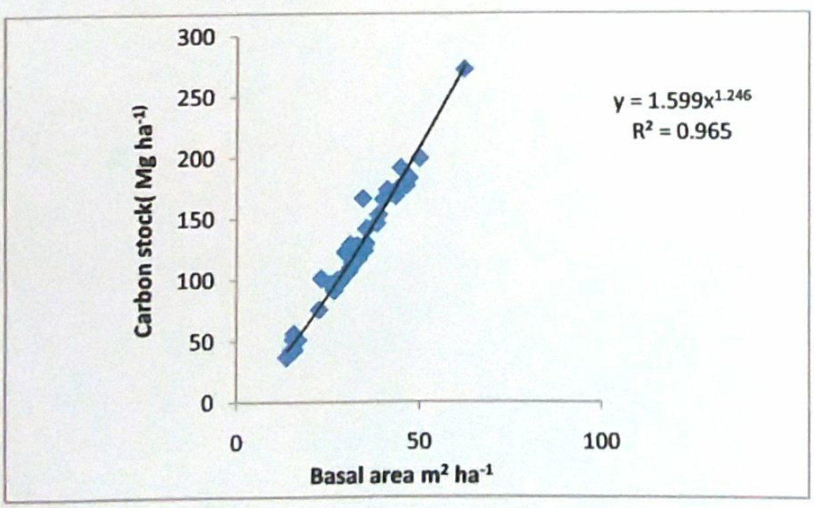

Figure 4.4 Relationship between basal area and total aboveground carbon stock

4.6 Mean basal area and Mean Tree Height

There was a strong relation between Mean basal area ha^{-1} multiply Mean height and total aboveground carbon stock and relationship was strongly significant. The value of R^2 is 0.92 (Figure 4.5).

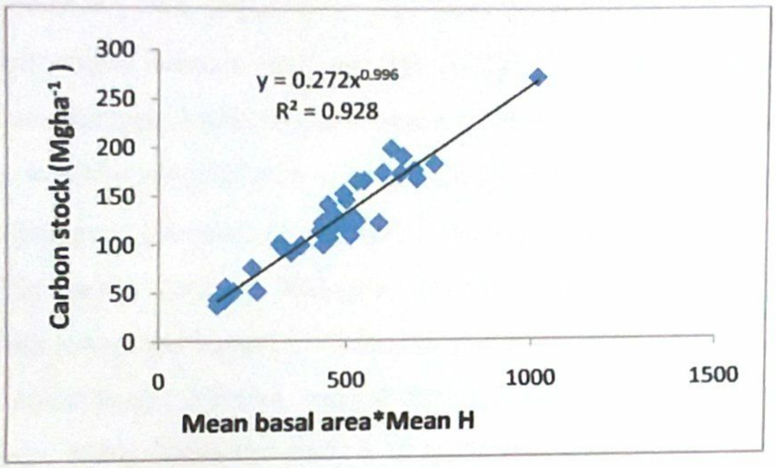

Figure 4.5 Relationship between mean basal area*mean height and total aboveground carbon stock

CHAPTER: FIVE

5.1 Discussion

It is important to obtain more accurate and precise biomass estimates for plantation forests or woodlots in order to improve about understanding of the role of plantation forests or woodlots in Bangladesh as well as in global carbon cycle. The above ground biomass in woodlot plantations in the present study ranged between 74.65 and 544.16 $Mgha^{-1}$ with lowest and highest value and the basal area in woodlot plantations ranged between 13.68 m^2ha^{-1} and 62.030 $m^2ha^{-1}$with lowest and highest value in Mahagony(*Switenia macrophylla*) plantation. In this study area, the average carbon stock in Mahagony (*Switenia Macrophylla*) plantation in the study area was estimated to 118.5Mg ha^{-1}. The carbon stocks in Mahagony plantation ranged between 37.32 Mg/ha and 272.08 $Mgha^{-1}$ with lowest and highest in Mahagony plantation in this study area where biomass of broadleaved tropical forests America, tropical Asia and total tropics: 170, 215 and 150 Mg ha^{-1} (Brown and lugo, 1984). From the study it is found that aboveground Woodlot Plantation biomass is higher than aboveground Natural Forest Biomass. So woodlot Plantation can be prospective substitution for degraded Natural Forest. The best Relationship between C stock and basal area (eq. $Y= 1.599x^{1\ 246}$) where R^2=0.96.

Several measures of stand structure and productivity were also assessed to know the relationship with aboveground carbon stock. Two attributes (e.g. stand basal area/ha (R^2=0.96) (Figure 4.4), and basal area/ha*mean height/plot (R^2=0.92) (Figure 4.5) were strongly related to aboveground carbon stocks, but stand mean height (R^2=0.20) (Figure 4.2) and stem density per hectare (R^2=0.056) (Figure 4.3) were weakly related because stem density per hectare of the study area was less with short rotation and similar height of different plots having wide variation in number of trees.

According to Kayah et al. (2012) DBH is very strongly (R^2=0.98) related with aboveground biomass. Again Henry et al. (2009) has shown tree volume is very strongly related with total aboveground biomass. So the more basal area, stem density/ha and DBH indicate the more amount of biomass and more biomass means more carbon stock. But with similar height of different plots having wide variation in number of trees. For this reason mean tree height is weakly related with aboveground carbon stock. So, by increasing woodlot plantation with long rotation with good diameter trees, we can increase the amount of aboveground carbon stocks which can play a vital role in global carbon cycle.

5.2 Conclusion

At present, natural forest is decreasing very rapidly at alarming rate due to anthropogenic activities (such as deforestation, industrialization, burning fossil fuels etc.) that enhance global warming but plantation forest is increasing more than before. Bangladesh is likely to be one of the worst suffers of Global Warming due to excessive carbon emission but she is not liable for this rather she is playing crucial role in carbon sequestration especially through new plantation forest. Woodlot plantation is one of the major parts of plantation forest and it has huge potential in the mitigation of global warming and adaptation to climate change. So, estimation of the forest carbon stocks is very essential which will enable us to assess the amount of carbon loss during deforestation or the amount of carbon that a forest can store when such forests are regenerated. Besides, Bangladesh is highly potential for carbon trading. So, it is very much necessary to assess the biomass or carbon stock of the woodlot plantation for getting the carbon trading facilities. Although there has been numerous studies carried out to estimate the forest biomass and the forest carbon stocks, there is still a further need to develop robust methods to quantify the estimates of biomass of all forest components and carbon stocks more accurately.

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