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Title: Biomass carbon stock (above ground and below ground) measurement of coastal plantation areas in Nijhum Dwip and Hatiya Island under Noakhali District, Bangladesh

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ABSTRACT

Coastal plantation and this types of forest play an important role to store the extend amount of atmospheric carbon. Coastal area constitutes around 32 percent of the area and 28 percent of the population of Bangladesh (Islam, 2004). Nearly 50 percent (1, 72,833 hectares) of Bangladesh's forests are in the coastal zone; they comprise both natural forests, including the Sundarbans and planted forest. Coastal plantation supports numerous ecosystem services, including atmospheric carbon storage, fisheries production and nutrient cycling. However, the areal extent of mangrove forests has declined by 30–50% over the past half century as a result of coastal development, aquaculture expansion and over-harvesting. Carbon emissions resulting from mangrove loss are uncertain, owing in part to a lack of broad-scale data on the amount of carbon stored in these ecosystems, particularly below ground. Here, this research work have quantified the ecosystem carbon storage by measuring trees and dead woods aboveground biomass in Nijhum deep and Hatiya deep coastal plantation area across a broad area of the southern part spanning between 21°1′ to 22°6′ North latitude and 90°3′ to 91°4′ East longitude. Where, the plantation area and diversity is not rich as those are plantation forest. The objective of my study is to estimate the biomass and carbon stock per hectare on those areas. That's why I have observed 80 study plots and took data (trees diameter and height) for further calculation. For completing this research work I have used Hossain's (2015) Chave's and Komiyama's equation and got significant results. The average biomass (includes above ground and below ground) is 182.52 Mg ha^{-1} and containing on average biomass carbon 91.264 Mg ha^{-1}. The average above ground biomass calculated is 113.1817 Mg $ha^{-1}$and average belowground biomass is 69.347 Mg ha^{-1}. The stem density is varies plot to plot but the average stem density of those coastal plantation area is 643 stems ha^{-1}. Data and Results indicate that the coastal region of Nijhum deep and Hatiya have potential site to plant mangrove trees and retain high biomass that's very much important to store atmospheric carbon.

Dedicated

To

My beloved Parents and

Late Grandmother

Biomass Carbon Stock (Above ground and Below Ground) Measurement of Coastal Plantation areas in Nijhum Dwip and Hatiya Island under Noakhali District, Bangladesh

Title of the Course: Project Thesis

Course No: FWT-4114

[This thesis is prepared and submitted to Forestry and Wood Technology Discipline, Khulna University, Khulna-9208 by M. M. Al-Mamun for a partial fulfillment of four years B.Sc.(Hon's) Degree in Forestry]

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APPROVAL

This project thesis submitted to the Forestry and Wood Technology Discipline, Khulna University, Khulna, Bangladesh. In partial fulfillments of the requirements for the B.sc (Honors) degree in forestry, I have approved the style and format of the project thesis.

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DECLARATION

I, M. M. Al- Mamun, declare that this thesis is the result of my own works and it has not been submitted or accepted for a degree in any other university.

I, hereby, give consent for my thesis, if accepted, to be available for photocopying and for inter-library loans, and for the title and summary to be made available to outside organizations only for research and educational purposes.

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M. M. Al- Mamun

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M. M. Al-Mamun

ABSTRACT

Coastal plantation and this types of forest play an important role to store the extend amount of atmospheric carbon. Coastal area constitutes around 32 percent of the area and 28 percent of the population of Bangladesh (Islam, 2004). Nearly 50 percent (1, 72,833 hectares) of Bangladesh's forests are in the coastal zone; they comprise both natural forests, including the Sundarbans and planted forest. Coastal plantation supports numerous ecosystem services, including atmospheric carbon storage, fisheries production and nutrient cycling. However, the areal extent of mangrove forests has declined by 30–50% over the past half century as a result of coastal development, aquaculture expansion and over-harvesting. Carbon emissions resulting from mangrove loss are uncertain, owing in part to a lack of broad-scale data on the amount of carbon stored in these ecosystems, particularly below ground. Here, this research work have quantified the ecosystem carbon storage by measuring trees and dead woods aboveground biomass in Nijhum deep and Hatiya deep coastal plantation area across a broad area of the southern part spanning between 21°1′ to 22°6′ North latitude and 90°3′ to 91°4′ East longitude. Where, the plantation area and diversity is not rich as those are plantation forest. The objective of my study is to estimate the biomass and carbon stock on this area. That's why I have observed some study plot and took data for further calculation. For completing this research work I have used Chave's and Komiyama's equation and got significant results. The average biomass (includes above ground and below ground) is 183.31 Mg ha^{-1} and containing on average biomass carbon 91.66 Mg C ha^{-1}. The average above ground biomass calculated is 113.97 Mg ha^{-1} and average belowground biomass is 69.35 Mg ha^{-1}. The stem density is varies plot to plot but the average stem density of those coastal plantation area is 643 stems ha^{-1}. Data and Results indicate that the coastal region of Nijhum deep and Hatiya have potential site to plant mangrove trees and retain high biomass that's very much important to store atmospheric carbon.

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CHAPTER-ONE
INTRODUCTION

Introduction:

Bangladesh is a tropical maritime nation on the northern border of the Bay of Bengal. The coastal region lies between latitude 21° to 23° north and longitude 89° to 93° east. The coastline is approximately 710 kilometers long and the coastal zone covers an area of about 2.85 million hectares, which is 23 percent of the country's total area (Karim, 2006). The coastal region includes offshore islands, mudflats, chars and new accretions. However due to the geomorphology of the area, the coastal zone is particularly susceptible to tropical storms and tidal surges which occur frequently in the Bay of Bengal. These natural calamities ravage the area almost regularly and are considered the greatest hindrance to the development of the region and the country as a whole. For this reason, mangroves as coastal shelterbelts are considered most important for the country. The coastal zone has extensive areas of both natural and planted mangrove forest. Natural forest includes the Sundarbans, the Chakaria Sundarbans and fringe mangroves along the eastern coast. The Sundarbans is the world's single largest tract of mangrove forest and in terms of mangrove biodiversity, the richest forest in the world; it is a Ramsar site, part of which has been designated as a World Heritage site. For about a century the Sundarbans has enjoyed the status of Reserved Forest and has been managed for its productive value. After a cyclone devastated the coastal region in the 1960s except for Khulna District, which is protected by the Sundarbans coastal afforestated zone with mangrove species was initiated to protect life and property from cyclones and tidal surges. Later, industrial raw material and fuel wood production, conservation of coastal ecosystem and the environment, protection of wildlife and aquatic resources, protection of agricultural land against salt intrusion, tourism, poverty reduction and enhancing land accretion were added to the objectives of development programmes. In this context, over the last four decades the Forest Department has successfully implemented several massive projects and has established some 148 000 hectares of mangrove plantations scattered over on- and offshore areas mostly along the central part of the coast (Islam, 2005).

Now a day, Carbon sequestration is one of the major concerns in this world because there is a huge amount of carbon is releasing day by day from different kinds of industrial and human activities even we continuously produce carbon dioxide by breathe. It is the main element of greenhouse gases that is responsible for global warming that's why carbon measurement and production issues have already became the vital concern to save our planet. To reduce greenhouse gases and balance the amount of carbon in our atmosphere carbon sinking is the best way.

Carbon sequestration is intimately related to the existence of living being in our planet and now-a-days, Global warming and biodiversity loss are the two important currently debated issues among the world's scientists and policy makers (Zhang et al., 2011), caused mainly by fossil fuel burning and deforestation during the last few decades (Van der Werf, 2009). The last century finished with an increase in global temperature by 0.74 °C and the atmospheric CO_2concentration of 379 ppm (UNFCC, 2007); (IPCC, 2013). Furthermore, atmospheric carbon dioxide would be doubled by 2050 if the current rate of increase continues and will lead to the global temperature rise of up to 2–4 °C (IPCC, 2013). Human activities, especially the burning of fossil fuels such as coal, oil, and gas, have caused a substantial increase in the concentration of carbon dioxide (CO_2) in the atmosphere. This increase in atmospheric CO_2 —from about 280 to more than 380 parts per million (ppm) over the last 250 years—is causing measurable global warming. Potential adverse impacts include sea-level rise; increased frequency and intensity of wildfires, floods, droughts, and tropical storms; changes in the amount, timing, and distribution of rain, snow, and runoff; and disturbance of coastal marine and other ecosystems. A projection by IPCC (2013) revealed that by the end of 21st century the global sea level will rise by 28–98 cm due to melting of polar ice, which would badly alter low-lying coastal countries (e.g. Bangladesh, Maldives, The Netherlands) existence and livelihoods pattern. Forests retention, coupled with various reforestation and afforestation programmes, tropical in particular, can play an important role in mitigating global climate change through sequestering atmospheric carbon (Dixon et al., 1994a, b; Jose, 2009; Kumar, 2011). Tropical forest systems sequester carbon faster, and store more carbon, than comparable temperate and boreal forests. Indeed, tropical forests are responsible for approximately 33% of terrestrial NPP and hold nearly ¼ of above ground terrestrial carbon (Bonan, 2008).

Yet, globally attention has been given to what extent managed landscapes, such as coastal afforestation, embankment plantation, Agroforesty, community forests, village woodlots and roadside plantations under participatory management, could hold carbon and contribute to climate change mitigation (Albrecht & Kandji, 2003); (Roshetko et al., 2007; Saha et al., 2010; Kumar and Nair, 2011; Nair, 2012)

Species-level tree biomass carbon estimation using diameter at breast height (dbh) with a tree density based allometric model is becoming popular (Pandey et al., 2014; Rahman et al., 2014). However, for quick calculation of biomass carbon, a basal area based allometric model could be another important option as both basal area and biomass carbon have a strong relation to dbh (Torres and Lovett, 2012; (Rahman, Khan, Haque, & Ahmed, 2015). Studies have made significant contributions in estimating ecosystem level aboveground carbon stocks using basal biomass (Torres and Lovett, 2012);(Rahman, Khan, Haque, & Ahmed, 2015). The present focus of REDD+ is examining to what extent carbon sequestration through forest restoration and plantation establishment is related to biodiversity conservation, poverty reduction, and carbon sequestration.

Considering the above discussion and justification, the aim of this current study is to know the present carbon stock and the potentiality of those areas to sink carbon.

Problem Statement:

Now a day, Carbon sequestration is one of the major concerns in this world because there is a huge amount of carbon is releasing day by day from different kinds of industrial and human activities even we continuously produce carbon dioxide by breathe. It is the main element of greenhouse gases that is responsible for global warming that's why carbon measurement and production issues have already became a vital concern to save our planet. At the same way, global natural forest is degrading day by day in rapidly. If we consider about only Bangladesh, Statistics says that about 6% of total forest area is decreased within few years (it includes Natural and plantation forest) and now in 2017 the forest cover is only 11% from 17% by volume of our country. So an alternative way is needed to augment our forest area. As it's the largest delta in the world it has great opportunities to plant trees in coastal region as well as it is the best way to sink atmospheric carbon. This study is related to measure those coastal regions carbon present per hector to get an overall concept about those sites potentiality and future possibility to increase coastal plantation forest. It also helps to realize the importance of coastal plantation in global warming issues and carbon trade concept.

1.2 Research Objectives:

The study is based on the following objectives_

i. To measure the biomass of coastal plantation area in Nijhum Dwip and Hatiya Island under Noakhali district.

ii. To compute the amount of biomass carbon stock per hectare in those plantation area.

CHAPTER-TWO

LITERATURE REVIEW

2.1 Carbon Sequestration

Carbon sequestration is the process involved in carbon capture and the long-term storage of atmospheric carbon dioxide. (Sedjo & Sohngen, 2012) Carbon sequestration involves long-term storage of carbon dioxide or other forms of carbon to mitigate or defer global warming. It has been proposed as a way to slow the atmospheric and marine accumulation of greenhouse gases, which are released by burning fossil fuels. (Hodrien, 2008)

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. 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 (UNFCC, 2007).

Through photosynthesis, trees and other plants take up atmospheric carbon dioxide (CO_2) and sequester it in their living tissues as biomass. Respiration in forests, both autotrophic (from plants) and heterotrophic (from non-plant organisms), causes the release of CO_2 reducing this total sequestration. Carbon (C) moving through a forest ecosystem in a given period of time (termed flux) is by convention considered negative when moving from the atmosphere to biomass (sequestration), and positive when moving from biomass into the atmosphere (release).

Carbon dioxide (CO_2) is naturally captured from the atmosphere through biological, chemical, and physical processes Artificial processes have been devised to produce similar effects, ("Energy Terms Glossary S", 2010) including large-scale, artificial capture and sequestration of industrially produced CO_2 using subsurface saline aquifers, reservoirs, ocean water, aging oil fields, or other carbon sinks.

2.2 Concept of Carbon Trading

It is referred to as emission reduction trading is a relatively simple concept. Carbon trading is an economic tool which allows for several parties to meet total emission reduction requirement as 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 emission at a lower cost than a second party, then first party could maximize emission reductions and sell any surplus reduction to the second party to help to meet its reduction requirements. The aim is to improve the overall flexibility and economic efficiency of obtaining emission reduction (waste concern, UNDP, 2012)

Carbon Trade Exchange (CTX) operates spot exchanges in multiple global environmental commodity markets, including carbon, Renewable Energy Certificates (RECs) and water. Carbon Trade Exchange allows buyers and sellers to trade voluntary credits, carbon as well as those issued by a United Nations program established under the 1997 Kyoto Protocol.

CTX was founded in London by Wayne Sharpe in 2009, after two years of research and development. CTX opened office in Sydney in 2009.

2.3 Ways of Carbon Sequestration

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

One is terrestrial sequestration. it is the natural intake of CO_2 by plants, which incorporate it in their wood, leaves, roots and also bind it to the underlying soil and much of this co2 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 tree in any place, mitigating deforestation or for adjusting the forest management practices. In the present time it is the most convenient and effective option for sequestrating carbon.

Geologic sequestration is the second way to sequestrate carbon. It is the process of burring the CO_2 deep within earth. It can be done by mechanical capture of CO_2 from an emission source(e.g. power plant) and the captured CO_2 in injected and sealed into deep rock units (Brown , 2010). Deep geological formations such as depleted oil and natural gas fields or deep natural reservoirs filled with saline water (saline aquifers) are the most suitable sites to hide carbon.

Last one is oceanic sequestration. Oceanic sequestration is dumping the co2 into the ocean depths. Pumping CO_2 into the deep ocean basins (350-3000m), where it is anticipated it may lakes of liquid, supercritical or solid hydrates. Those are the major type of carbon sequestration

2.4 Concept of Coastal Afforestation and Carbon Sequestration

The delta of Bangladesh is formed by the confluence of the aforesaid mighty rivers and their tributaries. The Ganges unites with the Jamuna (main channel of the Brahmaputra) and later joins the Meghna to eventually empty into the Bay of Bengal.

The alluvial soil deposited by these rivers has created some of the most fertile plains in the world. To stabilize the newly accreted mud flats (locally called 'Chars') at the estuaries of Bay of Bengals, Coastal Forest Divisions of Bangladesh Forest Department have been raising mangrove plantations since 1966. These Mangroves serve as protective barrier against cyclones and tidal surges.

Bangladesh has 710 Kilometer long coast line. The coastal zone covers 19 coastal districts (153 Upazilas) & Exclusive Economic Zone (EEZ) in the Bay of Bengal. Out of 19 districts, 12 (51 Upazilas) are 'exposed coast' subject to natural calamities. The landward distance of the delineated coastal zone from the shore is between 30 and 195 km whereas the exposed coast up to 57 km. Land of coastal area is used mainly for agriculture, shrimp and fish farming, forestry, salt production, ship-breaking yards, ports & industries. Land use in the coastal zone is diverse, competitive and often conflicting.

In 1964, the forest department started afforestation in coastal areas. At first, planting was carried out to increase the mangrove shelterbelt. In later years, plantation forestry mainly proceeded on stretches of government land along roads under the social forestry programme a total of 112 972 hectares had been planted by 2000.

2.5 Status of Coastal Plantation in Bangladesh

Different Coastal Plantation and their areas in the Coastal Circle, Barisal including Chittagong Coastal Division, Cox's Bazar (South) & Feni Division upto 2011-2012.

In different forest divisions of Coastal Circle, and in Chittagong Coastal, Cox's Bazar (south) and Feni Divisions in total 192,395.24 ha of mangrove, 8689.53 ha of non-mangrove, 2872.88 ha Nipa, 10.0 ha coconut, 40.0 ha Arica palm, 280.0 ha Bamboo & Cane and 12127.13 km of strip plantations have been raised up to June 2013. It is noted that 'Strip Plantations' of coastal region have been included in homestead forests by National Forests & Tree Resources Assessment in Bangladesh, 2005-2007. Out of total plantations more than 94% are mangroves (mostly *Sonneratia apetala*) and rests are negligible. 'Ditch-dyke' and 'Mount' plantations that are done under 'Community Based Adaptation to Climate Change through Coastal Afforestation in Bangladesh' project have been included in 'Non-mangrove' plantations. BCCRF funded 'Climate Resilient Participatory Afforestation and Reforestation (CRPAR) Project that has been started this year (2013), going to implement 'Enrichment Plantation' with mangrove species like Kankra (*Bruguiera gymnorrhiza*), Gewa (*Excoecaria agalocha*), Baen (*Avicennia marina, Avicennia officinalis*), Passur (*Xylocarpus mekongensis*), Sundri (*Heritiera fomes*), Khalshi (*Aegiceras Corniculatum*) etc. in the forests that are comparatively less dense, older and raised sites of different Coastal Divisions that was not tried much in the past. Plantation of *Nipa fruticans* has been also considered in this project which is a species of good soil binder and can effectively resist tidal and storm surges.

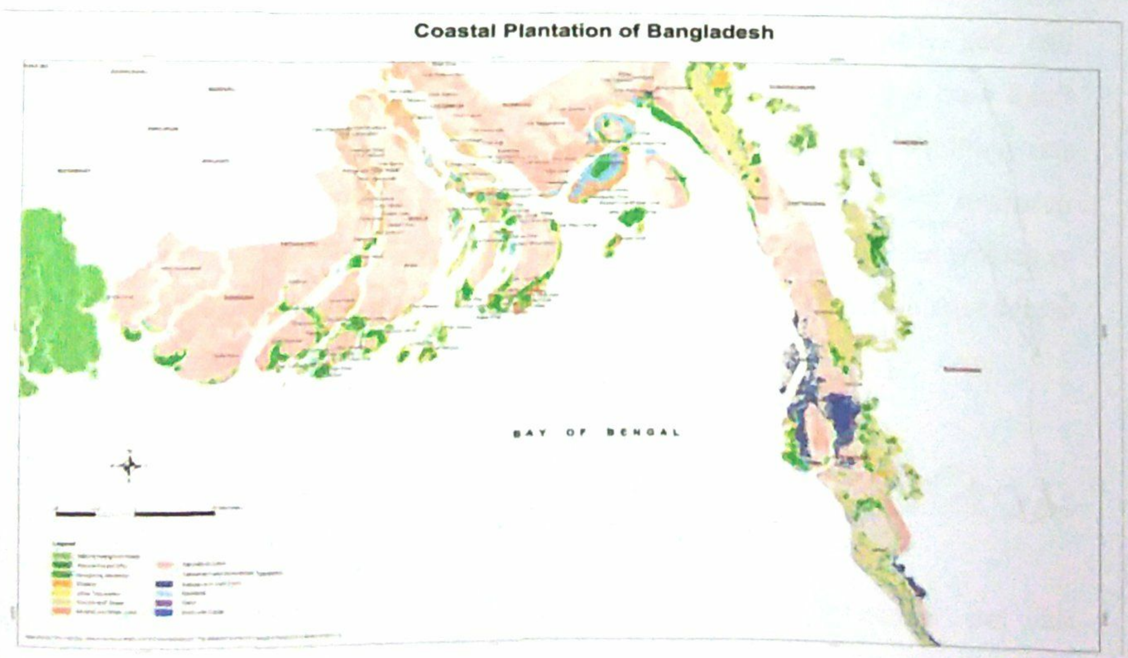

Figure: Coastal plantation area in Bangladesh

2.6 Concept of Plantation

A plantation is a large piece of land usually in a tropical or semi tropical area where one crop is intentionally planted for widespread commercial sale and usually tended by resident laborers. The crop grown include fast growing trees, timber producing trees, cotton, coffee, tobacco, sugarcane, sisal, oilseeds(e.g. oil palms), rubber trees and various fruits. Protectionist policies and neutral comparative advantage have something's 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 development of a worldwide economy that followed the expansion of European colonial empires. Like every economic, foreign ownership and political influences, and exploitative social system such as indentured labor and slavery (Wikipedia 2007)

2.7 Importance of Carbon Sequestration

Carbon dioxide (CO_2) capture and sequestration (CCS) could play an important role in reducing greenhouse gas emissions, while enabling low-carbon electricity generation from power plants. It helps to reduce the effect of greenhouse gases and conserves the biodiversity in the earth. An estimated in the U.S. Inventory of Greenhouse Gas Emissions and Sinks, more than 40% of CO_2 emissions in the United States are from electric power generation. CCS technologies are currently available and can dramatically reduce (by 80-90%) CO_2 emissions from power plants that burn fossil fuels. Applied to a 500 MW coal-fired power plant, which emits roughly 3 million tons of CO_2 per year, the amount of GHG emissions avoided (with 90% reduction efficiency) would be equivalent to: Planting more than 62 million trees, and waiting at least 10 years for them to grow and Avoiding annual electricity-related emissions from more than 300,000 homes.

2.8 Coastal Plantation and Blue Carbon Storage

Coastal strips cover 6% of the earth's forests, but they make up a massive 20% of the deforestation carbon.

The mangrove forests also sequester each year a large amount of 'blue carbon'. But with habit degradation very large pools of previously-sequestered carbon residing mostly in sediments, can be released to the atmosphere. Healthy mangrove forests, as well as marshes and sea grass meadows, are important and efficient method for sequestering carbon dioxide as 'blue carbon'.

Mangrove losses contributed half the total blue carbon stock reduction

2.9 Forest as a Climate Mitigation Tool

Different types of forest play an important role in the global carbon cycle (pan et al. 2011) and forestry can contribute to mitigate the climate change. In two ways the CO_2 concentration can possible to reduce in the air; (a) Do not allowing CO_2 to enter the atmosphere (i.e. control emission or carbon conservation) and (b)removing some of the excess CO_2 already in the atmosphere and sequestrating it where it less harm (brown 2010). In those two we can control CO_2 and can save our living planet.

2.10 Impact of Global Warming

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 1.6ton/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 22000 sq. kilometer 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: Bio diversity and forestry, Agriculture, Human health, Drainage, Fisheries and Fresh water (waste concern, UNDP, 2012)

2.11 Carbon Cycle in Forest

Carbon is the major component of all cellular life form. Trees utilize carbon as building materials 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 individuals plants die and decompose forest eventually reach steady states in which the amount of CO_2 released by dying plants in offset by new plants.

2.12 Carbon Pool

Carbon pool is a reservoir of carbon that has the capacity to accumulate or release carbon. Carbon pools include above ground biomass, below ground biomass, litter, dead material and soil. Significant amount of carbon and biomass is stored in coastal zone those are created by coastal plantation

2.13 Coastal Wetlands as Carbon Reservoirs

Anthropogenic contributions to atmospheric GHG are due largely to the combustion of fossil fuels. However, land-use activities, especially deforestation, are also a major source of GHG emissions, accounting for approximately 8–20% of all global emissions (van der Werf et al. 2011). While the role of terrestrial forests as a source and sink of GHGs is well known, new evidence indicates that another source of GHGs is the release, via land-use conversion, of carbon stored in the biomass and deep sediments of vegetated ecosystems such as tidal marshes, mangroves, and sea grass beds (Crooks et al. 2011, Pendleton et al. 2012). The exact amount of carbon stored by these ecosystems is still an active area of research (Donato et al. 2011; Four Qurean et al. 2013), but the potential contribution to GHGs from their loss is becoming clear. Yet these emissions are so far relatively unappreciated or even neglected in most policies relating to climate change mitigation.

Carbon is stored in vegetated coastal ecosystems throughout the world. Sea grass beds are found from cold polar waters to the tropics. Mangroves are confined to tropical and subtropical areas, while tidal marshes are found in all regions, but most commonly in temperate areas. Combined, these ecosystems cover approximately 49 million ha (Pendleton et al. 2012 and references therein).

The rapid loss of vegetated coastal ecosystems through land-use change has occurred for centuries and has accelerated in recent decades. The causes of habitat conversion vary globally and include conversion to aquaculture, agriculture, forest overexploitation, industrial use, upstream dams, drainage, dredging, eutrophication of overlying waters, urban development and conversion to open water due to accelerated sea-level rise and subsidence. Estimation of cumulative loss over the last 50 to 100 years ranges from 25–50% of total global area of each type of plantations. This decline continues today, with estimated losses of 0.5–3% annually depending on the ecosystem type, amounting to 8000 km2 lost each year (Pendleton et al. 2012 and references therein). At current conversion rates, 30–40% of tidal marshes and sea grasses and nearly 100% of mangroves could be lost in the next 100 years.

2.14 Policy Opportunities and New Mechanisms for Carbon Management

The turn toward blue carbon is a fairly recent development, facilitated by the growing sensibility for the policy relevance of Reducing Emissions from Deforestation and forest Degradation (REDD+), on the one hand, and the successful negotiation by a handful of countries of a peat carbon agenda, on the other. Indeed, both forests and peat lands include relevant blue carbon elements; most of the world's mangroves species represent forest vegetation types, and many wetlands are naturally forested (by mangroves or other trees) and thus fall into the category of forest land; peat lands are a wetland key category.

Thus, a blue carbon milestone was achieved in 2011, when the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP) established "wetland drainage and rewetting" (WDR) as an eligible activity under Article 3 (4) of the Protocol, permitting parties with an inscribed quantitative emission limitation and reduction objective (QUELRO) to account for all sinks and emissions from any wetlands (as long as they have been drained and/or rewetted after 1990). The new WDR accounting framework does not give rise to investment in blue carbon projects, but it is seen as an important step towards the integration of wetlands in the future mitigation architecture and the tobe-built climate finance mechanisms (von Unger 2014). In a technical dimension, the recently adopted 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands and the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (KP Supplement) will enable countries to adequately implement WDR accounting, if they choose to do so.

While the particular formats of future climate finance mechanisms are yet to be defined – the topic is one of the more contentious issues in international negotiations; discussions are led around the agenda items of nationally appropriate mitigation actions (NAMAs), a new market mechanism (NMM), a framework for various approaches (FVA), and of a REDD+ mechanism – there is growing consensus on a number of points. First, it is likely that countries in their current negotiations leading to the Paris-

COP will agree that blue carbon as a whole (or that at least certain blue carbon categories) will be covered by a comprehensive accounting and crediting framework under the UNFCCC; second, these credits will be expressed in tons of CO_2 eq; and third, they will serve as the basis for results-based funding and transactions.

In the emerging field of NAMAs and REDD+, blue carbon already plays a prominent role, and coastal wetlands benefit greatly from REDD and/or NAMA readiness activities. The enhancement of strong nature protection institutions, the build-up of a transparent land inventory and of clear land tenure allocations, and the policy mainstreaming of sustainable forest and wetland management into a wide range of laws and policies lays the groundwork for successful blue carbon interventions.

It should be noted that an important type of blue carbon – mangrove forests – has been recognized under Kyoto's climate finance mechanisms, namely the CDM. But this recognition was limited to afforestation and reforestation (A/R) interventions, excluding conservation activities, and it came with the liability of generating only temporary carbon credits, so called temporary certified emission reductions ("tCERs") and long-term certified emission reductions ("lCERs").10 As a result, the number of mangrove interventions under the CDM has remained small. It is too early to say what role, if any, the CDM will have in the climate regime currently under negotiation and meant to be in place by 2020. The discussions at the level of the Conference of the Parties to the UNFCCC (COP) show, however, a growing number of countries which are dissatisfied with the concept of temporary credits and which are willing to contemplate alternative choices to deal with the issue of permanence in sequestration projects.

2.15 United Nations REDD Programme

REDD+ is a voluntary climate change mitigation approach that has been developed by Parties to the UNFCCC. Aims to incentivize developing countries to reduce emissions from deforestation and forest degradation, conserve forest carbon stocks, sustainably manage forests and enhance forest carbon stocks. The United Nations Programme on Reducing Emissions from Deforestation and Forest Degradation (or UN-REDD Programme) is a collaborative programme of the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP) and the United Nations Environment Programme (UNEP), created in 2008 in response to

the UNFCCC decisions on the Bali Action Plan and REDD at COP-13. The overall development goal of the Programme is "to reduce forest emissions and enhance carbon stocks in forests while contributing to national sustainable development".
The UN-REDD Programme supports nationally led REDD+ processes and promotes the informed and meaningful involvement of all stakeholders, including indigenous peoples and other forest-dependent communities, in national and international REDD+ implementation. The Programme has expanded steadily since its establishment and now has over 60 official Partner Countries spanning Africa, Asia-Pacific and Latin America-Caribbean.

Reducing emissions from deforestation and forest degradation (REDD) is a mechanism that has been under negotiation by the United Nations Framework Convention on Climate Change (UNFCCC) since 2005, with the objective of mitigating climate change through reducing net emissions of greenhouse gases through enhanced forest management in developing countries.

In the last two decades, various studies estimate that land use change, including deforestation and forest degradation, accounts for 12-29% of global greenhouse gas emissions. For this reason the inclusion of reducing emissions from land use change is considered essential to achieve the objectives of the UNFCCC.

2.16 REDD+ as a climate change mitigation measure

Deforestation and forest degradation account for 17-29% of global greenhouse gas emissions, the reduction of which is estimated to be one of the most cost-efficient climate change mitigation strategies. Regeneration of forest on degraded or deforested lands can remove CO_2 from the atmosphere through the build-up of biomass, making forest lands a sink of greenhouse gases. The REDD+ mechanism addresses both issues of emission reduction and enhanced removal of greenhouse gases.

2.16.1 Reducing Emissions

Emissions of greenhouse gases from forest land can be reduced by slowing down the rates of deforestation and forest degradation, obviously covered by the first two of the REDD+ eligible activities. Another option would be some form of reduced impact logging in commercial logging, under the REDD+ eligible activity of sustainable management of forests.

2.16.2 Enhancing Removals

Removals of greenhouse gases (specifically CO_2) from the atmosphere can be achieved through various forest management options, such as replanting degraded or deforested areas or enrichment planting, but also by letting forest land regenerate naturally. Care must be taken to differentiate between what is a purely ecological process of regrowth and what is induced or enhanced through some management intervention.

2.17 REDD+ and the Carbon Market

In 2009, at COP-15 in Copenhagen, the Copenhagen Accord was reached, noting in section 6 the recognition of the crucial role of REDD and REDD+ and the need to provide positive incentives for such actions by enabling the mobilization of financial resources from developed countries. The Accord goes on to note in section 8 that the collective commitment by developed countries for new and additional resources, including forestry and investments through international institutions, will approach USD 30 billion for the period 2010 - 2012.

The Green Climate Fund (GCF) was established at COP-17 to function as the financial mechanism for the UNFCCC, so including for REDD+ finance. The Warsaw Framework on REDD-plus makes various reference to the GCF, instructing developing country Parties to apply the GCF for result-based finance.

2.18 Kyoto Protocol and Carbon Storage Concept

Because growing vegetation takes in carbon dioxide, the Kyoto Protocol allows Annex I countries with large areas of growing forests to issue Removal Units to recognize the sequestration of carbon. The additional units make it easier for them to achieve their target emission levels. It is estimated that forests absorb between 10 and 20 tons of carbon dioxide per hectare each year, through photosynthetic conversion into starch, cellulose, lignin, and wooden biomass. While this has been well documented for temperate forests and plantations, the fauna of the tropical forests place some limitations for such global estimates.

Some countries seek to trade emission rights in carbon emission markets, purchasing the unused carbon emission allowances of other countries. If overall limits on greenhouse gas emission are put into place, cap and trade market mechanisms are purported to find cost-effective ways to reduce emissions. There is as yet no carbon audit regime for all such markets globally, and none is specified in the Kyoto Protocol. National carbon emissions are self-declared.

In the Clean Development Mechanism(CDM), only afforestation and reforestation are eligible to produce certified emission reductions (CERs) in the first commitment period of the Kyoto Protocol (2008–2012). Forest conservation activities avoiding deforestation, which would result in emission reduction through the conservation of existing carbon stocks, are not eligible at this time. Also, agricultural carbon sequestration is not possible yet.

During the negotiations for the Kyoto Protocol, and then in particular its Clean Development Mechanism (CDM), the inclusion of tropical forest management was debated but eventually dropped due to anticipated methodological difficulties in establishing – in particular – additionally and leakage (detrimental effects outside of the project area attributable to project activities). What remained on forestry was "Afforestation and Reforestation", sectorial scope 14 of the CDM. Under this sectorial scope areas of land that had no forest cover since 1990 could be replanted with commercial or indigenous tree species. In its first eight years of operation, a total of 52 projects have been registered under the "Afforestation and Reforestation" scope of the CDM. The cumbersome administrative procedures and corresponding high transaction costs are often blamed for this slow uptake.

CHAPTER-3

MATERIALS AND METHODS

3.1 Study Area

Nijhum Dwip is a new emerging natural beauty of Bangladesh. It is a small island situated in Hatiya Upazilla, Noakhali district and it has no terrestrial connection with other district or a piece of land

Figure: Nighum Dwip and Hatiya Island under Noakhali District of Bangladesh. Its can called a daughter of Bay of Bengal and this dwip is surrounded by water. A cluster of islands (mainly, Ballar Char, Kamlar Char, Char Osman and Char Muri) emerged in the early 1950s as an alluvium in the shallow estuary of the Bay of Bengal on the south of Noakhali. Nijhum is one of the most beautiful islands of those areas. This island is situated between 21°1′ to 22°6′ North latitude and 90°3′ to 91°4′ East longitude. The total area of Nijhum dwip is 163.45km^2 including 38.65 km^2 (14.92 sq. miles) land area and 124.81 km^2 (48.19 sq. mi) water body. This island is inundated twice in everyday but every times forest floor don't flooded except strong tidal happens. Salinity level is medium and annual rainfall is low to moderate.

After liberation war, in 1974, Bangladesh government first took a coastal afforestation program in the north side of the island for twenty years duration covering an area of nine thousand acres; it has now developed into a deep forest with a variety of plant species. Keora (*Sonneratia apetala*) is the most abundant and main planted tree species in this site besides Gewa (*Excoecaria agallocha*), Kakra (*Bruguiera gymnorhiza)*, Bain (*Avicennia officinalis*) are also planted. Gewa grows very well naturally but in this area some hector of land is planted with Gewa tree species,

The forest department of the government of Bangladesh created mangrove forests in Nijhum Dwip and the main attraction in these forests is the herd of about 5000 cheetal or spotted deer.

In 2001, the government of Bangladesh declared the 40390 acres forest in jahajmara range including 9550 acre on Nijhum Dwip forests as National Park for the protection and development of biodiversity and natural forest resources. Now this island has been declared as the unique eco-touristic spot for its ideal natural setup with the rich bio-diversification factors and the perennial mangrove forest with wild animals like spotted deer, wild boar and rhesus macaque and for the ideal habitat for fish resources. Since south coast is open to the mouth of a great span of Bay of Bengal, whales were sometimes seen though very rare nowadays.

3.2 Sampling Design and Sample Size Determination

The plantation site of Nijhum Dwip and Hatiya under Noakhali district is generally composed of mainly Keora (*Sonneratia apetala*), Gewa (*Excoecaria agallocha)*, sometimes Kakra (*Bruguiera gymnorhiza)*, Bain (*Avicennia officinalis*) also seen randomly. From those deep areas there are 80 plots selected by randomly to cover all study sites. The size of each sample plot is 10m×10m (100 m^2). It's a Keora dominated area but some other older species like Bain, Kakra also present there. In statistical term, all plots are selected by random sampling method.

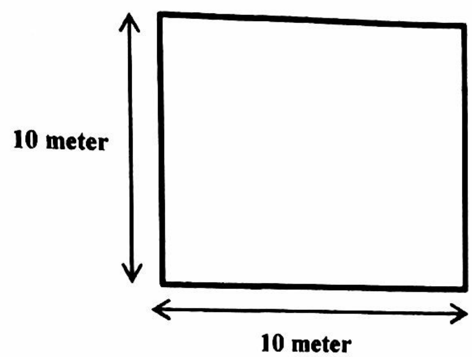

Figure: Plot layout

3.3 Research Approach

This research is based on quantitative approach as we take sample plots and trees for further calculation, measurement of dbh, and height. It is the general approach to estimate above ground biomass before statistical analysis. There are several research work have already done by using that approach. This approach is used because this is more convenient and easy to handle into a forest cover area moreover identifying sample and trees are also easy to count.

3.4 Data Collection

To complete this project thesis we required two types of data, one is primary data and another is secondary data. Data and its collection methods are discussed below_

3.4.1 Primary Data

Data, those are collected from direct field level and those were not used before is called primary data. To complete my research work tree diameter, tree height, GPS reading is needed that's why we collect those data from this site by manually. By using diameter tape we measure diameter at breast height (1.3 m above from the ground) of trees, height is measured by haga altimer, measurement tape is used to measure the plot size and a GPS is also used to get geographic location like altitude, latitude, elevation etc.

3.4.2 Secondary Data

The secondary data like total area of plantation those area, specific plantation tree species, plantation area by which we can get to determine the age of tree and by this way we can easily know about growth and height relationship, height and biomass relationship and the growth and development of those site. I have collected official data from the Nijhum deep and Ochkhali, Nolcira Range office, Hatiya and Seminar library of Forestry and Wood Technology Discipline.

3.5 Tools/ Equipment

To complete the research work some equipment's are used such as

- Diameter tape
- Measurement tape
- Hoga altimeter
- Geographic Location System (Garmin GPSMAP 76CSx)
- Microsoft office (2010) software

CHAPTER-4

DATA ANALYSIS

4.1 Species Diversity and Structure

Shannon Wiener Diversity Index is used to test the differences between species diversity, richness and evenness, basal area and tree density of the coastal plantation area across study sites. The evenness value by using this index is 0.624 so we can easily say that plantation areas evenness is medium level.

4.2 Biomass and Carbon Measurement

4.2.1 Above Ground Biomass and Carbon

Actually tree biomass includes above ground biomass including shoots, branch, twigs etc. and the below ground biomass includes roots biomass. Aboveground Biomass and carbon of live trees, poles, saplings and dead ones (having stem, branch and twigs) is estimated by the following general equation for mangrove tree species (Chave et al. 2005).

$$\text{Above Ground Biomass (AGB)} = \rho \times \exp\{-1.349 + 1.98\ln(D) + 0.207\ln(D^2) - 0.0281\ln(D^3)\}$$

The equation of (Hossain et al. 2015) is also used only for Gewa (***Excoecaria agalocha***) species

$$\text{Above Ground Biomass (AGB)} = \text{Antilog}(1.0996 \text{ Log } D^2 - 0.8572)$$

Where,

AGB = above Ground biomass,

D = Diameter at breast height (1.3m above ground)

ln= Natural logarithm

1.349= constant, 1.98= constant, 0.0281= constant

ρ = wood density (gcm^{-3})

For,

Species	Density(ρ)(g/cm^3)
Kakra (*Bruguiera gymnorhiza*)	0.86
Keora (*Sonneratia apetala*)	0.559
Bain (*Avicennia officinalis*)	0.67
Gewa (*Excoecaria agalocha*)	0.45

As there are four tree species are found those study area, the wood density is collected from secondary data and it is a publication related to the ecosystem carbon measurement in Sundarbans reserved forest area (Rahman, Khan, Haque, & Ahmed, 2015)and BFRI timber physics bulletin from Forestry and Wood Technology Discipline seminar library.

It is needed to convert above ground biomass (AGB) to Above Ground Carbon (AGC) if we want to measure carbon content of mangrove plantation. Conversion of dry biomass of trees, understory, and downed wood to carbon mass was done by multiplying 0.5 as forest biomass contains half carbon by mass (Gifford 2000).

Above Ground Carbon= Biomass measuring allometric equation×wood carbon content (%)

4.2.2 Belowground Biomass and Carbon Computation

Belowground biomass of trees was computed by using the general mangrove equation of Komiyama et al. (2005), while for palms, it was conservatively took 15 % of aboveground biomass (because general mangrove equation for belowground biomass does not apply to palms) (Macdicken1997).

$$\textbf{Below Ground Biomass (BGB)} = 0.199.\ \rho^{0.899}.D^{2.22}$$

Where, BGB = belowground biomass,

ρ = wood density,

D = Diameter at breast height (1.3m above ground)

0.899= Constant, 2.22= constant

Below ground carbon is computed by multiplying by 0.5 to the total below ground biomass.

Below Ground Carbon (BGC) = 0.5× below Ground Biomass (BGB)

Total Biomass= above ground biomass + below ground biomass

Total carbon in tree biomass= 0.5× (above ground biomass + below ground biomass)

4.3 Density and Basal Area

Following the formula of Moore and Chapman 1986, Shukla and Chandel 1980 and Dallmeier et al. 1992 quantative structure parameters of investigated tree were calculated:

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

Relative density= $\frac{\text{Total number of individuals of one species in all the plots}}{\text{Total number of plots studies}}$

Basal Area (BA) = $\frac{\pi \times \left(\frac{dbh}{2}\right)^{\wedge}2}{100}$

CHAPTER-FIVE

RESULTS AND DISCUSSION

5.1 Stand Varity and Species Composition

As there are several plots are taken from Nijhum Dwip and Hatiya Island, the species variation and stem density is not so rich. A Total 514 numbers of stems were found includes four species in 80 plots of these area and results show that about 643 individuals per hectare are present here.

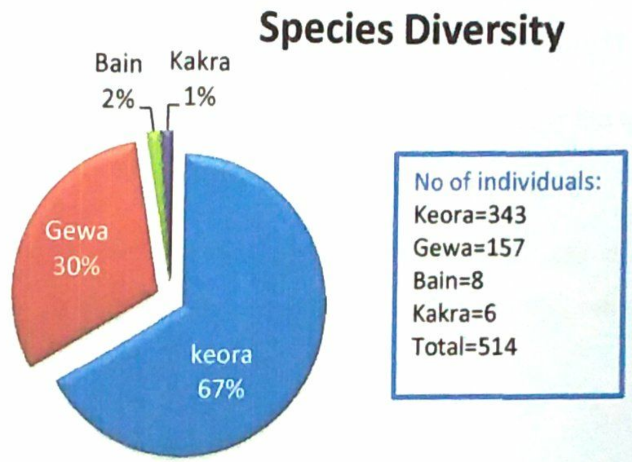

Figure: Species & its percentage

In this study area we found Four species (all are mangroves species) and those have total 514 species

Species name	Mean Height	Number of Individual	Species Percentages (%)
Keora (*Sonneratia apetala*)	10.50	343	67
Gewa (*Excoecaria agallocha*)	8.90	157	30
Bain (*Avicennia officinalis*)	10.88	8	2
Kakra(*Bruguiera gymnorhiza*)	5.70	6	1
Total		**514**	**100**
Stem Density (ha^{-1})		643	

5.2 Carbon Stock

The Average above ground biomass of coastal afforestation area in Nijhum Dwip and Hatiya Island areas is 113.18 Mg ha^{-1} ranged between 9.68 Mg ha^{-1} to 325.06 Mg ha^{-1} with lowest and highest value. And the average above ground carbon calculated is 56.59 Mg ha^{-1}(table no-1) with highest and lowest ranged between 162.53 Mg $ha^{-1}$to 4.84 Mg ha^{-1}.

On the other hand the below ground biomass and carbon of those study area is lower than the above ground biomass and carbon. The average BGB is 69.34 Mg $ha^{-1}$and ranged between 6.86 Mg h^{-1} to 193.14 Mg h^{-1} with minimum and maximum value. In this area 69.35 Mg C ha^{-1} average carbon storage is estimated (table no-1).

Average carbon stock in those study area (Nijhum Dwip and Hatiya Dwip) is **91.26** Mg C ha^{-1} and this is the main finding of my research work.

The stem density of different species includes Keora (*Sonneratia apetala*), Gewa (*Excoecaria agallocha)*, Kakra (*Bruguiera gymnorhiza)* and Bine (*Avicennia alba*) is approximately 643 stems per hectare.

Table no: 01. List of Important Attributes

[**AGB**= Above Ground Biomass, **AGC**= Above Ground Carbon, **BGB**= Below Ground Biomass, **BGC**= Below Ground Carbon]

Content	Minimum (Mg ha^{-1})	Maximum (Mg ha^{-1})	*Average (Mg ha^{-1})	#Average (Mg ha^{-1})
AGB	9.68	325.06	113.97	113.18
AGC	4.84	162.53	56.98	56.59
BGB	6.85	193.1	69.35	
BGC	3.42	96.56	34.67	
TOTAL (AGB+BGB)	16.53	514.16	183.32	182.52
TOTAL (AGC+BGC)	8.268	259.09	91.66	91.26

* Using Chave's and Komiyama equation

Using Chave's, Komiyama's and Hossain's equation

DBH verses Above Ground Carbon (AGC)

This graph shows that the relationship between Diameter and Above Ground Carbon (AGC) and it represents a strong relationship where the value of R^2 is 0.99226.

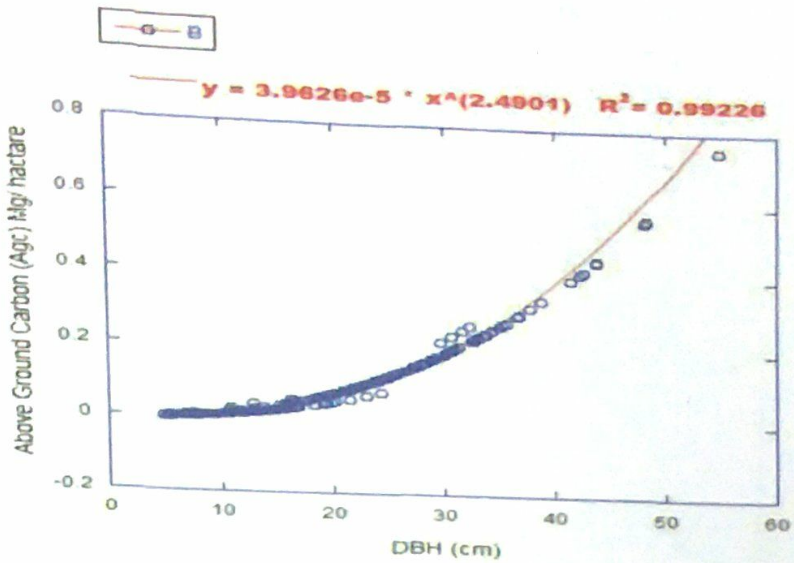

Figure: Relationship between DBH (1.3m above ground) and Above Ground Carbon

DBH verses Below Ground Carbon (BGC)

Presented graph shows a significant relationship between Below Ground Carbon and DBH where the value of R^2 is 0.99575

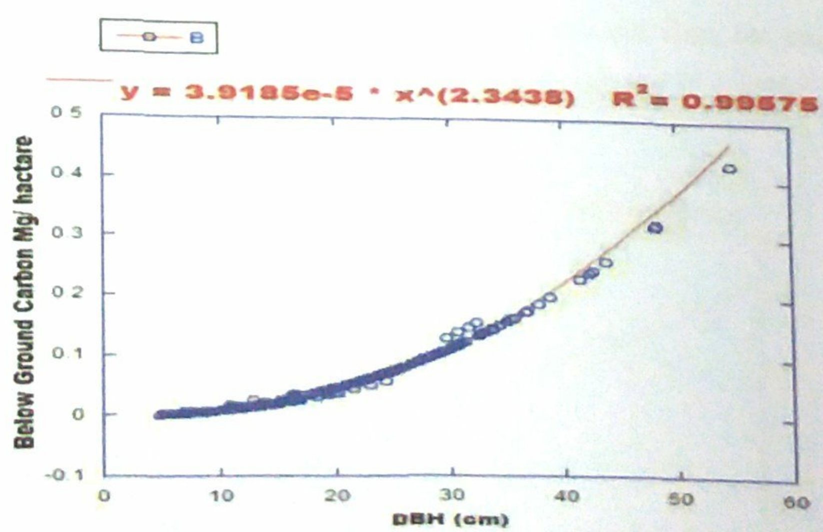

Figure: Relationship between DBH (1.3m above from ground) and Below Ground Carbon

Carbon Stock (AGC+BGC) Verses Diameter at Breast Height

This an important finding graph that shows the relationship between diameter at breast height (1.3 meter above from ground level) and total carbon stock of that site where the value of R^2 is 0.21907 that's why the relationship is not significant.

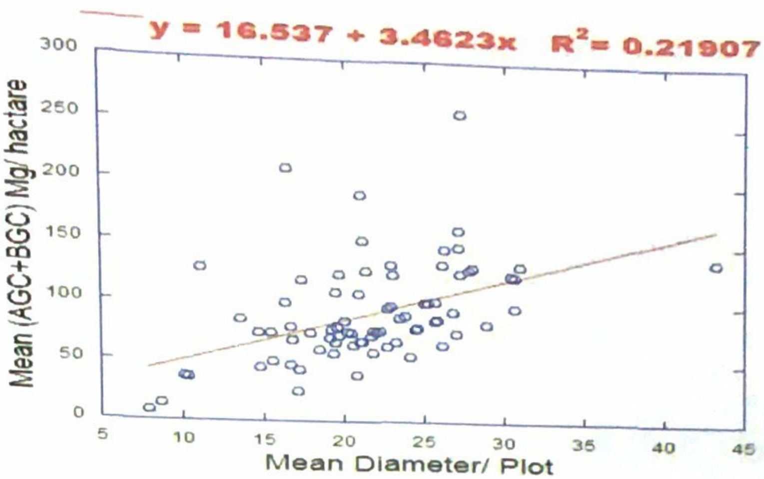

Figure: Relationship between Total Carbon (AGC+BGC) Stock and Diameter at breast height

Basal Area and Carbon Stock (AGC+BGC) in Mg ha^{-1}

Total carbon stock (AGC+BGC) and Basal area represents a special relationship that is important to estimate and predict the amount of carbon in a site. Here, the graph shows a strong relationship between those two variables and the value of R^2 is 0.9632.

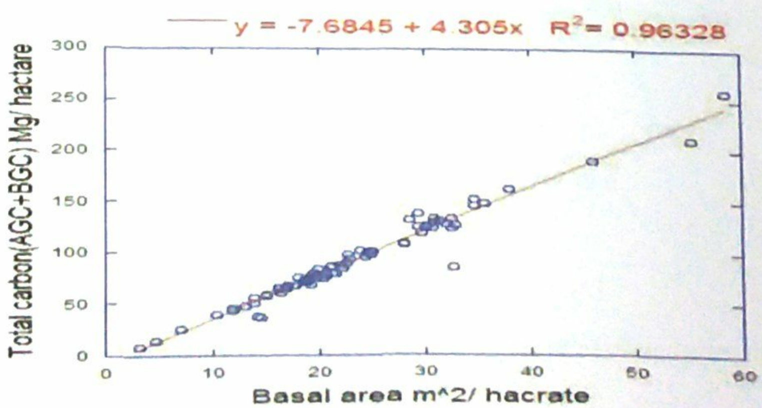

Figure: Relationship between Total Carbon (AGC+BGC) Stock and Basal Area

5.3 Discussion

The species diversity of Nijhum dwip and Hatiya Island is not so much because of intentionally plantation approach but passing after long time the environment and nature of those areas become as natural forest. There are many research work have already done on carbon stoking in our country except this area so this research works aim to measure the biomass stoking and to find out the potentiality of those kinds of coastal regions capability to hold atmospheric carbon. Therefore, the Chave's and Komiyama's allometric equation is used to calculate the presence of biomass carbon. The study represents a satisfactory result if we compare to other natural forest region or coastal plantation. The average above ground biomass is 113.18 Mg ha^{-1} with the lowest 9.68 Mg $ha^{-1}$and highest 325.06 Mg ha^{-1} where the above ground carbon stock in Sundarban is between 45.24 Mg ha^{-1} to 152.57 Mg ha^{-1}. Again, if we compare those areas with the below ground carbon, in Sundarbans has between 11.72 Mg ha^{-1} to 62.37 Mg ha^{-1} and my in my study areas have 3.43 Mg ha^{-1} to 96.56 Mg ha^{-1}. Comparison of different regions of the world results are given below, it clarifies and justifies the finding my research.

Source	Site	Above Ground Carbon (Mg ha^{-1})	Below Ground Carbon (Mg ha^{-1})
Present Study	Nijhum Dwip & Hatiya Island, Noakhali	4.84- 162.53	3.43-96.56
Rahman et al. 2015	Sundarban Mangrove Forest, Bangladesh	45.24-152.57	11.72- 196.54
Adame et al. 2013	Tropical Coastal Wetlands in the Karstic Landscape of the Mexican Caribbean	210 ± 33.9	
Adame et al. 2015	South pacific coast of Mexico	8.5-145.6	
Albert et al. 2012	Soloman Island	190.43	

In a natural ecosystem, the diameter of the tree is a determinant of aboveground biomass (Chave et al. 2004). The dominant species in each vegetation type may have an effect on aboveground biomass depending on their basal area (Ruiz-Jaen and Potvin 2010) as observed in this study. In This plantation area, Keora (*Sonneratio apetala)* is the most abundant tree species then Gewa (*Excoecaria agallocha*), Kakra (*Bruguiera gymnorhiza*) and Bain (*Avicennia officinalis*) is present in scattered way.

The findings of my study will may help the adjacent authority and global scientists for further analysis and they would easily understand the importance of those kinds of dwip or island to sequestrate the atmospheric carbon.

CHAPTER-SIX

Conclusion

The coastal and embankment plantation is necessary to augment our forest area at the same time to conserve atmospheric carbon and protect our planet. Natural forest is decreasing day by day in rapidly so we have way find out alternative way by planting denude and emerged area like dwip and coastal region. Our study is related to the coastal region and its plantations biomass and carbon. My research finding means mangrove trees biomass and carbon stock is more or less same to the natural forest. For that's perspective coastal plantation plays a vital role to sequester carbon. It not only conserves biodiversity and storage of carbon but also help in those areas peoples livelihood. The nature, species diversity and ecology is like natural forest so it can be an alternative of natural forest those have already degraded. As in every year there are millions on hectare decline by anthropogenic causes like overharvesting, burning fossil fuel, build in development infrastructure etc. and some natural disaster such as erosion, tidal surge, tsunami etc. those are the main obstacles to reduce forest land in recent year. Adjacent authorities have to find out embankment and new emerged land to make it as natural forest and this only possible by planting trees and avoid overharvesting of forest resources.

Reference(s)

Aguaron, E., & Mcpherson, E. G. (2012). Comparison of methods for estimating carbon dioxide storage by sacramento's urban forest. In R. Lal, & B. Augustin , *carbon sequestration in urban ecosystems* (pp. 43-71). california, USA: USDA forest service, research park.

Adame MF, Kauffman JB, Medina I, Gamboa JN, Torres O, Caamal JP, Reza M (2013) Carbon stocks of tropical coastal wetlands within the karstic landscape of the mexican caribbean. PLoS One 8(2):e56569. doi:10.1371/ journal.pone.0056569

Ahmed, G. U., & Haque, S. S. (1993). Percentage distribution of species and diameter class in natural forest of Bangladesh. *17(1)*, 109-113. University. Stud.

Albrecht, A., & Kandji, S. (2003). Carbon sequestration in tropical agroforestry systems. *Agricult. Ecosys. Environ, 99(1-3)*, 15-17.

Al-Maruf, A. (n.d.). Pulping and paper making potential of six mangrove species in Bangladesh. *Indian academy wood science*(DOI 10. 1007/S13196-015-0153-3).

Alongi, D. M. (2002). Present state and future of the worlds mangrove forest. *Environ. conserv, 29*, 331-349.

Baral, S., Malla, R., Khanal, S., & Shakya, R. (2013). Tress on farms: diversity, carbon, carbon pool and contribution to rural livelihoods in Kanchanpur district of nepal.

Bonan, G. (2008). forest and climate change: forcing, feedbacks, and the climate benefits of forest. *SCIENCE, 320(5882)*.

Brakenhielm, S., & Liu, Q. (1998). long term effects of clear felling on vegetation dynamics and species diversity in a boreal pine forest. 207-220.

Brown , D. (2010). Roadside management strategies to reduce greenhouse gases. 11-41.

Chave J, Condit R, Aguilar S, Hernandez A, Lao S, Perez R (2004) Error propagation and scaling for tropical forest biomass estimates. Philos Trans R Soc B 359:409–420

Detwiler, R., & Hall, C. (1988). Tropical forest and global carbon cycle. *Science, 239*, 42-47.

Duke, N. C. (2007). A world without mangroves? *science 317*, 41-42.

"Energy Terms Glossary S". . (2010). Nebraska Energy Office .

FAO, F. a. (2007). The worlds mangroves 1980-2005. *FAO Forestry paper*, 153.

Giri, C. (2011). Status and distribution of mangrove forests of the world using earth observation satelite. *20*, pp. 154-159.

Hodrien, C. (2008, October 24). Squaring the Circle on Coal - Carbon Capture and Storage (PDF). *Claverton Energy Group Conference.*

IPCC. (2013). *Fourth IPCC assesment report: climate change 2013.* Cambridge, UK: Cambridge University press.

Isalm, R. (n.d.). Pre and post tsunami coastal planning and land-use policiesz and issues in bangladesh.

Maruf, A. A., & Jahan, M. (2015). Indian academy wood science. *12*(doi:10.1007/s13196-015-0153-3), 116.

Mian, M. B. (2014). *above ground carbon stock of woodlot plantation in chowgacha upazilla of jessore district.* khulna: khulna university .

Pendleton, L., Donato, D., Murray, B., Crooks, S., & Jenkins, W. (2012). estimating "blue carbon" emission from conversion and degration of vegetated coastal ecosystems. *PLoS ONE, 7(9)*(Doi: 10.1371/journal.pone.0043542).

Polidoro, B. (2010). The loss of species: Mangrove extinction risk and geographic areas of global concern. *plos one 5.*

Rahman, m. m., Khan, m. i., haque, A. F., & Ahmed, i. (2014). carbon stock in the sundarbans mangrove: spatial variation types and salinity zones. *wet lands ecol manage, 23*, 269-283.

Ruiz-Jaen MC, Potvin C (2010) Can we predict carbon stocks in tropical ecosystems from tree diversity? Comparing species and functional diversity in a plantation and a natural forest. New Phytol. 189(4):978–987. doi:10.1111/j.14698137.2010.03501.x

Sedjo, R., & Sohngen, B. (2012). "Carbon Sequestration in Forests and Soils". Annual Review of Resource Economics. Annual Reviews. *4*(doi:10.1146/annurev-resource-083110-115941.), pp. 127–144.

UNFCC. (2007). Climate change : impacts, vulneraties and adaptation in developing countries. Bonn, Germany: climate change secretariat(UNFCCC) Martin luther king street 8.

Van der Werf, G. (2009). CO2 emissions from forest loss. *Nature geosci, 2*, 737-738.

William, A., Cornforth, TTemilola, E., & Terri, P. (2013). *Advanced land observing satelite phased arrey type L-Band SAR(ALOSPALSAR) to inform the conservation of mangroves: sundarbans as a case study*. remote sensing.

http://www.drpr.com.au/media_releases/28-08-12.

http://www.climateactionreserve.org/blog/2013/04/02/seamless-exchange-trading-of-top-tier-carbon-credits-now-available-through-revolutionary-partnership/

Bouillon, S., Rivera-Monroy, V. H., Twilley, R. R., Kairo, J. G. & Mangroves, in The Management of Natural Coastal Carbon Sinks (eds Laffoley, D. & Grimsditch) (IUCN, 2009).

TFD,2008. Beyond REDD: The role of forests in climate. Yale University, 360 prospect street, New haven, Connecticut 06511, USA.Available at www.theforestdialogue.org

Pendleton L, Donato DC, Murray BC, Crooks S, Jenkins WA, Sifleet S, Craft C, Fourqurean JW, Kauffman JB, Marba N, et al. 2012. Estimating global "blue carbon" emissions from conversion and degradation of vegetated coastal ecosystems. PLoS one 7:e43542. doi:43510.41371/journal/ pone.004342.

Crooks S, Herr D, Tamelander J, Laffoley D and Vanderver J. 2011. Mitigation climate change through restoration and management of coastal wetlands and near-shore marine ecosystems: Challenges and opportunities. World Bank Environment Department. Paper 121.

Donato C, Kauffman J, Murdiyarso D, Kurnianto S, Stidham M and Kanninen M. 2011. Mangroves among the most carbon-rich forests in the tropics. Nature Geoscience 4:293–97.

Pendleton L, Donato DC, Murray BC, Crooks S, Jenkins WA, Sifleet S, Craft C, Fourqurean JW, Kauffman JB, Marba N, et al. 2012. Estimating global "blue carbon" emissions from conversion and degradation of vegetated coastal ecosystems. PLoS one 7:e43542. doi:43510.41371/journal/ pone.004342.

van der Werf, G.R., Morton, D.C., DeFries, R.S., Olivier, J.G.J., Kasibhatla, P.S., et al. (2009) CO2 emissions from forest loss. Nature Geoscience 2: 737–38. doi: 10.1038/ngeo671

von Unger M, Emmer I, Couwenberg J and Joosten H. In press. Carbon market approaches for peatlands and forests Umweltbundesamt.

Chave J, Coomes DA, Jansen S, Lewis SL, Swenson NG, Zanne AE (2009) Towards a worldwide wood economics spectrum. EcolLett 12(4):351–366. http://dx.doi.org/10.1111/j. 1461-0248.2009.01285.x

IPCC (2013) Summary for Policymakers. In: Stocker TF, QinD, Plattner GK, Tignor M, Allen SK, Boschung J, Nauels A, XiaY,BexV, MidgleyPM(eds)

ClimateChange2013:the physical science basis. contribution of working group I to the fifth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge, United Kingdom

IPCC Wetland Supplement http://www.ipcc-nggip.iges.or.jp/public/ wetlands/

Blue Carbon Indonesia www.facebook.com/pages/Blue-CarbonIndonesia/311239892223268

Mangrove Forest Rehabilitation Report (2014) http://www.mangroverestoration.com/pdfs/Final%20PDF%20-%20Whole%20 EMR%20Manual.pdf

The Blue Carbon Portal www.bluecarbonportal.org

UN-REDD Programme official website.

"UN-REDD Programme 2016-2020 Strategic Framework".

"UN-REDD Programme Online Collaborative Workspace".

"Fact Sheet: About REDD+". UN-REDD Programme. February 2016.

Philip Fearnside (2000). "Global warming and tropical land-use change: Greenhouse gas emissions from biomass burning, decomposition and soils in forest conversion, shifting cultivation and secondary vegetation". Climatic Change. 46: 115–158. doi:10.1023/a:1005569915357.

Myers,Erin C. (Dec 2007). "Policies to Reduce Emissions from Deforestation and Degradation (REDD) in Tropical Forests" (PDF). Resources Magazine: 7. Retrieved 2009-11-24.

G.R. van der Werf, D. C. Morton, R. S. DeFries, J. G. J. Olivier, P. S. Kasibhatla, R. B. Jackson, G. J. Collatz and J. T. Randerson (Nov 2009). "CO2 emissions from forest loss". Nature Geoscience. 2 (11): 737–738. doi:10.1038/ngeo671.

Albert, J.A, Warren-Rhodes, K, Schwarz, A.J and Duke, N.D (2012) 'Mangrove Ecosystem Services & Payments for Blue Carbon in Solomon Islands', The WorldFish Center, Solomon Islands. AAS-2012-06

"UNFCCC document FCCC/CP/2013/10/Add.1" (PDF). Retrieved 2014-02-21.

UNFCC. 2009."Copenhagen Accord of 18 December 2009" (PDF). Retrieved 2009-12-28.

"UN-REDD Programme - Support to Partner Countries". Un-redd.org. Retrieved 2014-03-02

Karim, M.R. 2005. Priorities for rehabilitation, current activities and needs for mangroves and other coastal vegetation of Bangladesh: A discussion paper.

Presented in the Regional Workshop on Rehabilitation of Tsunami-affected Forest Ecosystems: Strategies and New Directions, 7–8 March 2005, Bangkok, Thailand.

Ministry of Environment and Forest. 1992. The Environment Policy, 1992. Government of Bangladesh.

Ministry of Environment and Forest. 1994. Forest Policy 1994. Government of Bangladesh.

Islam. M. M. 2006. Appendix 3. Country papers/presentations about Coastal forest rehabilitation and management in Bangladesh

Ruiz-Jaen MC, Potvin C (2010) Can we predict carbon stocks in tropical ecosystems from tree diversity? Comparing species and functional diversity in a plantation and a natural forest. New Phytol. 189(4):978–987. doi:10.1111/j.14698137.2010.03501.x