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Biomass and Floristic diversity of homegarden: A case study in Rupsha upazilla

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BANGLADESH

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DEDICATED TO

MY BELOVED PARENTS

DECLARATION

I am Afrina Ashrafi, declare that this thesis is the results of my own works and it has not been submitted or accepted for acceptance degree in any other university.

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Afrina Ashrafi

ABSTRACT

In Bangldesh, homegarden agroforesty is one of the popular land-use practices, providing both ecological and financial benefits. According to FAO (2003), homegardens comprise about 11 % of the total forest area of Bangladesh. High biological diversity is an inherent property of the homegarden because of their forest-like structure and composition. Again species diversity has the strongest positive direct effect on aboveground biomass. This study describes the total above ground and below ground biomass and diversity of plant species (trees, shrubs, herbs and climbers) in homegarden of Rupsha upazila, Khulna. A total of 121 (62% native) species were recorded from 60 homegardens in which there were 59 tree species, 21 shrubs species, 22 herbs species and 19 climber species. The total 60 homegarden covered an area of 6.72 ha. Among the tree species Cocos nucifera shows heighest IVI (39.42) and *Bixa orellana* shows lowest IVI (0.15), and according to the relative density most important shrubs were *Codiaeum variegatum* (28.97). Annonaceae and Leguminosae was the most dominated tree family. For Herb Species, Amaranthaceae and Araceae is the most found family. The leading family of shrub and climber family was found Solanaceae and Cucurbitaceae respectively. But On the basis of number of individual plants of each family, Palme and Euphorbiaceae were recorded as a leading tree and shrubs family respectively. Again among the recorded 121 species, fruit plant species were dominant. For trees, the Shanon-winner index for diversity was 4.78, Species Richness index 8.29 and species Evenness index 0.81. For shrub, the Shanon-winner index for diversity was 3.55, Species Richness index 3.34 and species Evenness index 0.74. From this study it is found that in 60 homegarden of Rupsha upazilla the average above ground biomass and average below ground biomass in 60 homegarden of Rupsha upazilla is 78.68±4.82 Mg ha^{-1} 9.35±0.51 Mg ha^{-1} .This study shows the average above ground carbon and below ground carbon is39.34±2.41 Mg ha^{-1} and 4.67±0.25 Mg ha^{-1} . Mean above and below ground biomass carbon stocks (AGB+BGB) was found 44.02±2.66 Mg ha^{-1} This study aims to estimate the total biomass and the plant diversity status in homegarden of Rupsha upazilla, Khulna.

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List of Acronyms

BBS	Bangladesh Bureau of Statistics
IPCC	Intergovernmental Panel on Climate Change
EFFB	Encyclopedia of Flora and Fauna of Bangladesh
DBH	Diameter at Breast Height
FAO	Food and Agriculture Organization
GPS	Global Positioning System
NGO	Nongovernmental Organization
HG	Homegarden
IVI	Important Value Index
RD	Relative Density
RF	Relative Frequency
RDo	Relative Dominance
Ha.	Hector
AGB	Above Ground Biomass
BGB	Below Ground Biomass
AGC	Above Ground Biomass
BGC	Below Ground Biomass
Mg	Mega gram = 10^6 gram

CHAPTER: 1

INTRODUCTION

1.1Background and Justification of the study

With a population of 129 million, Bangladesh is one of the most densely populated countries in the world. Over 76% of the population lives in rural areas and they are heavily dependent on homegardens for their livelihood (BBS 2012). The homegarden is regarded as a more reliable place for tree farming being adjacent to living quarters. Farmers of Bangladesh are the owners of homegardens of different size. It usually consists of one house, open and a cultivated area. It occurs in regions with either high and low human population densities and is always located in proximity of human dwellings, often delimited from their surroundings by hedges, fences or other barriers. In a homegarden a wide ranges of plant biodiversity for timber and food crops were found (Bashar 1999). It is one of the potential sources of plant genetic diversity in Bangladesh. The number of homestead in Bangladesh is 15.4 million which occupies 2.083% of the total land area of the country. In the view of present scenario of rapidly growing population leading to over exploitation of natural resources and possible irreversible environment damage, homestead forest is now considered as the most alternative way for sustaining the natural resources (Alam and Mohiuddin 1992).

Homegardens have several functions: economic, social and cultural, aesthetic and ecological (Wezel and Bender 2003). Homegardens, whether found in rural or urban areas, are characterized by a structural complexity and multifunctionality which enables the provision of different benefits to ecosystems and people. At the same time, homegardens are important social and cultural spaces where knowledge related to agricultural practices is transmitted and through which households may improve their income and social status. It provides the family with food and other goods, including construction materials, ornaments or additional income (Del and Mendoza 2004). Homegardens are the primary source of fuel in forest poor regions of Bangladesh. It maintains high levels of productivity and stability (Michon et al. 1983). It also helps to reduce carbon emissions from fossil-fuel burning through fuelwood production and conservation of carbon stocks in existing natural forests by alleviating pressure on these forests (Kumar and Nair 2004; Kumar 2006; Mattsson et al. 2013).

Homegarden plays an important role as a site for biodiversity conservation in agricultural landscape. On the other hand species diversity is one of the most intuitive and widely adopted measures of biodiversity at both ecological and biogeography scales. In terms of composition, high diversity of species with an immediate use in the homestead is the most prominent feature of homegardens (Hoogerbrugge and Fresco 1993). Traditional home gardens typically have a multilayered arrangement, in which differentiated root structures utilize nutrients from various soil levels and both ground and aerial space are efficiently utilized (Eyzaguirre and Linares 2004). Control of soil erosion and soil fertility are often maximized by the presence of trees, with fallen leaves providing natural mulching and the accumulation of humus. A generally reduced application of chemical fertilizers and pesticides protects natural habitats for wild flora and fauna (Daniels and Kirkpatrick 2006) and maintains high microorganism diversity (Birol et al. 2005a). The multilayered, forest-like structure of homegardens contributes substantially to the ecological sustainability of the village ecosystems (Kehlenbeck and Maass 2004). Biodiversity conservation is one of the important ecosystem services that have been negatively impacted by anthropogenic activities. However, deforestation and degradation have resulted in reduced forest land cover and loss of diversity. In Bangladesh where natural forest cover is less than 10 percent, homegardens, which are maintained by at least 20 million households, represent one possible strategy for biodiversity conservation.

Biodiversity conservation and global climate change are the two burning issues those got an immense attention to scientific community and policy makers in the recent decades (Saha et al., 2009; IPCC, 2013). Increasing level of atmospheric CO_2 due to burning of fossil fuels, degradation and deforestation of natural forest land, is the main driver of this climate change resulting the reduction of carbon stock. The well-adapted agroforestry system of homegardens could have potential for achieving multiple goals of climate change adaptation and mitigation through the service as a sink of carbon storage. The rich agrobiodiversity of homegardens ensures longer term stability of carbon storage, augments biomass production, enhances nutrient cycling and increases soil organic carbon (Kumar and Nair 2004; Montagnini 2006; Henry et al. 2009). Watson et al. (2000) defined Carbon sequestration as the removal of CO_2 from the atmosphere and store into green plant biomass (sink) where it can be stored indefinitely through the process of photosynthesis. Dixon (1994); Cannel (1995); Richter et al. (1995); Montagnini and Porras (1998); Montagu et al. (2005), reported that the assessment of biomass provides information on the structure and functional attributes of trees. With approximately 50% of dry biomass comprises of carbon. Biomass assessments illustrate the amount of carbon that may be sequestered by trees; biomass is an important indicator in carbon sequestration therefore estimating the biomass in trees is the first step in carbon accounting.

Different aspects on the homegarden in different regions of Bangladesh were studied by some authors. The floristic composition in the homestead of Bangladesh was studied by many researchers (Kabir and Edward, 2008; Alam and Mohiuddin 1992; Alam et al 1996; Das 1990; Hasan and Mazumdar 1990; Siddiqi and Khan 1999). Some researchers (Alam et al. 1990, Bashar 1999; Islam 1998; Miah et al. 1990; Millat-e-Mustafa et al. 2002; Momin et al. 1990) studied homegarden agroforestry, homegarden plantation and traditional use. But very few studies were so far conducted on both assessment of biodiversity and biomass of homegarden in Bangladesh. Rupsha upazila is rich in biodiversity and approximately 25% populations of this are fully dependent on their homegarden plant resources. Therefore, considering the above backdrop, the present study was under taken in Rupsha upazila as a model of homegarden for the assessment of biomass and biodiversity.

1.2Objectives

- To explore the floristic composition and species diversity in homegarden of Rupsha upazilla.
- To estimate the amount of above ground biomass in homegarden of Rupsha upazilla.

CHAPTER:II

LITERATURE REVIEW

2.1 Concepts of Homegarden

Homegardening is a traditional agroforestry system where a clearly bounded piece of land immediately surrounding the dwelling house is cultivated with a mixture of perennials and annuals (Fernandes & Nair 1986, Wojtkowski 1993, Wiersum 2004). The definition, structural and functional of homegarden varies from place to place according to the local physical environment, ecological characteristics, and socioeconomic and cultural factors (Kumar and Nair 2004). According to Fernandes and Nair (1986) homegarden can be defined as land use system involving deliberate management of multipurpose trees and shrubs in intimate association with annual and perennial agricultural crops and invariably livestock within the compounds of individual houses, the whole tree crop animal unit being intensively managed by family labor.

Again Shrestha.(2002) states that a homegarden is a micro environment composed of a multi species (annual to perennial, root crops, climbers etc), multi-storied and multi-purpose garden situated close to the homestead. It is a traditional land use practice around a homestead where several plant species are maintained by members of the household and their products are intended primarily for household consumption.

Homegardens may be characterized by diverse species composition, complex structure and multiple functions. They provide a year round supply of household subsistence needs, income opportunities, social and environmental stability, and religious and ceremonial values from their various plant components (Christanty 1990; Abdoellah et al. 2001). At least 20 million homegardens across Bangladesh (FAO 2003) show promise of holding high-plant species diversity (Millat-e-Mustafa et al. 1996; Uddin et al. 2002).

2.2 Historical development of homegarden

Home gardening is one of the world's most ancient agricultural practices. History of evolution of homegarden is antiquated and not precise. Most probably, next to shifting cultivation, homegarden is the oldest land use activity. India has a historical tradition of growing trees on farms and around homes. Historically, their origin dates back to settled agriculture, proceeding the era of shifting cultivation. It evolved through generations of gradual intensification of cropping in response to increasing human pressure and the corresponding shortage of arable lands (Kumar and Nair 2004). The Javanese homegardens have reportedly originated as early as the seventh millennium B.C. (Hutterer 1984), and the Kerala homegardens are thought to be at least 4000 years old. Natural history studies in Southern India during the late 1800s to early 1900s suggested that people traditionally used their homesteads for a variety of needs such as food, energy, shelter, and medicines (Kumar and Nair 2004). From these pre-historic and probably scattered origins, homegardens have gradually spread too many humid regions in South and South-East Asia including Java (Indonesia), the Philippines, Thailand, Sri Lanka, India, Bangladesh as well as in temperate regions (Fernandes and Nair 1986). Finally centuries of cultural and biological transformation and the accrued wisdom and insights of farmers interaction with environment, without access to outer inputs, capital or scientific skills was the essence of homegarden evolution.

2.3 Homegarden components

Homegardening is a traditional agroforestry practice in Bangladesh. Diverse species composition in a complex structure is a characteristic feature of Bangladesh homegardens. In homegarden, the vertical stratification of vegetation has been long recognized as one of its characteristic features, though the variation of height within any one stratum has led to some arguments as to the distinctness of the various strata recognized by various authors. Barrau (1961), Michon (1983), Altieri and Farrell (1984), Fernandes et al. (1984), Okafor and Fernandes (1987), Odulo and Aluma (1990) from various geographical regions give schematic presentation of vertical structure and observe that the canopies of most homegargens consist of 2-5 layers. Fernandes and Nair (1986) provide a useful general summary of layers:

<1 m — Vegetables, medicinals plants, tubers, roots

1-3 m — Foods plants e.g. cassava, banana, papaya, yams

3-5 m — Saplings of fruit/timber trees all growing taller

5-10 m — Fruit/timber trees, some growing taller

>10 m — Fruit/timber trees

They stress that layers are dynamic and there is constant recruitment from one layer to another. Soemarwoto (1987) first analyzed layers in Javaneses homegardens as above, then gave the percentage the number of the species and numbers of plants contained in each layer, showing that it was highest in the lowest layer and lowest in the upper layer, thus adding an elements to the picture of vegetation distribution over the garden as a whole.

2.4 Socio-economic aspects of Homegarden

Over long periods in the history of land use in highly populated humid tropical lowlands, homegardens have apparently remained as engines of economic and social development. Planting and maintaining of homegardens also reflect the culture and status of the household, especially the women, in the local society. Some of the economic, social and/or cultural foundations of homegardening, in comparison with other farming system components under similar situations are as follows-

- Low capital requirements and labor costs – suitable for resource poor and small-holder farming situations.
- Better utilization of resources, greater efficiency of labor, even distribution of labor inputs and more efficient management.
- Diversified range of products from a given area and increased value of outputs.
- Increased self sufficiency and reduced risk to income from climatic, biological or market impacts on particular crops/products.
- Higher income with increased stability, greater equity and improved standards of living.
- Better use of underutilized land, labor or capital, besides creating capital stocks to meet intermittent costs or unforeseen contingencies.
- Enhanced food/nutritional security and ability to meet the food, fuel, fodder, and timber requirements of the society
- Better preservation of indigenous knowledge

2.5 Ecosystem services of Homegarden

- Nutrient addition through the litter of nitrogen fixing species is a common practice in many homegardens.
- The ecological benefits rendered by the perennial trees in the homegardens such as nutrient cycling, litter dynamics, safety net role, nutrient pumping by deep roots are prominent among the drivers of biophysical sustainability (Seneviratne et al. 2010)
- Homegardens play significant sources of minerals and nutrients (Asfaw and Woldu 1997).
- Homegarden acts as a testing site for introduced crops such as introduced banana varieties, apple, grape vine etc to check their sustainability for large scale cultivation.
- Again, nutrient turnover is strongly influenced by the species composition and biomass of the tree components (Kumar and Nair 2004; Seneviratne et al. 2006) through homestead gardening.
- Multi-strata organization involving vertical and horizontal zonation is a characteristic feature of homegardens that favour unique light and space regimes and congenial soil climate impacting resilience to climate change (Kumar and Nair 2004; Maria et al. 2008).
- Stand characteristics of homegarden agroforestry including tree density, species richness, species diversity and soil properties can directly or indirectly affect soil organic carbon content.
- Homegardens is dynamic systems and are highly acknowledged for retaining higher diversity that represents microenvironments within larger farming systems; a mimics the natural, multi-layered ecosystem; and is agroecosystem (Kumar and Nair 2004; Mohan et al. 2007; Kumar 2011; Kunhamu et al. 2015; Kumar 2016a).

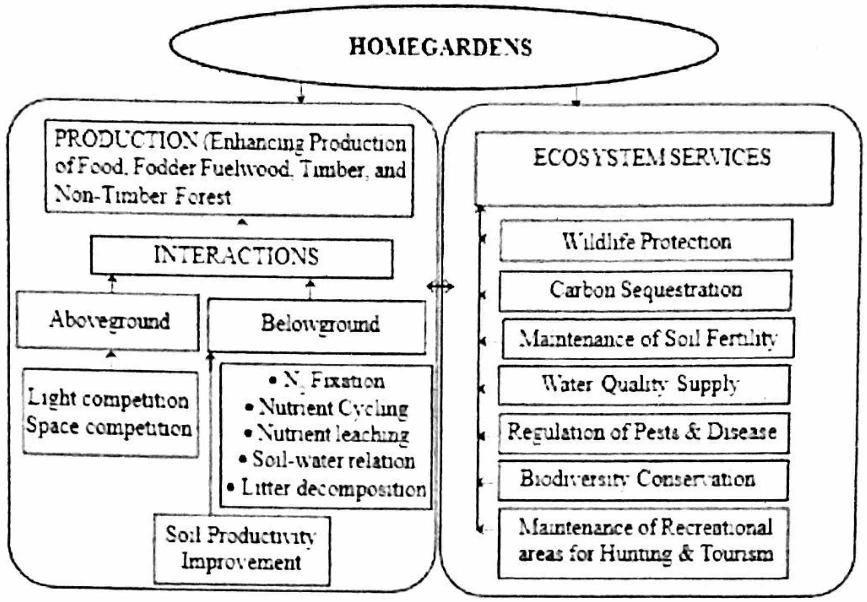

Fig2.1: Ecosystem services of homegarden.

2.6 Homegardening and Biodiversity conservation

High biodiversity is an intrinsic property of the homegardens (Kumar and Nair, 2004). Homegarden size is yet another factor that decides species diversity (Devi and Das, 2013). Many reports suggested that, an inverse relation between species diversity and garden size. For example, recent reports on structural and functional features of the peri-urban homegardens of southern Kerala, India, where 90 homegardens with 30 each belonging to three holding size classes viz. large (> 0.08 ha), medium (0.04-0.08 ha) and small (< 0.04 ha) were surveyed from Neyyattinkara Municipality area, Trivandrum. Altogether, 95 species were recorded belonging to 80 genera and 35 families in large homegardens. Shannons diversity index was 3.77, 3.23 and 3.87 respectively for large, medium and small homegardens and respective value for Simpsons Dominance Index were 0.92, 0.89 and 0.81. The average tree density of small, medium and large classes was 147, 165 and 76 and number of species per homegardens was 24, 48 and 94, respectively (Kunhamu et al. 2015). Among the total 107 species recorded in the homegardens of Mizoram, the highest diversity was in the small gardens (81 species) which declined in number as 53 and 37 for medium and large sizes respectively (Sahoo et al. 2010). Space utilization is more intensive in the small homegardens that are often run by subsistence farmer who meet the multifarious requirements from the small area in their premise. Reports from Latin American homegardens also suggested species diversity and density per unit area was higher for small gardens in comparison to the large gardens, and species density per hectare for small gardens was four times that of the larger ones (Maria et al. 2008). A structural and ecological change in the homegardens as function of garden size probably is one of the priority areas of research. In addition to size, religion, custom and traditions also influence the floristic that demand good deal of focus.

2.7 Challenges and major threats to Biodiversity in Bangladesh

Several socio-economic, bio-physical and organizational factors influence the loss of Biodiversity in Bangladesh (Mukul et al., 2014b & 2012a). Following are some key reasons behind the rapid biodiversity loss in the country.

- High population density, extreme poverty, and unemployment: Bangladesh is one of the world's densely populated countries with an extreme poverty and high unemployment rate. More than 85% population of the country are living in rural areas and somehow depends on various natural resources which lead to exploitation of plant and animal products for people's livelihood and income (Mukul et al., 2012a). Rural fuel consumption pattern, which is strongly concerned with degradation of natural forest area is another important issue related to biodiversity depletion in the country (Mukul et al., 2014c.
- Climate change and sea level rise: Bangladesh is one of the largest victims of climate change and associated sea level rise. The majority of the country will go under water if the water level rises by 50 cm. The country has already experienced severe change in precipitation pattern, temperature etc. The climate change in the country will largely impact the persistence of large living animals and the ecosystems of which they are part (Alamgir et al., 2015).
- Habitat loss, degradation and fragmentation: Biodiversity conservation is strongly associated with the intact ecosystems and natural landscape, however, transformation of land use patterns, expansion of agricultural lands, changes in cropping pattern, introduction of high yielding varieties, urbanization, expansion of road networks, embankments, and other manmade factors have caused immense damage to wild habitats

in all ecosystem types in the country. Following are some common reason of habitat loss, degradation, and fragmentation:

  - Land use change and agricultural expansions
  - Encroachment
  - Shifting cultivation
  - Urbanization
  - Commercial shrimp cultivation in coastal areas

- Illegal poaching, logging and fuel wood collection: There is a big international market (largely illegal) of unregulated wild animals and their parts (e.g. teeth, bones, fur, ivory) mainly for their aesthetic and medicinal value (see Mukul et al., 2012b& 2014b). Besides, illegal logging, fuelwood collection, unsustainable harvest of non-timber forest products including medicinal plants are also responsible for the depletion of biodiversity in the country (Mukul et al., 2010; Khan et al., 2009).
- Environmental pollution and degradation: One of the major threats to aquatic biodiversity in Bangladesh is pollution of soil and water. The aquatic ecosystem is the greatest victim and is polluted by toxic agrochemicals (i.e. chemical fertilisers, insecticides) and industrial effluents that cause depletion of aquatic and/or marine biodiversity.
- Invasive alien species: A large number of exotic and non-native plant species have been introduced to the country since British colonial period for agriculture, horticulture, forestry, and fisheries (Mukul et al., 2006). Some of the species have become escapes accidentally and having adapted to local conditions proliferated profusely. Some species although have naturalised but many have become invasive over local flora and fauna. Besides, replacing natural plantation with the monoculture of short rotation and fast growing species have threatened the existence of local fauna as they have not adapted to those species (Uddin et al., 2013).
- Limitations in legal and policy framework: Lack of adequate institutional or administrative frameworks and suitable policies, weak implementation of existing policies, lack of integration of sectoral activities are other additional challenges to the biodiversity conservation in Bangladesh (Chowdhury et al., 2014; Rashid et al., 2013).
- Lack of public awareness: Lack of biodiversity-related information and knowledge inevitably leads to poor awareness and capacity for biodiversity conservation.

2.8 Climate change, carbon dioxide and homegarden

IPCC, (2001) estimated that the level of CO2 in today's atmosphere is 31% higher than it was at the start of the industrial revolution about 250 years ago. IPCC (2007) reported that the amount of carbon dioxide in the atmosphere has increased from 280 ppm in the pre-industrial era (1750) to 379ppm in 2005, and is increasing by 1.5 ppm per year. The UNFAO (2003) estimated that since 1980, 25% of all carbon dioxide emissions associated with human activities was a result of tropical deforestation. Waston et al. (2000) studied that the deforestation and the burning of forests release CO_2 to the atmosphere. According to IPCC, (2000) the estimation of the total global carbon sequestration potential for afforestation and reforestation activities for the period 1995-2050 was between 1.1-1.6 Gt carbon per year and of which 70% will be in the tropics.

Dwyer et al. (1992) investigated that worldwide concern about global climate change has created increasing interest in trees to help reduce the level of atmospheric CO_2. Sampson et al. (1992) investigated that forests are the most critical for taking C out of circulation for long periods of time. Of the total amount of C tied up in earthbound forms, an estimated 90% is contained in the world's forests, including trees and forest soils. For each cubic foot of merchantable wood produced in a tree, about 33 lb. (14.9 kg) of C is stored in total tree biomass. . Pandey (2002) reported that forests sequester 1 Gt C annually through the combined effect of reforestation, regeneration and enhanced growth of existing forests. Funder (2009) reported that Agroforestry systems help to offset the 1.6 billion tons of carbons emited due to deforestration and forest degrafation annually.

2.9 Homegarden as a potential for Biomass carbon sequestration

Homegardens also serve as sink of carbon, thereby, playing an ecological role in the current global climate change scenario (Saha et al. 2009). Homegarden agroforestry has high carbon storage (sequestration) potential in their multiple plant species, especially in woody perennial species, and soil; they help in conservation of C stock in existing forests by alleviating the pressure on natural forest (Schroth et al. 2004). Roshetko et al. (2002) studied that the homegardens and other tree-rich smallholder systems offer potential rate of carbon storage in their woody biomass. Michon and Mary (1994) reported that homegardens production now commonly serves household and market demand, providing families with much needed income.

Kumar (2006) reported that most agroforestry systems are important in respect to carbon sequestration, carbon conservation and carbon substitution, the homegardens perhaps are unique for all above three mechanisms i.e., they sequester carbon in biomass and soil, reduce fossil-fuel burning by promoting wood fuel production, help in the conservation of carbon stocks in existing forests by alleviating the pressure on natural forests. Henry et al. (2009) studied that greater agro-biodiversity of homegardens may ensure longer term stability of carbon storage and the specific management practices that tend to enhance nutrient cycling and increase AGB are particularly relevant in this respect. Kumar et al. (1994) Homegarden size and survival strategies of the gardeners are other determinants of biomass and above ground carbon pools.

2.10 Status of carbon assessment in Bangladesh

Shin et al. (2007) reported that diversified forest ecosystems, i.e., wet forest lands, rain forests, moist deciduous forest, semi-arid areas and mangroves, Bangladesh forestry sector is acting as an important carbon sink. It has been estimated that about 5000 species of higher plants with thick foliage and species diversity occur in Bangladesh. On an average, 92 t C ha^{-1} is stored by the existing tree tissues in the forests of Bangladesh. Among them, closed large-crown forests 121 t C ha^{-1}, closed small-crown forests 87 t C ha-1, disturbed closed forests 110 t C ha^{-1} and disturbed open 49 t C ha^{-1}. ESSD (1998) reports that forest soils in Bangladesh store carbon at a rate of 115 t C ha^{-1},100 t C ha-1 and 60 t C ha^{-1} in moist, seasonal and dry soils, respectively. Shin et al. (2007) commented that due to the over extraction of the forest resources and encroachment in the forests, soil carbon reduce fast. Danesh et al. (2011) reported that in the reforested degraded hill forests contain 190 t C ha^{-1} in particular. In Bangladesh carbon assessment has been carried out by the Forest Department in Sundarbans reserve forest and protected area. The results revealed that the carbon stock in Sundarban reserved forest were105.6 megaton in 4,11,693 ha area, which converts to 256 Mg C ha^{-1}. The carbon stock (above ground and root carbon) in six protected area of Bangladesh namely Dudpukuria-dhopachari wildlife sanctuary, Fasiakhali wildlife sanctuary, Inani national park, Medhakachapia national park, Sitakundo reserved forest, and Teknaf wildlife sanctuary area contained 105.46 Mg ha^{-1}, 110.16 Mg ha^{-1}, 25.99 Mg ha^{-1}, 187.75 Mg ha^{-1}, 22.51 Mg ha^{-1} and 43.08 Mg ha^{-1} respectively. From the above discussion, it is clear that there is no mentionable research in accounting carbon stock in terms of urban area like as urban green patches, botanical garden, urban roadside, urban park and institutional area etc. in Bangladesh. Therefore, the present study has the immense importance to enlarge the assessment of urban carbon sequestration database as well as it enabled the policy makers to take action plan for national environmental sustainability issues.

CHAPTER: 3

MATERIALS AND METHOD

3.1 Study area

3.1.1 Location

The study was conducted in Rupsha upazila of Khulna district of Bangladesh. Its total area is 120.15 sq km, located in between 22°43' and 22°52' north latitudes and in between 89°33' and 89°41' east longitudes. It is bounded by Terokhada upazila on the north, Fakirhat and Batiaghata upazilas on the south, Mollahat and Fakirhat upazilas on the east, kotwali (Khulna) and khalishpur thanas on the west. Main rivers are Rupsa, Bhairab, Nabaganga and Basukhali. (Banglapedia, 2015)

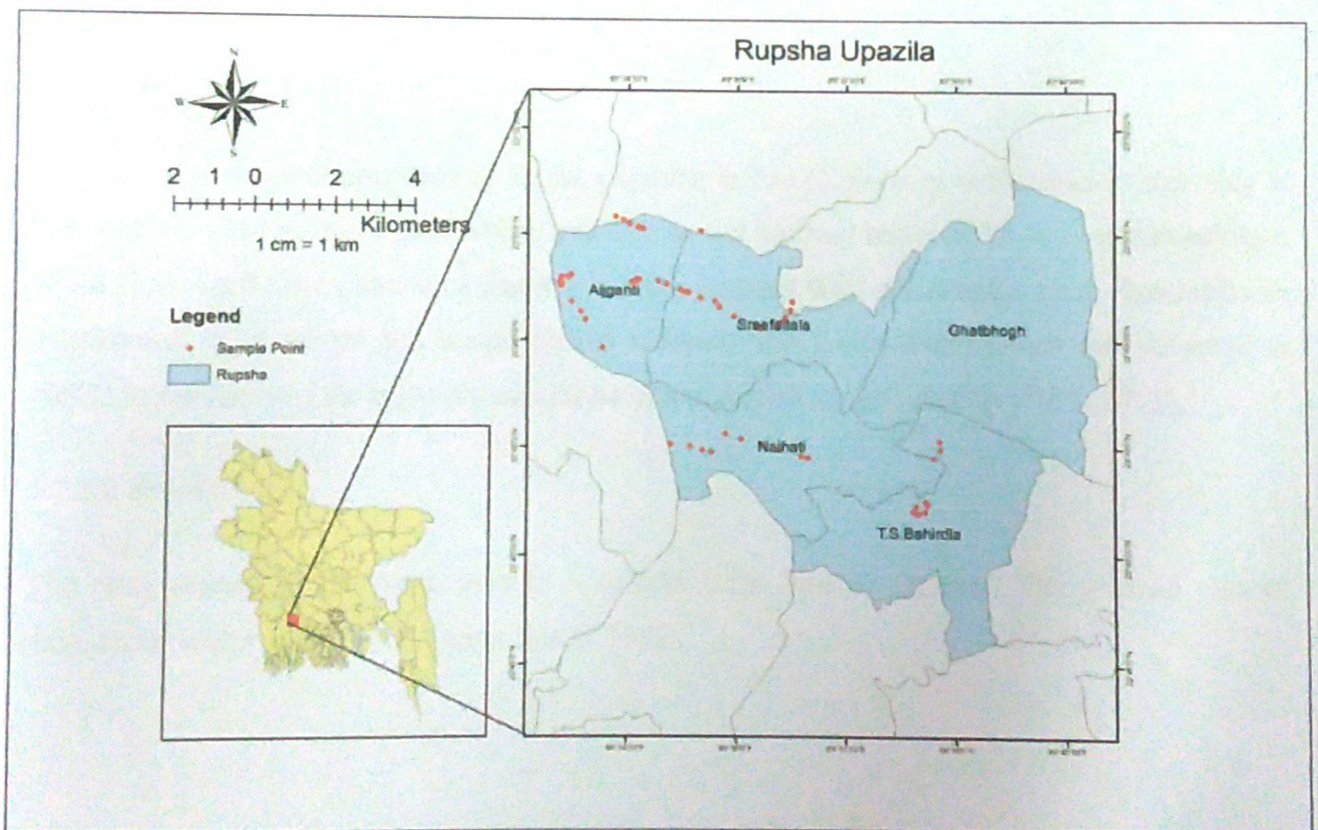

Fig 3.1: Location of the study area

3.1.2 Demographic Information

Rupsha thana was turned into Upazila in 1983. It consists of 5 Unoin parisad, 60 Mouzas and 72 villages. Total popu;ation: 167604; male 51.98%, female 48.02%; Muslim 82.28%, Hindu 17.55%, and others 0.17%. *Religious institutions* Mosque 175, temple 56, church 2. Noted religious institutions: Rupsa Jami Mosque, Aijganti Jami Mosque, Senerpukur Jami Mosque. *Literacy rate and educational institutions* Average literacy 54.68%; male 58.23%, female 50.93%. Educational institutions: college 7, secondary school 5, primary school 65, brac operated school 38, satellite school 5, madrasa 11, orphanage 6. *Cultural organisations* Library 5, cinema hall 1, theatre stage 2, club 21, women organisation 25. (BBS, 2015).

3.1.3 Climatic condition

Climatic condition depends on temperature, rainfall etc. The rainy season duration is June to October. Winter season duration is November to February. Dry season duration is March to May.(BBS, 2015).

3.1.3.1 Temperature

The annual average temperature of Rupsha upazila is 26o C. January is the coldest and May is the hottest month in this region where monthly means varying between 12.4o C in January and 34.6o C in April. The climate of Rupsha is quite pleasant with not usually much fluctuation in temperature in in winter and humid during summer. The lowest temperature was recorded at 100°C in January and the highest temperature was recorded at 38°C in May (BBS, 2015).

3.1.3.2 Rainfall

The rainy season of the study area is 5 months from June to October. The average rainfall recorded at last 5 years is 163.4 mm. (BBS, 2015).

3.1.3.3 Humidity

The humidity of the study area is very high. The highest relative humidity of 2011was 91.33%, recorded at September. The lowest relative humidity of 2011was 70.66%, recorded at March. The monthly average relative humidity of 2011 was 81.82 %.(BBS, 2015).

3.1.3.4 Soil Condition

Soil is silt loamy. It possesses P^{H} ranges 7-8. Other characteristics of soil are as follows-

- Non-calcareous dark grey flood plain.
- Calcareous dark grey flood plain soil.
- Calcareous brown grey flood plain soil.
- Non-calcareous brown grey flood plain soil.
- Somewhere saline and somewhere non saline soil. . (BBS, 2015).

3.1.3.5. General land use pattern

Main sources of income of Rupsha upazilla are agriculture 24.99%, non-agricultural labor 16.57%, industry 1.86%, commerce 21.14%, transport and communication 5.97%, service 13.87%, construction 2.26%, religious service 0.21%, rent and remittance 0.48% and others 12.65%. Ownership of agricultural land may vary in which Landowner 37.75% and landless 62.25%. Main crops of Rupsha upazilla are Paddy, jute, maskalai, mustard, ground-nut, potato, ginger, vegetables. On the other hand main fruits are Mango, jackfruit, blackberry, banana, papaya, pineapple, coconut, betel nut, guava, litchi, and lemon. . (BBS, 2015).

3.2 Method

3.2.1 Sampling design

Rupsha upazilla consist of five union named Aichgati Union, Shreefaltola Union, Noihati Union, T.S.Bahirdia Union and Ghatbog Union,64 Mouza and 78 villages composed of many household. Every household planted with multistory species plants is called homegarden. Total homegarden was considered as a sampling unit. A total 60 homegarden was surveyed from four unions except Ghatbog union. Each Homegarden was selected purposively through systematic transect method for primary data collection in respective to their size and tree coverage. A minimum distance of 300m between two homegarden was maintained.

3.2.2 Data collection

Almost all the species present in each sample homegarden was recorded by local name. The diameter at breast height (DBH) and height are two main biophysical measurements which were considered for each tree sample. DBH (1.3 m height) of all the tree species was measured by using diameter tape and height was measured with Hoga altimeter. All individual of trees and shrubs species were counted. The herbs and climbers were just recorded not counted due to the difficulties of differentiating the individuals. The location of each sample homegarden was recorded by GPS.

3.2.3 Data analysis

For analyzing the collected data from 60 homegarden of Rupsha Upazila, the following parameters were considered. At first each species from 60 HG was classified into family, Life form (tree, shrub, herb and climber), origin (indigenous or exotic), local uses, conservation status and Threat to the Species. The information was taken from the Encyclopedia of Flora and Fauna of Bangladesh, 2008. For describing floristic composition of species of the study area the basal area, relative density, relative dominance, relative frequency and Importance Value Index (IVI) were calculated (Moore and Chapman, 1986 and Shukla and Chandel, 1980.

3.2.4 Measurement of basal area, relative density, relative dominance, relative frequency

Relative Density and Relative Frequency of tree and shrub were calculated. Trees Relative Dominance was also calculated by estimating tree diameter at breast height. The basal area/ha is calculated according to the following formula (Shukla and Chandel, 1980).

Basal area= $\pi D^2 /4$

Where, D = Diameter at breast height in meter, π= 3.14.

1. Density = Number of a species/Total area sampled.
2. Frequency = Area of HG in which a species occurred / Total area sampled.

3. Dominance = Total Basal area of a species / Total area sampled.
4. Relative Density = (Density of a species / Total Density of all species) * 100
5. Relative Frequency =(Frequency of a species /Total Frequency of all species) * 100
6. Relative Dominance =(Dominance of a species / Total Dominance of all species) * 100

3.2.5 Importance Value Index

Importance Value Index index was used to determine the overall importance of each species in the homegarden. In calculating this index, the percentage values of the relative frequency, relative density and relative dominance were summed up together and this value was designated as the Importance Value Index or IVI of the species.

Importance Value Index = Relative Density+ Relative Frequency+ Relative Dominance.

3.2.6 Diversity index

The shanon-winner index for diversity (Michael, 1990), Species Richness Index and Species Evenness Index (Margalef, 1958) were also calculated to quantify the species diversity in each hpmegarden of Rupsha upazilla.

1. The Shanon-winner index for diversity, $H = -\sum_{k=0}^{n} \mathrm{Pi} * \log 2 \mathrm{PI}$

Where, H = Index of Species Diversity

Pi = No. of Individual of one Species/Total No. of Individuals in the Samples

2. Species Richness Index, R = (S-1)/ln N

Where, R = Species Richness Index,

S = Total Number of Species,

N = Total Number of Individuals of all the Species.

3. Species Evenness Index, E = H/$\log_2$ S

Where, E = Species Evenness Index,

H = Shanon-Winner Index of Diversity

S = Total No. of Species.

3.2.7 Above ground biomass (AGB)

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., 2014 developed allometric equation for tropical trees that can be used for wide graphical and diameter range. The following equation (Chave et al., 2014) was used to calculate the above ground biomass of all trees of homegarden.

$$\mathbf{AGB = 0.0673 \times (\rho\, D^2H)^{0.976}}$$

Where, AGB = above ground biomass; ρ= Wood density.

D is in cm, H is in m, and ρ is in $g.cm^3$.

Wood specific gravity is an important predictor of AGB, especially when a broad range of vegetation types is considered. Wood density of every species was collected from secondary data such as FAO's list of wood densities for tree species from tropical Asia, (Zanne et al., 2009), Global wood density database and the density of species that was not found in the above list was calculated from the average of genus density. (Patwardhan et. al., 2003).

3.2.8 Below Ground Biomass (BGB)

To determine the below ground biomass and carbon, the regression model developed by Cairns et al., 1997, which is based on knowledge of above ground biomass was employed. It is the most cost effective and practical methods of determining root biomass.

$$\mathbf{BGB = exp\,(-1.0587 + 0.8836 \times ln\ AGB)}$$

Where; BGB = Belowground biomass, ln = Natural logarithm, AGB = Above ground biomass,

3.2.9 Conversion of Biomass to Carbon (above ground and below ground biomass):

After estimating the biomass it will be multiplied by 0.5 as wood contains half percent of carbon of it total biomass.

Carbon (Mg) = Biomass estimated by allometric equation x 0.5.

CHAPTER: 4

RESULTS AND DISCUSSION

4.1 Results

4.1.1 Species diversity and structure

The sample area was 6.72 ha from a total 60 Homegarden in Rupsha upazilla. The average Homegardens area was 0.11 ha. It varies from size 0.59 to 0.04 ha according to the HG categories. There was about 121 plant species within 59 Families. A total of 75 indigenous species and 47 exotic species were found. Out of 121 species, 59 were tree species, 21 shrub species, 22 herb species and 19 climber species (Table 4.1).

Table 4.1: Plant species composition and structure of the Homegarden of Rupsha upazilla, Khulna, Bangladesh.

No of HG Surveyed	Total HG Area Surveyed (Ha.)	Average HG Area (Ha.)	HG Area Range (Ha)	Total No of Species Found	Total No of Families Found
60	6.72	0.11	0.59-0.04	121	59

Components	No of Species	No of Families	No of Individuals	No of Individuals per HG	No of Individuals per Ha.
Tree	59	28	1393	24	208
Shrub	21	15	978	17	148
Herb	22	17			
Climber	19	12			

4.1.2 Family Composition

A total number of 59 families were encountered the study. Tree species have the highest number of families (28) followed by herb (17), shrub (15) and climber (12) species (Fig 4.1).

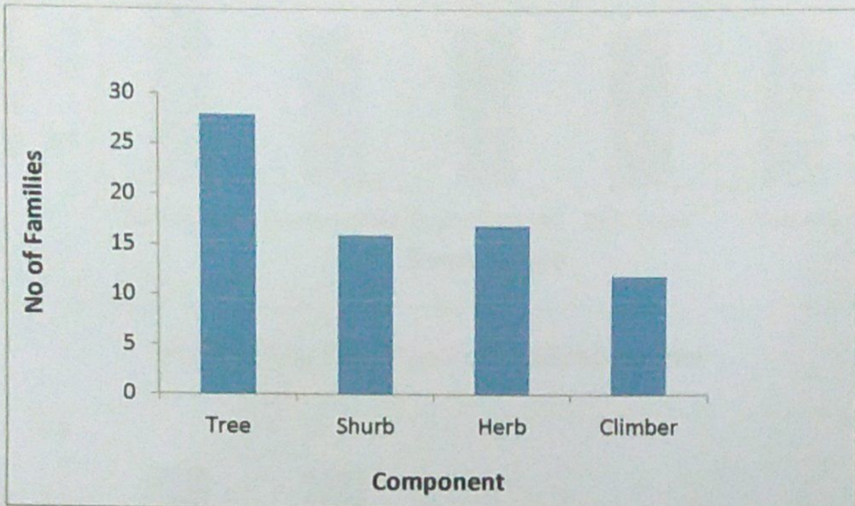

Fig 4.1: Family dominance of 60 Homegardens

Among the tree species, Leguminosae family is the most dominated family followed by Annonaceae, Moraceae, Meliaceae, Palmae, Myrtaceae, and Rutaceae (Fig 4.2). For Shrub Species, Solanaceae, Apocynaceae, Lythraceae and Oleaceae are most dominated family than others (Fig 4.3). For Herb Species, Amaranthaceae and Araceae is the most found family than others (Fig 4.4). For Climber Species, Cucurbitaceae is the most dominant family (Fig 4.5).

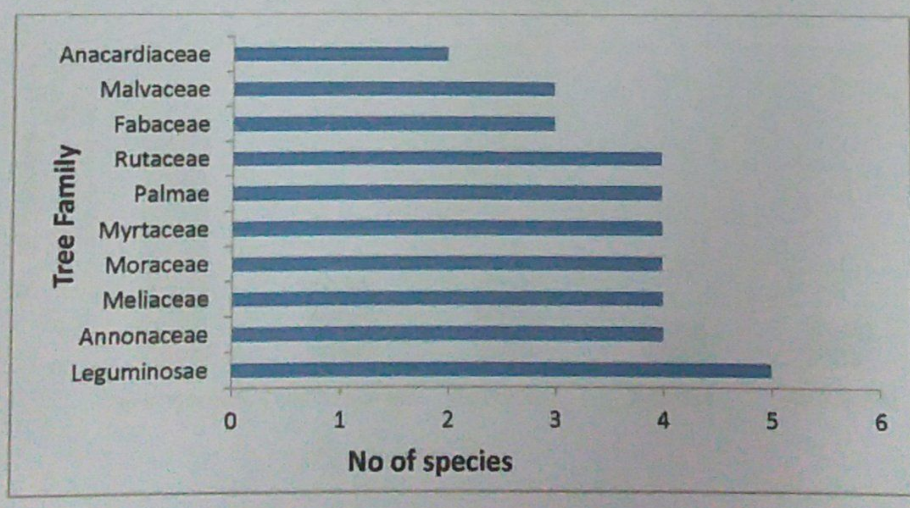

Fig 4.2: Top Ten Families of Tree Species

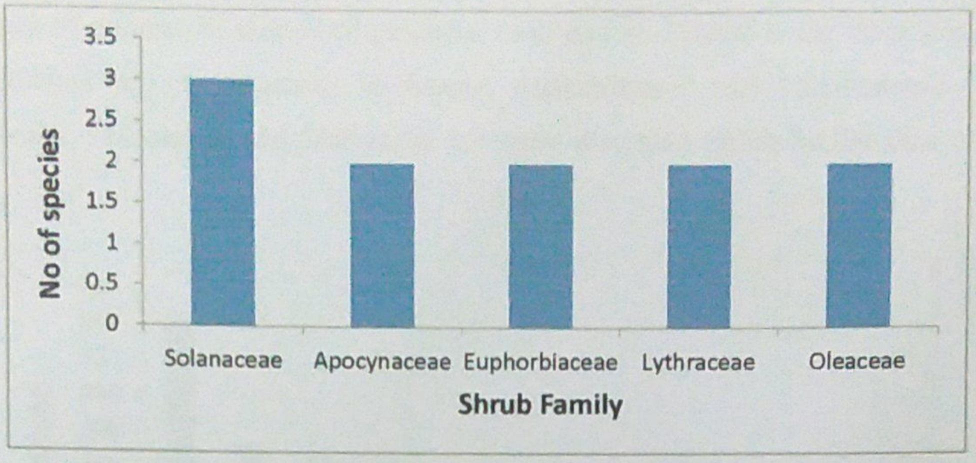

Fig 4.3: Top Five Families of Shrub Species

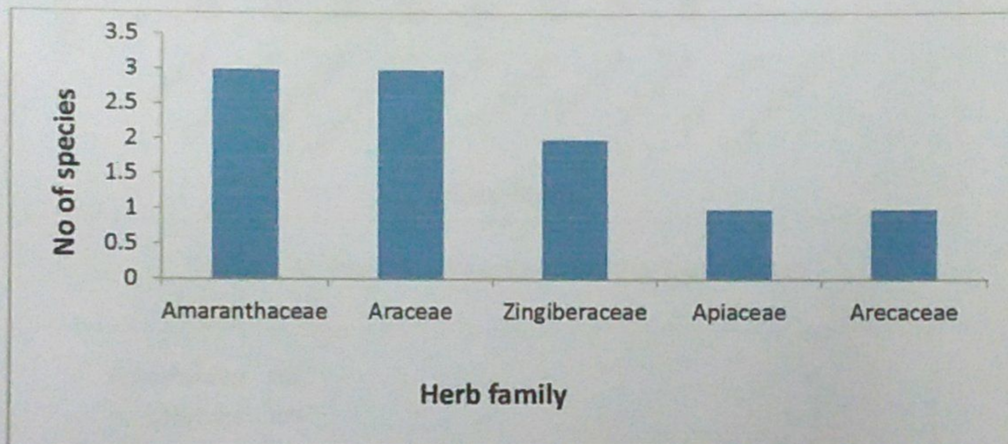

Fig 4.4: Top Five Families of Herb Species

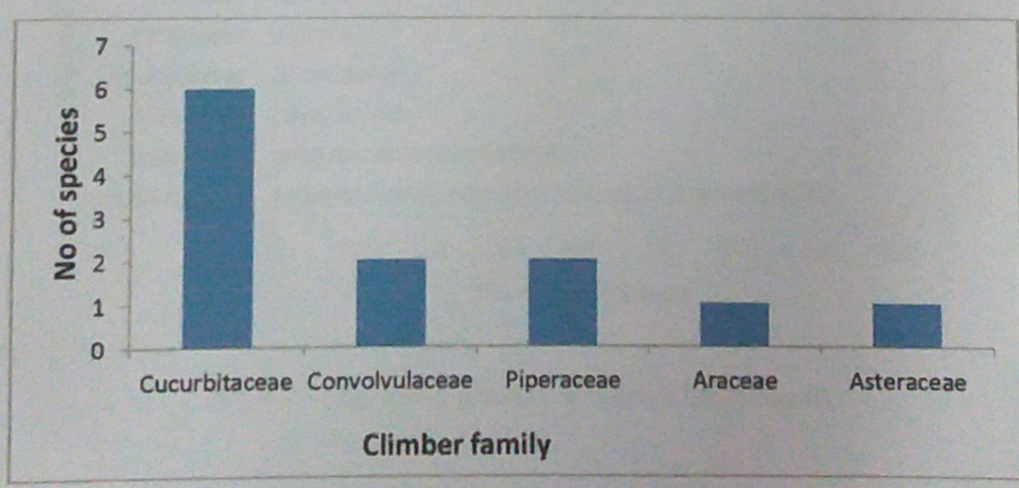

Fig 4.5: Top Five Families of Climber Species

On the basis of number of individual plants of each family, Palmae is the most dominant tree family followed by, Annonaceae, Myrtaceae, Anacardiaceae and Leguminosae (Fig 4.6). Euphorbiaceae, Solanaceae and Malvaceae are more dominant Shrub family than others (Fig 4.7).

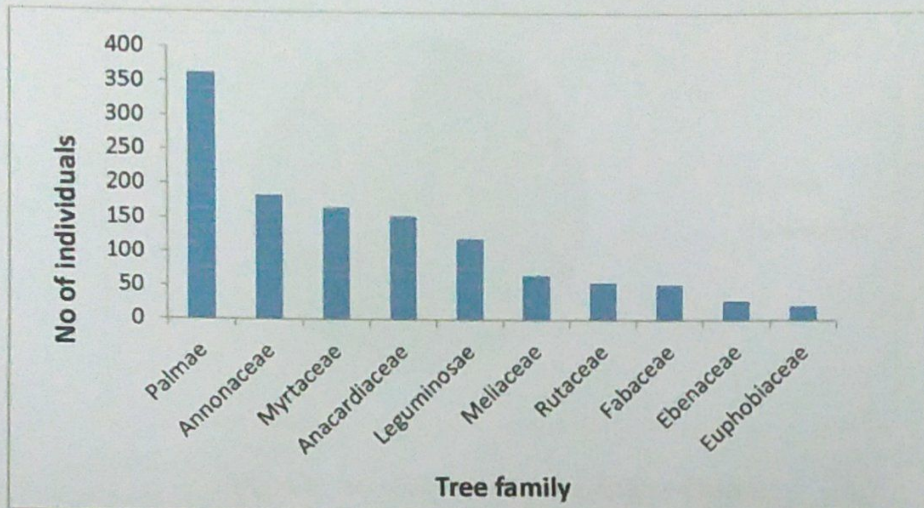

Fig 4.6: Top Ten Families of Tree Individuals

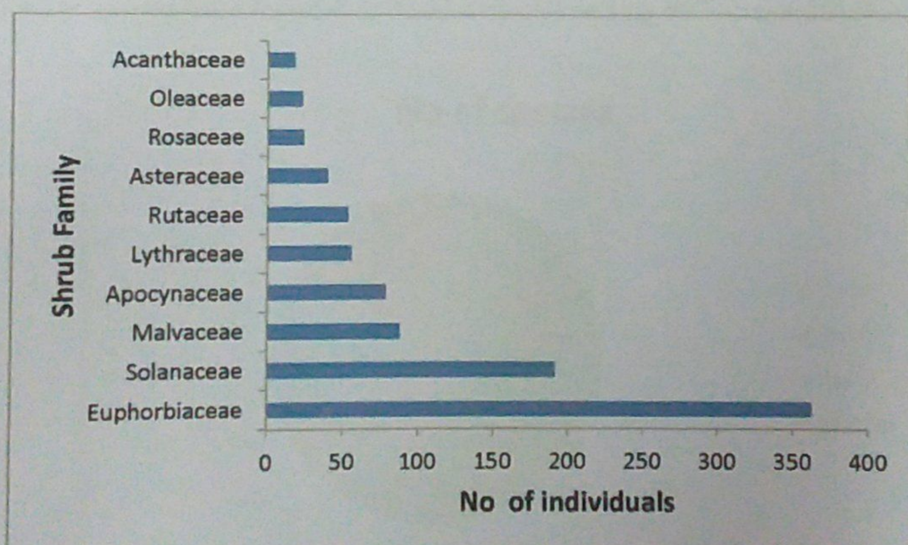

Fig 4.7: Top Ten Families of Shrub Individuals

4.1.3 Floristic Composition

A total number of 121 species belonging to 59 families were found in Rupsha Upazilla, Khulna. There are about 75 species of Indigenous and 46 species are Exotic (Fig 4.8).

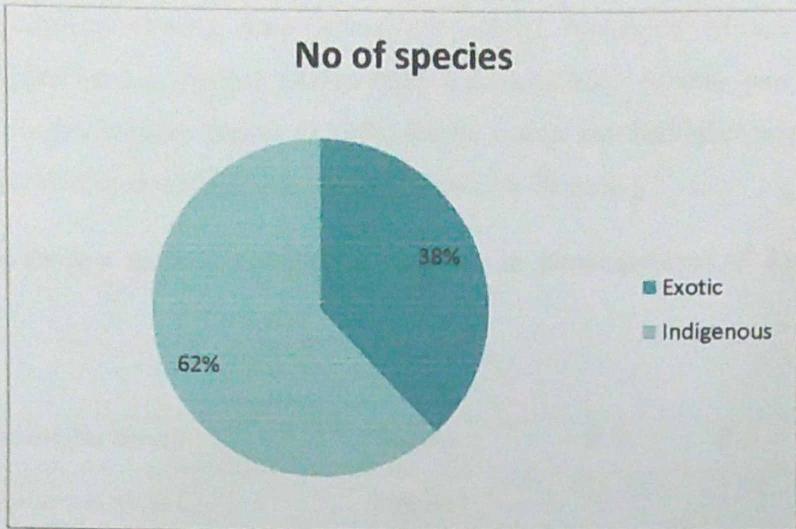

Fig 4.8: No of Species According to Origin

According to the number of species with different life form 49% tree, 17% shrub, 18% Herb and 16% Climber species were founded in Rupsha upazila among 60 homegarden (Fig 4.9)..

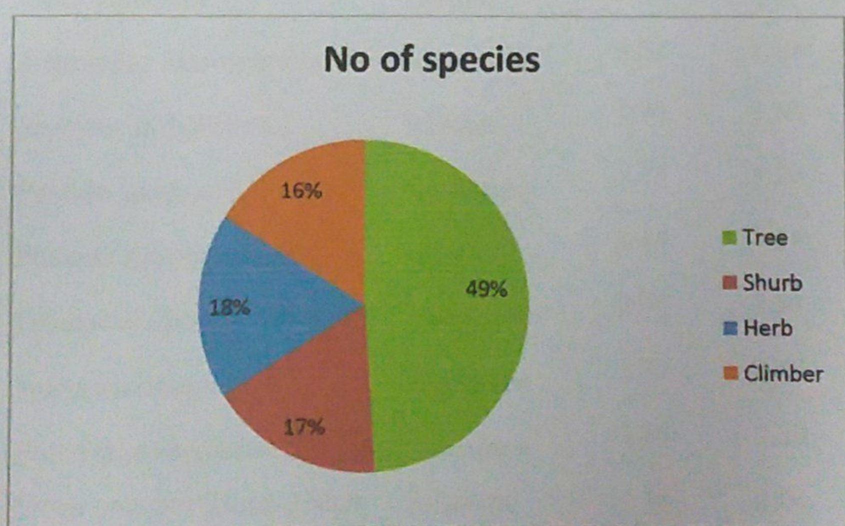

Fig 4.9: No of Species According to life form

4.1.4 Most important and least important species

4.1.4.1 Most important tree species

In 59 tree species, the highest Importance Value Index (IVI) was recorded in Coconut (*Cocos nucifera*), Siris (*Albizia saman*), Aam (*Mangifera indica*), Mehegony (*Swietenia mahagoni*), Supari (*Areca catechu* L.), Kathal (*Artocarpus heterophyllus*). Among this species *Cocos nucifera* has the higher relative density (12.20), *Albizia saman* has the higher relative dominance (25.84) and *Mangifera indica* (8.02) has the higher relative frequency.

Table 4.2: The twenty most important tree species in Homegardens of Rupsha upazilla, Khulna.

Tree Name	Scientific Name	Family	R.D	R.F	R.Do	IVI
Narikel	*Cocos nucifera* L.	Palmae	12.20	7.04	20.21	39.46
Siris	*Albizia saman* (Jacq.) Merr.	Leguminosae	6.39	4.56	25.84	36.79
Aam	*Mangifera indica* L.	Anacardiaceae	10.27	8.02	9.30	27.58
Mehegoni	*Swietenia mahagoni* L.	Annonaceae	9.48	5.69	8.07	23.23
Supari	*Areca catechu* L.	Palmae	10.48	5.92	2.69	19.09
kathal	*Artocarpus heterophyllus*	Myrtaceae	4.52	3.29	2.65	10.46
Tal	*Borassus flabellifer* L.	Palmae	1.94	3.18	4.17	9.29
peyara	*Psidium guajava* L.	Myrtaceae	3.73	3.29	0.64	7.67
khejur	*Phoenix sylvestris* (L.) Roxb.	Palmae	1.44	1.24	3.47	6.15
Gab	*Diospyros discolor* Willd.	Ebenaceae	2.08	2.69	1.14	5.91
jamrul	*Syzygium samarangense*	Myrtaceae	2.37	2.57	0.79	5.73
Debdaru	*Polyalthia longifolia* (Sonn.)	Meliaceae	2.08	2.29	0.78	5.15
Batabi lebu	*Citrus maxima* (Burm.) Merr.	Rutaceae	1.58	2.06	1.42	5.06
Tetul	*Tamarindus indica* L.	Leguminosae	1.08	2.32	1.60	5.00

kocha	*Erythrina fusca* Lour.	Fabaceae	1.94	2.00	0.90	4.83
Boroi	*Ziziphus mauritiana* Lam.	Rhamnaceae	1.51	1.86	1.40	4.77
Bel	*Aegle marmelos* (L.) Corrêa	Rutaceae	1.58	2.43	0.73	4.74
neem	*Azadirachta indica* A.Juss.	Meliaceae	1.51	2.30	0.79	4.59
sofeda	*Manikara zapota* (L.)	Sapotaceae	1.51	2.50	0.24	4.26
Amra	*Spondias pinnata* (L. f.) Kurz	Anacardiaceae	0.79	1.25	2.11	4.15

Here, R.D. = Relative Density; R.F. = Relative Frequency; R.Do. = Relative Dominance; IVI = Importance Value Index

4.1.4.2 Most important Shrub species

In 21 Shrub species, the highest Importance Value Index (IVI) was recorded in patabahar (*Codiaeum variegatum (L.)*), morich (*Capsicum annuum L.*), joba (*Hibiscus rosa-sinensis L.*).Among these *Codiaeum variegatum (L.)* shows the highest relative density (28.97) and highest relative frequency (6.86).

Table 4.3: The ten most important shrub species in Homegarden of Rupsha upazilla, Khulna.

Shrub name	**Scientific name**	**Family**	**R.D**	**R.F**
patabahar	*Codiaeum variegatum* L.	Euphorbiaceae	28.97	6.86
morich	*Capsicum annuum* L.	Solanaceae	12.06	2.86
joba	*Hibiscus rosa-sinensis* L.	Malvaceae	8.66	2.05
Berachita	Pedilanthus tithymaloides Poit.	Euphorbiaceae	7.53	1.78
begun	*Solanum melongena* L.	Solanaceae	6.19	1.46
noyontara	*Catharanthus roseus* L.	Apocynaceae	6.08	1.44
kagoji lebu	*Citrus aurantiifolia* (Christm.)	Rutaceae	5.57	1.32
gada	*Calendula officinalis* L.	Asteraceae	3.92	0.93
mendi	*Lawsonia inermis* L	Lythraceae	3.30	0.78
golap	*Rosa abietina* Gren. ex	Rosaceae	2.58	0.61

Here, R.D. = Relative Density; R.F. = Relative Frequency; IVI = Importance Value Index

4.1.4.3 Least important tree species

In 59 tree species, the least Importance Values (IVI) were recorded in Jafran (*Bixa orellana L.),* Polas (Butea monosperma (Lam.), Tej pata (*Cinnamomum tamala*), Bokul (*Mimusops elengi L.*) and Rokto kanchan (*Bauhinia variegata (L.*).

Table 4.4: The ten least important species of trees in Homegardens of Rupsha upazilla, Khulna.

Tree Name	Scientific Name	Family	R.D	R.F	R.Do	IVI
Jafran	*Bixa orellana* L.	Bixaceae	0.07	0.06	0.02	0.15
polas	Butea monosperma (Lam.)	Leguminosae	0.07	0.06	0.02	0.16
Tej pata	*Cinnamomum tamala*	Lauraceae	0.07	0.10	0.03	0.21
Bokul	*Mimusops elengi* L.	Sapotaceae	0.07	0.11	0.04	0.22
Rokto kanchan	*Bauhinia variegata* (L.)	Fabaceae	0.07	0.14	0.02	0.24
Segun	*Tectona grandis* L.f.	Lamiaceae	0.07	0.16	0.02	0.25
Jibon	*Trema orientalis* (L.) Blume	Ulmaceae	0.07	0.24	0.09	0.40
Bola	Hibiscus tiliaceus L.	Malvaceae	0.14	0.26	0.03	0.43
Ulot chombol	*Abroma augusta* (L.) L.f	Malvaceae	0.14	0.26	0.04	0.44
shaora	*Streblus asper* Lour.	Moraceae	0.14	0.26	0.11	0.52

Here, R.D. = Relative Density; R.F. = Relative Frequency, R.Do. = Relative Dominance; IVI = Importance Value Index

4.1.4.4 Least important shrub species

Out of 20 shrub species, the least important species are Night Queen (*Epiphyllum oxypetalum.*), Gondhoraj (*Gardenia jasminoides J.Ellis*) and Hamjum (*Polyalthia suberosa (Roxb.)*).

Table 4.5: The five least important species of shrubs in Homegardens of Rupsha upazilla, Khulna.

Shrub name	Scientific name	Family	R.D	R.F
Night Queen	*Epiphyllum oxypetalum.*	Cactaceae	0.52	0.12
Gondhoraj	*Gardenia jasminoides* J.Ellis	Rubiaceae	0.62	0.15
Hamjum	*Polyalthia suberosa* (Roxb.)	Annonaceae	0.62	0.15
Hasnahena	*Cestrum nocturnum* L.	Solanaceae	0.62	0.15
Beli	*Jasminum sambac* L.	Oleaceae	1.13	0.27

Here, R.D. = Relative Density; R.F. = Relative Frequency; IVI = Importance Value Index

4.1.5 Species diversity index

This study shows the diversity index only for tree and shrub. The Shanon-winner index for diversity of trees (4.78) was higher than shrubs (3.61). Species Richness Index of trees (8.29) was higher than shrubs (3.34) and Species Evenness Index of trees (0.81) is also higher than shrubs (0.74). So most of the cases, diversity of tree species are always higher than shrubs species.

Table 4.6: Diversity Index of Plant Species

Components	Shanon-winner Diversity Index, H	Species Richness Index, R	Species Evenness Index, E
Tree	4.78	8.15	0.81
Shrub	3.55	3.34	0.74

4.1.6 Local Uses of Plant Species

Again among the recorded 121 species, fruit plant species are dominant. Medicinal species, vegetables, ornamental species and timber species also found in high level. Other uses species such as fodder, fuel wood, dyes etc are also found in the HG of Rupsha upazilla (Fig 4.10).

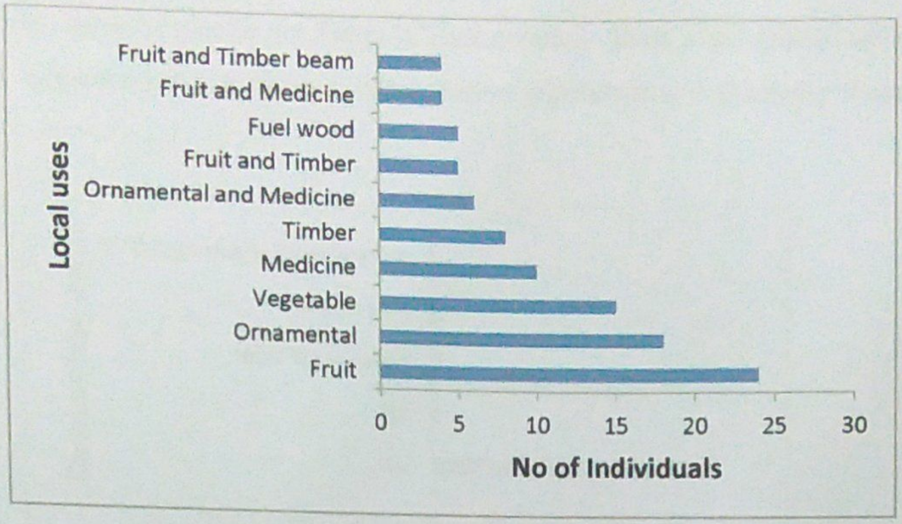

Fig 4.10: Local Uses of Plant Species in Rupsha Upazilla

4.1.7 Threats of Plant Species and Conservation Status According to Encyclopedia of Flora and Fauna in Bangladesh (EFFB):

Out of 121 plant species, most of the species are found under No Threat and No Major Threat. Some species are found no apparent threat, habitat loss, over-exploitation, deforestation, less plantation and increased felling, indiscriminate harvesting and no major threat but some native varieties are disappearing for introducing new varieties (Fig 4.11).

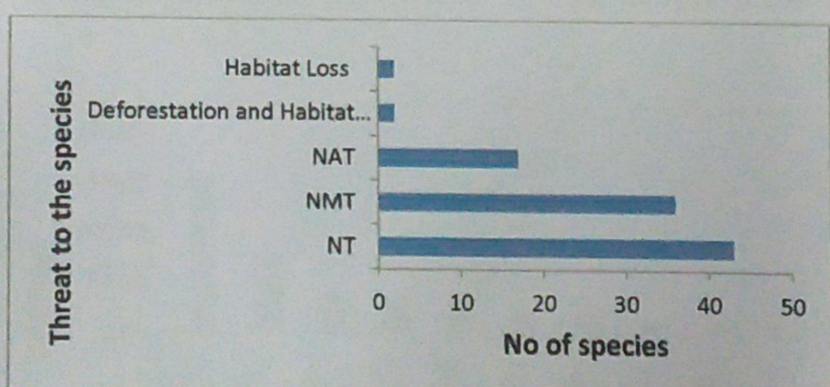

Fig 4.11: Threats of Plant Species in Rupsha upazilla, Khulna

Out of 121 Species, Most of species are found in least concern .Some plant species are found in vulnerable, near threatened, not evaluated, conservation dependent and gradually disappearing (Fig 4.12).

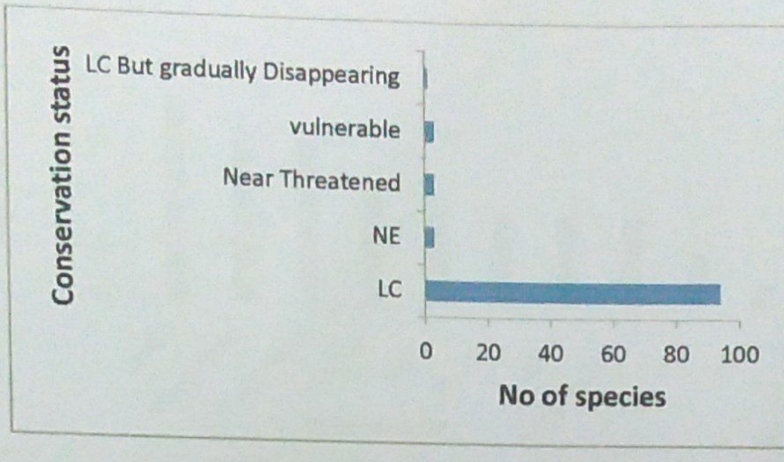

Fig 4.12: Conservation Status of Plant Species in Rupsha upazilla, Khulna.

4.1.8 Above ground Biomass (AGB) of Tree species

In 60 homegarden of Rupsha upazilla the average above ground biomass per tree is 8.86 Mg. The above ground biomass per tree species is ranged between 0.01 to 158.22 Mg. Out of 60 tree species the highest AGB are recorded by *Albizia saman* (158.22), *Cocos nucifera(*81.34*)*, *Swietenia mahagoni* (39.83), *Borassus flabellifer* (37.65) and *Mangifera indica* (37.10) (Fig 4.13).

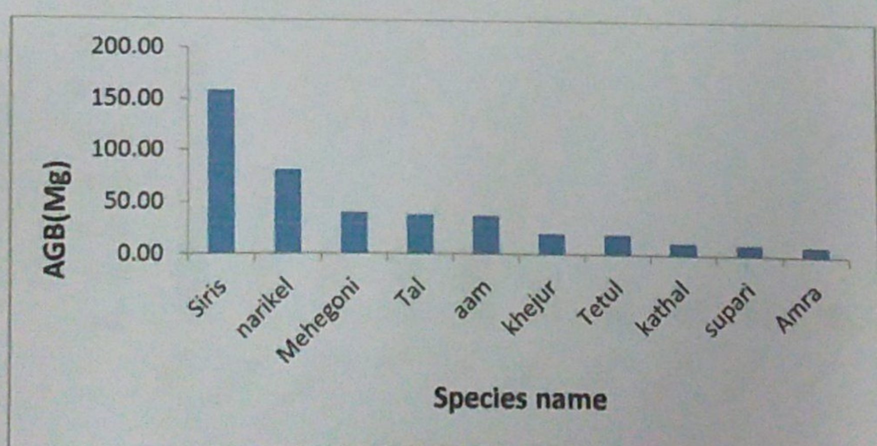

Fig 4.13: Top ten tree species of AGB

Tree species having least above ground biomass are jafran (*Bixa orellana)* (0.02), Bola (*Hibiscus tiliaceus)* (0.05), Rokto kanchan (*Bauhinia variegate)* (0.09) Polas (*Butea monosperma*) (0.09) and Tejpata (*Cinnamomum tamala*) (0.09) (Fig 4.14).

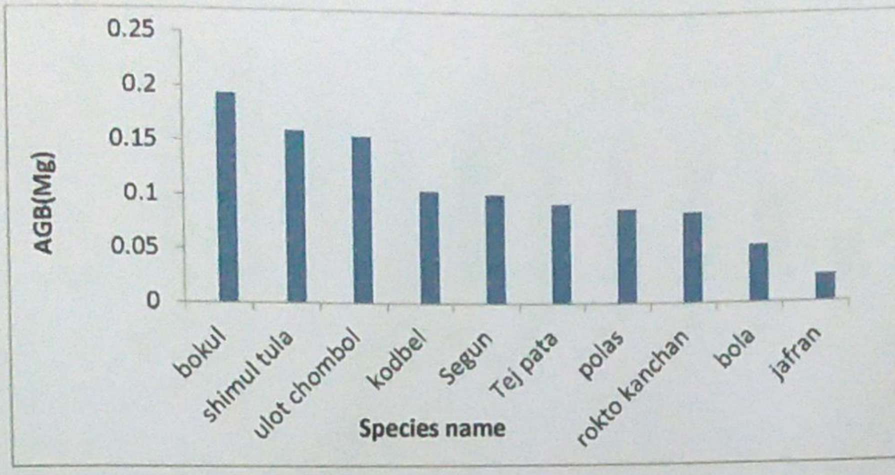

Fig 4.14: Least ten tree species of AGB(Mg)

4.1.9 Below ground Biomass (BGB) of Tree species

In 60 homegarden of Rupsha upazilla the average below ground biomass per tree is 2.04 Mg. which is ranged between 0.01 to 30.44 Mg. Out of 60 tree species the highest AGB are recorded by *Albizia saman* (30.44), *Cocos nucifera(*16.91*)*, *Swietenia mahagoni* (9.00), *Borassus flabellifer* (8.56) and *Mangifera indica* (8.45) (Fig 4.15).

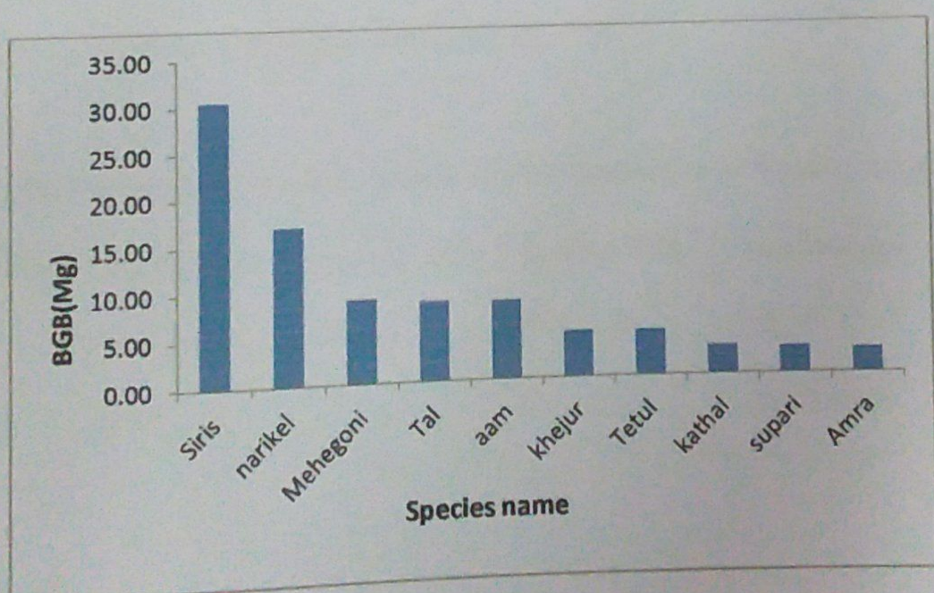

Fig 4.15: Top ten tree species of BGB (Mg)

Tree species having least above ground biomass are jafran (*Bixa orellana)* (0.01), Bola (*Hibiscus tiliaceus)* (0.03), Rokto kanchan (*Bauhinia variegate)* (0.04) (Fig 4.16).

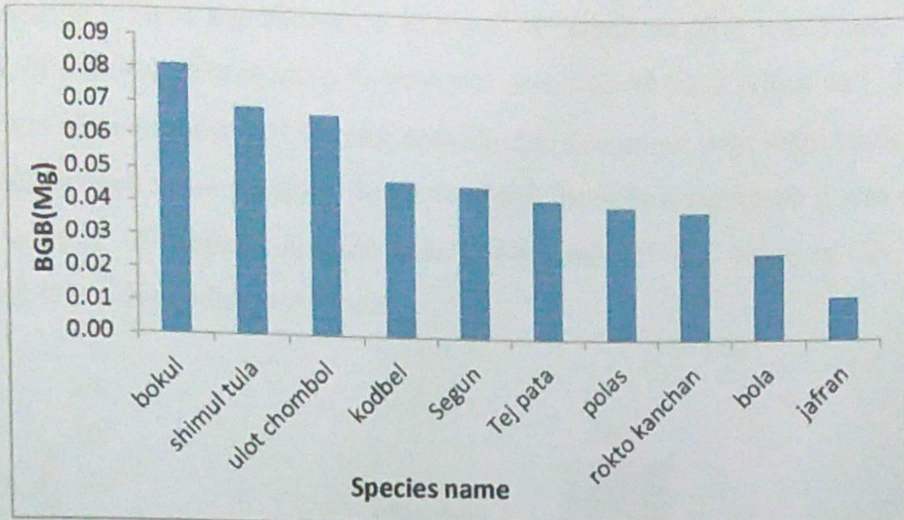

Fig 4.16: Least ten tree species of BGB (Mg)

This study shows the average above ground biomass, average below ground biomass, average above ground carbon and average below ground carbon in 60 homegarden of Rupsha upazilla is 78.68±4.82 Mg ha^{-1}, 9.35±0.51 Mg ha^{-1} ,39.34±2.41 Mg C ha^{-1} and 4.67±0.25 Mg C ha^{-1} respectively. The total biomass of Rupsha upazilla was found 88.03±5.32 Mg ha^{-1} and the total carbon of the surveyed area was found 44.02±2.66 Mg C ha^{-1}.

Table 4.7: Total biomass and carbon content in 60 homegarden of Rupsha upazilla.

Average AGB (Mg ha^{-1})	Average AGC (Mg C ha^{-1})	Average BGB (Mg ha^{-1})	Average BGC (Mg C ha^{-1})	Total biomass (Mg ha^{-1})	Total carbon (Mg C ha^{-1})
78.68±4.82	39.34±2.41	9.35±0.51	4.67±0.25	88.03±5.32	44.02±2.66

4.1.10 Homegarden Biomass Carbon Content

The total above ground biomass and below ground biomass (root biomass) of Homegarden was 88.03±5.32 Mg ha^{-1}. From the allometric equation of carbon stock it was found that the total carbon stock of standing homegarden in surveyed area was 44.02±2.66Mg ha^{-1}. The estimated biomass carbon of homegarden of Rupsha upazilla was compared with other major forest types of Bangladesh through some previous literature. From the following figure it was observed that the carbon content of Rupsha upazilla was almost half of the value of Sal forest. And comparatively lower than other two forest.

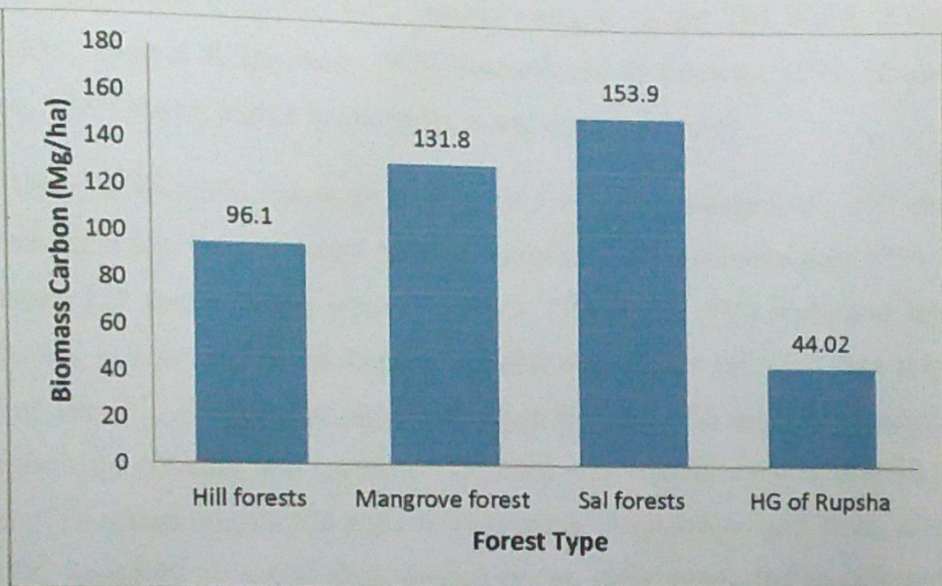

Figure 4. 17: Comparison of Homegarden biomass Carbon with Other Forest

4.2 Discussion

4.2.1 Diversity index

The continued degradation and loss of Bangladesh's primary forest has created major challenges in meeting basic needs for forest products and services. In the face of rapid degradation of public forests of the country, these homestead forests are considered as major supplier of forest products and services to both rural and urban inhabitants of Bangladesh. Many articles were published across the world and also in Bangladesh about homestead Agroforestry. In comparison to other published across the world and Tropical and subtropical Asia, Homegardens in southwestern Bangladesh exhibited high species richness (Kabir and Webb, 2008). Globally (Karyono, 1981; Padoch & De Jung, 1991; Soemarwoto & Conway, 1992; House & Ochoa, 1998; Jensen, 1993) shows higher homegarden plant species diversity.

In Rupsha Upazilla the total surveyed area of 0.11 ha (60 homegardens), 122 species in 59 families were recorded. Leguminosae families accounted for approximately 12% of the total species. Among 122 species, there were 49% trees, 17% shrubs, 18% herbs and 16% climbers. The tree species in homegarden of Rupsha Upazilla was higher (60 spp) than those found in homestesd of Jessore (28 spp), Patuakhali (20 spp), Rajshahi (28 spp), and Rangpur (21 spp) district respectively (Abedin and Quddus, 1990) but was slightly smaller than those found in homesteads of Sandwip upazila (76 spp) of Chittagong (Mohammed and Kazi, 2005). Millat-e Mustafa, 1997 found 92 perennial plant species in one study conducted in different part of the country. Alam & Masum, 2005 found 142 species in Sandwip upazilla (the offshore island). This variation may be because of differences in geographic and physiographic coverage, environmental gradient and purpose of plantation.

The list of most important species is almost same compared with the study of southwestern Bangladesh (Kabir and Webb, 2008) and this study. However, the list of southwestern Bangladesh (Kabir and Webb, 2008) based on RF and the present study is based on IVI. The importance Value Index (IVI) indicates a complete picture of phytosociological character of a species in the community (Hossain 45 et al., 2004). In Rupsha upazilla some of the most important tree species are Coconut (*Cocos nucifera*), Siris (*Albizia saman*), Aam (*Mangifera indica*), Mehegony (*Swietenia mahagoni*), Supari (*Areca catechu* L.), Kathal (*Artocarpus heterophyllus*) and the most important shrub species are in patabahar (*Codiaeum variegatum*

(L.)), morich (*Capsicum annuum L.*), joba (*Hibiscus rosa-sinensis L.*) which showed the maximum IVI (Table-4.1.4).

Data obtained from Shanon-Winner Species Diversity Index for tree species (4.78) show higher value than shrubs (3.55), which represents higher dominancy of tree species with more diversity. For shrub, herb and climber species, plant diversity was always less than tree species. The calculated value of Species Richness Index and Species Evenness Index was 8.29and 0.81 respectively for tree that represent the more species richness of tree and more evenly the total number of individuals is distributed. Species Richness Index and Species Evenness Index for shrub was 3.34 and 0.74. In an 11.52 ha area of homestead forests in northwest Bangladesh the Shanon-Winner Species Diversity Index value was reported in a range of 1.31–2.10 (Alam and Sarker 2011) and in a 5.4 ha homestead forest area in central Bangladesh an H value of 2.62–3.33 was reported by Muhammed et al. (2011). Chandrashekara and Baiju (2010) estimated a diversity index of 1.02–2.97 in 32 ha of home gardens in Kerala, India.

According to Kabir and Webb (2008) the most common use of homegarden, species are food, medicinal, fuelwood ornamental and commercial purpose. This is almost same as my study. In present study it was observed that the fruit trees were dominated over the other species in the home gardens of Rupsha upazilla. Similar observations were made by several authors (Millat-e-Mustafa 1997, Siddiqi and Khan 1999) in different regions in Bangladesh. Other common local uses of plant species of Rupsha upazilla are ornamental, vegetable, medicine, timber, fuel wood etc respectively.

4.2.2 Above and below Ground Biomass (AGB and BGB)

Biomass is important for soil, fire and water management. It is related to vegetation structure, which, in turn, influences biodiversity. It determines the magnitude and rate of autotrophic respiration. And, finally, biomass density (the quantity of biomass per unit area, or Mg dry weight ha^{-1}) determines the amount of carbon emitted to the atmosphere (as CO_2, CO, and CH_4 through burning and decay) when ecosystems are disturbed. So it is important to obtain more accurate and precise biomass estimates for homegarden in order to improve about understanding the role of homegarden in Bangladesh. From this study it is found that in 60 homegarden of Rupsha upazilla the average above ground biomass is 78.68±4.82 Mg ha^{-1} ranges from 83.50-

73.86 Mg ha^{-1}. The average above ground biomass per tree is 8.86 Mg where *Albizia saman* (158.22 Mg) shows the highest AGB and jafran (*Bixa orellana)* (0.02 Mg) shows the lowest value. The above ground carbon that is derived from AGB by multiplying 0.5 and this study shows the average above ground carbon in 60 homegarden of Rupsha upazilla is 39.34±2.41 Mg ha^{-1}. Again the average below ground biomass is 9.35±0.51 Mg ha^{-1} ranges from 9.85-8.84 Mg ha^{-1}. The average below ground biomass per tree is 2.04 Mg where *Albizia saman* (30.44 Mg) shows the highest AGB and jafran (*Bixa orellana)* (0.01 Mg) shows the lowest value. The average above ground carbon in 60 homegarden of Rupsha upazilla is 4.67±0.25Mg. The present study shows that the total biomass (AGB+BGB) and the total carbon stock of 60 homegarden of Rupsha upazilla is 88.03±5.32 Mg ha^{-1} and 44.02±2.66 Mg C ha^{-1} respectively which is lower than the homegarden of SAU campus (169.37 ha^{-1}±34 Mg C ha^{-1})(Shariful, 2013). The present average homegarden aboveground carbon stock reported in 60 homegarden of Rupsha upazilla (39.34±2.41 Mg ha^{-1}) was higher than that of Sumatran homegardens (35.3 Mg ha^{-1}), Indonesia but lower than Javanese homegarden (58.6 Mg ha^{-1}) (Roshetko *et al.*, 2002 and Jensen, 1993). The mean biomass carbon of present study was lower than mean biomass carbon (65-158 Mg ha^{-1}) in Bangladesh (Gibbs et al., 2007), 96.1 (±17.86) Mg ha^{-1} in Hill Forest of Bangladesh (Shin et al., 2007, Mukul 2014, Ullah and Al-Amin 2012 and Alamgir and Al-Amin 2007), 131.8 (±17.21) Mg ha^{-1} in mangrove Forest of Bangladesh (Rahman et al. 2014 and Donato et al. 2011) and 153.9 Mg ha^{-1} in Sal Forest of Bangladesh (Kibria and Saha 2011).

The homegarden of Rupsha upazilla was stored a significant amount of carbon per hectare. In order to maximize the amount of carbon stock on Rupsha upazilla as a means of offsetting CO_2 from atmosphere policies and planting programme should focus on the tree species that sequester the most carbon in their biomass. Therefore, the present study found that practicing more homestead Agroforestry system in Rupsha upazilla will be able to enrich the current species diversity status and also maximize the above ground carbon stock as much as possible.

CHAPTER: V
CONCLUSION AND RECOMMENDATION

Changes in biomass result from changes in land use and management can affect the area of forests, their age structure, community composition, and hence rates of carbon accumulation and loss which, in turn, influences biodiversity. The most important structural attribute of homegarden is the great diversity of trees herbs, shrubs, vines; which may be a consequence of the interplay of several socio economic and biophysical processes. Moreover, homegarden were important source of supplementary food, fodder, fuelwood, first aid and timber resources for the households in the study area. The present studied homegardens of Rupsha upazilla represent a wide range of biomass carbon, tree species diversity and species composition which gives comparatively significant result than the homegardens of many different ecological zones. These homegarden may be a habitat for the species that are threatened due to the deforestation and habitats lost and are likely to be more effective strategies for retaining carbon in the landscape and potentially increasing carbon sequestration. The carbon estimates found here are reflecting the differences in tree density, tree diversity and management practices between individual homegardens. So in Rupsha upazilla there is an ample scope to increase the carbon stock by extending the homegarden practice and homegarden of Rupsha upazilla can play important role to atmospheric carbon sequestration in addressing the global climate change issue. This study was conducted within a limited time and budget. The future study will be helpful to obtain a clear picture about the change in tree biomass as well as in change in carbon stock, biodiversity conservation and carbon sequestration rate which will contribute in the planning sustainable land management issues.

A homegarden is a complex agroforestry system whose vital information cannot be gathered in a short time. Time and Budget constraint, was the limitation of this study. And in most the cases the owners of the homestead were reluctant to give answer and they were not free to join into the discussions. In this study I used Encyclopedia of Flora and Fauna of Bangladesh 2008 for the identification of threats and conservation Status of species. IUCN red list should be used but I could not found the update version of the IUCN red list. I hope that in further study in this area, those limitations will be minimized.

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APPENDIX

List of Tree Species

SL no	Species	Scientific Name	Family	Origin	Native country	Local Use	Other local name	English Name	Threats to The species	Conservation Status	wood density	R.D	R.F	R.Do	IVI
1	Aam	*Mangifera indica L.*	Anacardiaceae	I	Tropical Asia & Assam Myanmar Region	Fruit	No	Mango	No major Threat	LC	0.480	10.27	8.02	9.30	27.58
2	Amloki	*Phyllanthus emblica L.*	Euphorbiaceae	I	Cambodia, Hong Kong, India,Loas	Fruit and Medicine	Amla, Ambolati, Awla	Emblic Myrobalan, Indian Gooseberry	NT	LC	0.680	0.79	1.53	0.14	2.46
3	Amra	*Spondias pinnata (L. f) Kurz*	Anacardiaceae	I	India & Myanmar	Fruit	Deshi Amra, Pial, Thoura	Hog Plum	NAT	LC But gradually Disappearing	0.358	0.79	1.25	2.11	4.15
4	Ashfol	*Dimocarpus longan Lour.*	Sapindaceae	I	Southwestern India	Fruit and medicine	Kathlichu	Eyeball Tree, Dragon's Eye, Buldock	Deforestation and fire wood collection	Near Threatened	0.700	0.36	1.33	0.31	2.00
5	Ata	*Annona reticulata L.*	Annonaceae	E	Tropical America	Fruit	Nona, Nona ata	Bullock's Heart	NMT	LC	0.550	1.44	1.65	0.22	3.30
6	Babla	*Acacia farnesiana (L.) Willd.*	Mimosaceae	E	Tropical South America, Now Pantropical	Fruit and Timber	Belatibabla, Guiya Babla	Sweet Acacia, Stinking Acacia	NAT	LC	0.735	0.29	0.38	0.14	0.81
7	Batabi lebu	Citrus maxima (Burm.) Merr.	Rutaceae	I	Southest Asia	Fruit	Jambura	Pummelo, Shaddock,Bitter Orange	NMT	LC	0.74	1.58	2.06	1.42	5.06
8	Bel	*Aegle marmelos (L.) Corrêa*	Rutaceae	I	India	Fruit	no	Bael Fruit,Bengal Quince	NAT	LC	0.880	1.58	2.43	0.73	4.74
10	Bokul	*Mimusops elengi L.*	Sapotaceae	I	South Asia, Southeast Asia and northern Australia	Medicine	No	Spanish cherry,Bullet wood,Asian bullet wood	less cutivation	Near Threatened	0.88	0.07	0.11	0.04	0.22
11	Bola	Hibiscus tiliaceus L.	Malvaceae	E	Coastal tropical, sub-tropical area	Medicine and Resin	No	Sea hibiscus, Mahoe	NAT	LC	0.45	0.14	0.26	0.03	0.43

SL no	Species	Scientific Name	Family	Origin	Native country	Local Use	Other local name	English Name	Threats to The species	Conservation Status	wood density	R.D	R.F	R.Do	IVI
12	Chalta	*Dillenia indica L.*	Dilleniaceae	I	Tropical Asia	Fruit	No	Elephant apple	NT	LC	0.685	0.86	1.19	0.26	2.32
15	Debdaru	*Polyalthia longifolia (Sonn.)*	Meliaceae	I	India, Sri lanka	Timber		Mast Tree	NMT	LC	0.590	2.08	2.29	0.78	5.15
14	Dewa	*Artocarpus lacucha Buch.-Ham.*	Moraceae	I	India,Myanmar, Malaysia	Fruit and timber	Dewphal, Bon Khanthal, kaufol	Monkey Jack	NT	LC	0.640	0.29	0.69	0.19	1.16
13	Dumur	*Ficus hispida L.f.*	Moraceae	I	India, Pakistan, Myanmar, China,Malayashia	Fruit	Kakdumur	no	Habitat Loss	LC	0.3815	0.65	1.10	0.27	2.01
16	Eucalyptus	*Eucalyptus camaldulensis Dehnh.*	Myrtaceae	E	Australia, Europe	Fuel wood	No	River red gum Dihn			0.756	1.29	1.22	0.87	3.38
17	Folsa	*Grewia asiatica L.*	Malvaceae	I	India And Sri Lanka	Fruit	No	No	NMT	LC	0.585	0.29	0.45	0.09	0.83
18	Gab	*Diospyros discolor Willd.*	Ebenaceae	E	Philippines	Fruit	Beelati Gab	Mabolo, Valvet Apple	NMT	LC	0.758	2.08	2.69	1.14	5.91
19	Ipil Ipil	*Leucaena leucocephala (Lam.) de Wit*	Leguminosae	E	Tropical America	Timber	No	Horse Tamarind, Wild Tamarind	NT	LC	0.683	0.86	1.04	0.61	2.52
20	jafran	*Bixa orellana L.*	Bixaceae	E	South America, Mexico	fruit	jafrong	lipstick tree	NMT	LC	0.36	0.07	0.06	0.02	0.15
22	Jam	*Syzygium cumini L.*	Annonaceae	I	India and sri Lanka	Fruit	Kala Jam	Black Berry, Java Palm, Black Palm	NT	LC	0.760	1.58	1.47	0.83	3.89
21	Jamrul	*Syzygium samarangense (Blume) Merr. & L.M.Perry*	Myrtaceae	E	Andamans, Nicobars and Malacca	Fruit	no	Wax Jambu, Java apple	NMT	LC	0.560	2.37	2.57	0.79	5.73
23	jiapoti	*Putranjiva roxburghii Wall*	Euphorbiaceae	I	West Himalayan To Sri Lanka	Fuel wood	Jiapura	No	NT	LC	0.675	0.79	1.04	0.19	2.03
25	Jibon	*Trema orientalis (L.) Blume*	Ulmaceae	I	Tropical America, Sri Lanka	Fuel wood and Fodder	Jinal, Chikan, Banjiga	Indian Nettle Tree, Charcoal Tree	NAT	LC	0.340	0.07	0.24	0.09	0.40

SL no	Species	Scientific Name	Family	Origin	Native country	Local Use	Other local name	English Name	Threats to The species	Conservation Status	wood density	R.D	R.F	R.Do	IVI
35	kamini	*Murraya paniculata (L.) Jack*	Rutaceae	I	South and Southest asia	Ornamental	Kamini	Cosmetic Bark, Orange Jasmine	NAT	LC	0.88	0.57	1.22	0.27	2.06
32	Kamranga	*Averrhoa carambola L.*	Averrhoaceae	I	Indian Sub Continent	Fruit	Kamranga	Star Fruit, Carambola	NT	LC	0.600	0.79	1.72	0.33	2.83
31	Kath Badam	*Terminalia catappa L.*	Combretaceae	E	Madagascar, along the coast of Tropical Asia	Fruit and timber	Deshibadam	Indian Almond, Tropical Almond	NT	LC	0.510	0.43	0.83	1.16	2.42
28	Kathal	*Artocarpus heterophyllus Lam.*	Myrtaceae	I	India	Fruit and Timber	Kathal	Jack fruit, jack	NT	LC	0.494	4.52	3.29	2.65	10.46
29	Khejur	*Phoenix sylvestris (L.) Roxb.*	Palmae	I	India and Pakistan	Fruit and Timber beam	Deshi Khejur	Wild Date Palm, Indian Oil Palm	NT	LC	0.737	1.44	1.24	3.47	6.15
26	Kocha	*Erythrina fusca Lour.*	Fabaceae	I	India, Sri lanka	Fuel wood	pania Mandar	Indian Coral Tree	NT	LC	0.33	1.94	2.00	0.90	4.83
27	kodbel	*Limonia acidissima Groff*	Rutaceae	I	South India And Sri Lanka	Fruit	NO	Wood Apple, Elephant apple and Monkey Fruit	NMT	LC	0.771	0.29	0.54	0.05	0.88
33	Koroi	*Albizia procera (Roxb.) Benth.*	Mimosaceae	I	India	Timber	Sil Koroi, Jat Koroi, Sada Koroi	White Siris	NT	LC	0.640	0.22	0.30	0.09	0.60
34	Krishnochura	*Delonix regia (Hook.) Raf.*	Leguminosae	E	Madagascar	Ornamental	Golmohar	Flame Tree, Royal Poinciana	NT	LC	0.579	0.22	0.24	0.25	0.70
37	Latim	*Ficus auriculata Lour.*	Moraceae	I	India, Nepal, China, and Southeast Asia	Fuel Wood and Fodder	bera dumur	Roxburgh fig tree,Elephant ear fig,Eves apron	Not evaluated by the IUCN Redlist	LC	0.468	0.29	0.47	0.19	0.94
38	Lichu	*Litchi chinensis Sonn.*	Sapindaceae	E	South Est China, Indo-Chinese Peninsula	Fruit	no	Litchi			0.960	1.15	1.79	0.48	3.41

SL no	Species	Scientific Name	Family	Origin	Native country	Local Use	Other local name	English Name	Threats to The species	Conservation Status	wood density	R.D	R.F	R.Do	IVI
39	Mehegoni	*Swietenia mahagoni (L.) Jacq.*	Annonaceae	E	West indies, Coasts of central America	Timber	No	Spanish Mahagoni, West Indian Mahagoni	NMT	LC	0.510	9.48	5.69	8.07	23.23
41	Neem	*Azadirachta indica A.Juss.*	Meliaceae	E	Myanmar	Timber and medicine	Nimba	Margosa Tree, Indian Lalic	NAT	LC	0.660	1.51	2.30	0.79	4.59
42	Pepe	*Carica papaya L.*	Caricaceae	E	Maxico & Costa Rica	Fruit	Pepe	Papaya	NT	LC	0.1875	1.44	1.48	0.34	3.25
44	Peyara	*Psidium guajava L.*	Myrtaceae	E	India, Myanmar	Fruit	Sabri Aam	Guava	NT	LC	0.600	3.73	3.29	0.64	7.67
45	Polas	**Butea monosperma (Lam.) Taub.**	Leguminosae	I	India, Bangladesh, Nepal, Sri Lanka, Myanmar, Thailand,	timber, resin, fodder, medicine, and dye.	No	Bastard Teak, Parrot Tree	LC		0.560	0.07	0.06	0.02	0.16
43	Puia/toon	*Toona ciliata M.Roem.*	Meliaceae	I	Pakistan	Timber	Toon, Peo, Pryatoon, Kuma,Prias	Toon,Australian Red Cedar, Cedar	NMT	LC	0.376	0.50	0.41	0.25	1.17
46	Rokto kanchon	*Bauhinia variegata (L.) Benth*	Fabaceae	I	China, Burma, India, Nepal, Pakistan, and Sri Lanka	Fuel wood and Fodder	No	Ebony tree	NT	LC	0.700	0.07	0.14	0.02	0.24
51	Sajina	*Moringa oleifera Lam.*	Moringaceae	I	Indian Sub Continent	vegetables and fodder	Sojne	Ben oil Tree, DrumStick Tree	NAT	LC	0.262	0.72	1.94	0.63	3.28
48	Sal	*Shorea robusta Gaertn.*	Dipterocarpaceae	I	native to the Indian subcontinent.	Timber	Sakhua		NT	LC	0.730	0.36	0.64	0.55	1.55
55	Segun	*Tectona grandis L.f.*	Lamiaceae	E	India, Myanmar	Timber	Shegoon, Teak	The Teak Tree	NT	LC	0.720	0.07	0.16	0.02	0.25
47	Shaora	*Streblus asper Lour.*	Moraceae	I	Bhutan, Cambodia, China, India, Laos	Medicine	Shora, Harbi, Hekra, Harban	Siamese Rough Brush, Tooth Brush Tree	NT	LC	0.720	0.14	0.26	0.11	0.52
54	Shimul tula	*Bombax ceiba L.*	Bombacaceae	I	India, Myanmar, South China, Thailand	Cotton and fuel wood	Simul, Tula Gachh	Red Silk Cotton Tree	NT	LC	0.28	0.29	1.42	0.07	1.78

SL no	Species	Scientific Name	Family	Origin	Native country	Local Use	Other local name	English Name	Threats to The species	Conservation Status	wood density	R.D	R.F	R.Do	IVI
53	Sissoo	Dalbergia sissoo DC	Fabaceae	I	India, Bhutan, Myanmar Pakistan Afganistan	Fuel wood	No	Sissoo, South Indian Red Wood	NMT	LC	0.760	1.79	1.08	0.40	3.28
49	Sofeda	*Manikara zapota (L.) P.Royen*	Sapotaceae	E	West indies, Tropical America	Fruit	No	Sapodilla, Naseberry, Sapota	NT	LC	0.810	1.51	2.50	0.24	4.26
50	Supari	*Areca catechu L.*	Palmae	E	Malaysia	Fruit and Timber beam	Gua	Betel nut palm, Areca nut palm	NT	LC	0.46	10.48	5.92	2.69	19.09
58	Tal	*Borassus flabellifer L.*	Palmae	I	India, Pakistan, Bangladesh	Fruit and Timber beam	Palmyra Palm, Toddy Palm	Less plantation and Increased felling	LC		0.870	1.94	3.18	4.17	9.29
57	TejPata	*Cinnamomum tamala (Buch.-Ham.) T.Nees & Eberm.*	Lauraceae	I	Tropical & Subtropical Himalayan regions, Bhutan, India & Nepal	Cooking and medicence	Huara	Cassia Cinnamon, Cassia Lignea	Habitat Loss	NE	0.640	0.07	0.10	0.03	0.21
56	Tetul	*Tamarindus indica L.*	Leguminosae	E	Tropical Africa	Fruit and Timber	Tentul, Amli,Ambli	Tamarind	NT	LC	1.280	1.08	2.32	1.60	5.00
59	Ulotkambal	*Abroma augusta (L.) L.f*	Malvaceae	I	India, Warmer Parts of china	Medicine	Gach chola,Tambol	Devil's Cotton	Over-exploitation	Near Threatened	0.278	0.14	0.26	0.04	0.44

List of Shrub Species

SL no	Species	Scientific Name	Family	Origin	Native country	Local Use	Other local name	English Name	Threat to the species	Conservation status	R.D	R.F
60	bashok	*Justicia adhatoda L. Nees*	Acanthaceae	I	India, Laos, Vietnam.	Medicine	Vasak, Alok-bizak	White Draagon's Head	NMT	LC	1.75	0.41
61	Begun	*Solanum melongena L.*	Solanaceae	E	South Asia	Vegetable	Baigun	Brinjal, Egg Plant, Aubergine	NAT	LC	6.19	1.46
62	Beli	*Jasminum sambac L.*	Oleaceae	I	India, Malaysia, Indonesia	ornamental	Bely,Ban Mallika, Mogra	Arabian Jasmine	NT	LC	1.13	0.27
63	Berachita	Pedilanthus tithymaloides Poit.	Euphorbiaceae	I	India	Medicine	Rangchita, Belatisiz	Jew's Slipper	NMT	LC	7.53	1.78
64	Dalim	*Punica granatum L.*	Lythraceae	I	Balkans to Himalayas	Fruit	No	Pomegranate	NAT		2.37	0.56
65	Gada	*Calendula officinalis L.*	Asteraceae	E	Mexico	Ornamental and Medicine	Genda	African Marigold	NT	LC	3.92	0.93
66	Golap	*Rosa abietina Gren. ex H.Christ*	Rosaceae	E	China & India	Ornamental	Kata Golap	Tea Rose	NMT	LC	2.58	0.61
67	Gondhoraj	*Gardenia jasminoides J.Ellis*	Rubiaceae	E	China, Japan	Ornamental	No	Gardenia, Cape jasmine	NMT	LC	0.62	0.15
68	Hamjum	*Polyalthia suberosa (Roxb.)Benth and hook*	Annonaceae	I	India,Sri lanka, Mianmar	Fruit	Barachali, Murmuri	No	NAT	LC	0.62	0.15
69	Hasnehena	*Cestrum nocturnum L.*	Solanaceae	E	West Indies	Ornamental	No	Night Jesmine	NMT	LC	0.62	0.15
70	Joba	*Hibiscus rosa-sinensis L.*	Malvaceae	E	China	Ornamental	Rokta Joba	China Rose, Shoe Flower	NAT	LC	8.66	2.05
71	Kagoji Lebu	*Citrus aurantiifolia (Christm.) Swingle*	Rutaceae	E	East Indies	Fruit	Pati lebu	Lime, Sour Lime, Common Lme	NMT	LC	5.57	1.32
72	Karamcha	*Carissa carandas L.*	Leguminosae	I	India, Malaysia	Fruit and Medicine	No	Christ's Thorn	NMT	LC	1.34	0.32

73	Mendi	*Lawsonia inermis L.*	Lythraceae	E	Africa, Arabia, Egypt, Srilanka, Pakistan< India	Dyes and Medicine	Mendi, Sudi	Henna, Indian Privet, Mignonette Tree	NAT	LC	3.30	0.78
74	Morich	*Capsicum annuum L.*	Solanaceae	E	Tropical America	Vegetable	Kacha Morich, Lanka Morich	Spur piper, pepper, chilloes	NT	LC	12.06	2.86
75	Night queen	*Epiphyllum oxypetalum (DC.) Haw.*	Cactaceae	E		Ornamental		Night Blooming Cereus, Orchid cactus			0.52	0.12
76	Noiontara	*Catharanthus roseus (L.) G.Don*	Apocynaceae	E	Native of Madagascar, widely naturalized in the tropics	Ornamental	No	Madagascar Periwinkle			6.08	1.44
77	Patabahar	*Codiaeum variegatum (L.) Blume*	Euphorbiaceae	E	Indonesia, Malaysia, Australia, and the western Pacific Ocean	Ornamental	Variegated Croton				28.97	6.86
78	Rengun	*Combretum indicum(L.) DeFilipps*	Combretaceae	I	Sri Lanka, India, Pakistan	Ornamental	Jhumka phul, Rajana	Flame of the Woods	NT	LC	1.44	0.34
79	Sheuli	*Nyctanthes aculeata Craib*	Oleaceae	I	Sub Tropical Himalaya, India, Pakistan,Myanmar	Ornamental	Shefali, Shefalica	Night-flowering Jasmine, Coral Jasmine,Sorrowful Tree	NMT	LC	1.44	0.34
80	Sorpogondha	*Rauvolfia serpentina (L.) Benth.*	Apocynaceae	E	India, Pakistan, Sri Lanka and Burma,	Medicine	Chandar, Nakuli, Sugandhanakuli,	Sepentina root, Black snakeroot, Rauwolfia root			2.47	0.59

List of Herb Species

SL no	Species	Scientific Name	Family	Origin	Native country	Local Use	English Name	Threat to the species	Conservation Status
81	Bash Jhar	*Dendrocalamus longispathus Kurz.*	Poaceae	I	India, Northern Thailand & Myanmar	Construction			
82	Bon kachu	*Colocasia nymphaeifolia Kunth*	Colocasieae	I	Bangladesh	Vegetable and Ornamental	Kachu	NT	LC
83	Bet	*Calamus tenuis Roxb.*	Arecaceae	I	India and Myanmar	Furniture	Javot bet, Jali bet, Sachi bet	NMT	LC
84	Data Shak	*Amaranthus lividus Roxb.*	Amaranthaceae	I	Bangladesh	Vegetable and medicine	Gobura Notey	NMT	LC
85	Dheros	*Abelmoschus esculentus (L.) Moench*	Malvaceae	E	Southeast Asia	Vegetable	Bhendi	NT	LC
86	Ghrito kumari	*Aloe vera (L.) Burm.f.*	Asphodelaceae	I	Tropics & Sub Tropics	Ornamental and Medicine	Ghritakanchan, Musabbar	NMT	LC
87	Ghatkol	*Typhonium roxburghii schoot*	Araceae	I	South India And Sri Lanka	vegetable	No	Deforestation and Habitat Destruction	Vulnerable
88	Holud	*Curcuma longa L.*	Zingiberaceae	I	Tropics	Dyes and Medicine	Haldi	NT	LC
89	kola	*Musa acuminata Colla*	Musaceae	I	Tropical asia	Fruit	Kanch Kola	NAT	LC
90	Kolaboti	*Heliconia metallica Planch. & Linden ex Hook.*	Heliconiaceae	E	Tropic & sub Tropic Region	Ornamental	Sarbajoya	NT	LC
91	Man Kacchu	*Alocasia indica (Lour) Koch*	Araceae	I	India, Pacific island	Vegetable and Ornamental	Fankachu	NAT	LC
92	Morog ful	*Celosia argentea L.*	*Amaranthaceae*	I	Throught India, Sri Lanka	Ornamental	Shet Morog Phul	NMT	LC
93	Ol Kachu	*Amorphophallus paeoniifolius (Denn.) Nicol.*	Convolvulaceae	I	India, Sri Lanka, Java	Vegetable and Medicine	No	NMT	LC
94	Palao Pata	*Pandanus amaryllifolius Roxb.*	Pandanaceae	I	Malayasia	Cooking and medicene	No	NT	NE
95	Pani Kochu	*Colocasia lihengiae C.L.Long*	Araceae	I	Yunnan (Southern China)	Vegetable and Ornamental	No	Deforestation & Habitat Destruction	Vulnerable
96	Piaj Ful	*Zephyranthes grandiflora Lindl.*	Liliaceae	E	Warmer Part Of America	Ornamental	Golapi Ghashphul	NT	LC
97	Pathor kuchi	*Bryophyllum pinnatum(Lam.) Oken*	Crassulaceae	E	Asia, Australia, New Zealand, West Indies, Macaronesia	Ornamental and Medicine	Kaphpata, Gatrapuri	NT	LC
98	Soti	*Curcuma zedoaria (Christm.) Roscoe*	Zingiberaceae	I	Bhutan, India, Indonesia, Malaysia	Medicine	Failla	NMT	LC
99	Sondha maloti	*Mirabilis jalapa L.*	Nyctaginaceae	E	Afganistan,Pakistan,India,Bangladesh	Ornamental and Medicine	Krishnakeli		

100	Thankuni	*Centella asiatica (L.) Urb.*	Apiaceae	I	Tropics & Sub Tropics Of the New And Old World	Vegetable and Medicine	Thulkuri, Brahmabuti, Brahmokuti	NMT	LC
101	Time Ful	*Gomphrena globosa L.*	Amaranthaceae	E		Ornamental			
102	Tulsi	*Ocimum tenuiflorum L.*	Lamiaceae	I	Throughout South Asia	Medicine	Babui Tulsi	Over-exploitation & Non-cultivation	NE

List of Climber Species

SL no	Species	Scientific Name	Family	Origin	Native country	Local Use	English Name	Threat to the species	Conservation status
103	Angur	*Vitis vinifera L.*	Vitaceae	E	Europe, and southwestern Asia,Morocco,Portugal,southern Germany, Iran	Fruit and Wine	No	NT	LC
104	Chal Kumra	*Benincasa hispida (Thunb.) Cogn.*	Cecuritaceae	I	Tropical & Subtropical Countries	Vegetable	No	NMT	LC
105	Chui Jhal	*Piper retrofractum Vahl*	Piperaceae	I	Thailand,India & china	vegetable	Choi,Chab	NT	LC
106	Dhundul	*Luffa acutangula (L.) Roxb.*	Cucurbitaceae	I		vegetable	Tita Dhundul	NMT	LC
107	Germany lota	*Mikania cordata (Burm.f.) B.L.Rob.*	Asteraceae	I	Tropical Asia, Philippines, Papua New Guinea	Medicine	Assam-lata, Tarulata	NT	LC
108	Jhinga	*Luffa acutangula (L.) Roxb.*	Cucurbitaceae	I	China, India, Pakistan, Nepal, Malaysia, Russia	Vegetable	Ghosalata	NMT	LC
109	Kolmi	*Ipomoea aquatica Forssk.*	Convolvulacea e	I	Circumtropical	vegetable	No	NMT	LC
110	Lau	*Lagenaria siceraria (Molina) Standl.*	Cucurbitaceae	I	Africa, China, India, Japan	Vegetable	Kodu, Pani Lau	NMT	LC
111	Misty kumra	*Cucurbita maxima Duchesne ex Lmk.*	Cucurbitaceae	E	Bolivia, Southern Peru & Northern Argentina	Vegetable	Mithakumra	NMT	LC
112	Money plant	*Epipremnum aurenum*	Araceae	E	Australia, Southeast Asia, India, Pakistan, Nepal, Bangladesh, Hawaii	Ornamental	No	NT	
113	Mete alu	*Dioscorea alata L.*	Dioscoreaceae	I	Bangladesh	Vegetable	Chupri alu, Kham Alu	NAT	LC
114	Nil konthi	*Clitoria ternatea L.*	Fabaceae	E	Indonesia, Malaysia, Australia,Africa and America	ornamental and Medicine	Oporajita		
115	Pui shak	*Basella alba L.*	Basellaceae	E	Tropic of old World	Vegetable	Poi, Putika	NT	LC
116	Pan	*Piper betle L.*	piperaceae	I	Shrilanka,india,Bangladesh	raw food			
117	Shim	*Lablab purpureus (L.) Sweet*	Leguminosae	I	Bangladesh	Vegetable	Urshi, Ushi	NT	LC

118	Telakochu	*Coccinia grandis (L.)*	Cucurbitaceae	I	Africa, China, India, Japan	Medicine	No	NMT	LC
119	Uste	*Momordica charantia L.*	Cucurbitaceae	I	Tropical Country	Vegetable and medicine	Uchchhey	NMT	LC
120	misti alu	Ipomoca batatus	Convolvulaceae	I		vegetable			
121	pani singara	trapa bispinosa	trapaccae	I		fruit			

Here, I=Indigenous, E = Exotic, NMT = No **Major Threat**, NAT = N0 Apparent major Threat, NT = No Threat, LC = Least Concern, NE = Not Evaluated, VL= Vulnerable, RD= Relative Density, RF=Relative Frequency, RDo= Relative Dominance and IVI= Important Value Index.