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Eucalyptus agroforestry system in Chittagong: socio-economic potentiality amid controversies

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Abstract

The study aimed to uncover the socio-economic potentialities of *Eucalyptus* of existing prominent agroforestry systems in the rural landscape of Sitakunda and Mirsharai upazila of Chittagong district. Data were collected from 90 agroforestry practitioners irrespective of age, sex and occupation following a semi-structured questionnaire and 30 experimental plots were taken from three different agroforestry systems viz. homegardens, boundary of the crop field and on fallow lands, where farmers used to cultivate *Eucalyptus* as a component of agroforestry. To determine trends toward planting Eucalyptus, homegardens were categorized into three age group viz. <15 year, 15-30 year, >30 year. Considering age group of the homegardens, significant difference is prevailed among three types of homegarden. Average MAI of *Eucalyptus* in homegarden, crop field boundary and fallow land were 10.681$m^3h^{-1}yr^{-1}$, 48.618$m^3h^{-1}yr^{-1}$ and 45.181$m^3h^{-1}yr^{-1}$ at an average age of 8.9 year, 6 year and 6.3 year respectively. Farmers are aware with the present controversies of *Eucalyptus* which is disclosing through mass media. All agroforestry practitioners believed that *Eucalyptus* is responsible for reducing agricultural crop production and it is applicable for other trees also. However, they are still planting *Eucalyptus* ignoring the controversies as it does not require intensive technical input and management.

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Introduction

The words "systems" and "practices" are often used synonymously in agroforestry literature. However, some distinction can be made between them. An agroforestry system is a specific local example of a practice, characterized by environment, plant species and their arrangement, management, and socioeconomic functioning. An agroforestry practice denotes a distinctive arrangement of components in space and time. Although hundreds of agroforestry systems have been recorded, they all consist of about 20 distinct agroforestry practices. In other words, the same or similar practices are found in various systems in different situations. It may be noted that both the systems and the practices are known by similar names; but the systems are (or ought to be) related to the specific locality or the region where they exist, or other descriptive characteristics that are specific to it (Nair, 1993). Agroforestry is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. In agroforestry systems there are both ecological and economical interactions between the different components (Lundgren and Raintree, 1982). Socioeconomic criteria such as scale of production and level of technology input and management have also been used as a basis for classifying agroforestry systems (Lundgren, 1982). By the end of the nineteenth century, however, establishing forest or agricultural plantations had become an important objective for practicing agroforestry. In the beginning, the change of emphasis was not deliberate. At an outpost of the British Empire in 1806, U.Pan Hle, a Karen in the Tonze forests of Thararrawaddy Division in Myanmar (Burma), established a plantation of teak *(Tectona grandis)* by using a method he called "taungya," and presented it to Sir Dietrich Brandis, the Governor. Brandis is reported to have said, "This, if the people can ever be brought to do it, is likely to become the most efficient way of planting teak" (Blanford, 1958). From this beginning, the practice became increasingly widespread. It was introduced into South Africa as early as 1887 (Hailey, 1957) and was taken, from what was then Burma, to the Chittagong and Bengal areas in colonial India in 1890 (Raghavan, 1960). The genus *Eucalyptus*, which includes more than 600 species, is popular for plantations all over the tropics. In general, the genus is very adaptable and fast growing, and has a wide range of utility, ranging from sawn wood and processed wood products to a high calorific valued fuel wood, as well as a variety of environmental and ornamental uses (Poore and Fries, 1985). In rural communities, eucalyptus plantations increase the local fuel wood supply, thus mitigating the pressure on natural forests (Schönau, 1991). However, of all the widely-used plantation species in the tropics, the *Eucalyptus* species have attracted by far the most criticism (Evans, 1992). The *Eucalyptus* spp. have been criticized for causing a variety of short- to long term ills, poisoning the soil, draining nutrients, failing to prevent soil erosion, repelling wildlife, and yielding no fodder or green manure (Poore and Fries, 1985; Kumar, 1991). On the other hand, it has been claimed that the *Eucalyptus* spp. may improve soil characteristics when planted on degraded or deforested sites by improving the structure of the surface soil, by penetrating relatively impermeable layers of sub-soil and by drawing up nutrients from a depth (Poore and Fries, 1985). Ahmed et al. (2007) reported that *Eucalyptus* plants of above 10-years old had the most adverse effect on the crop yield as it caused 15% reductions on an average under its canopy while plants within the age of 7-10 years and 5-7 years old causes yield reduction about 12% and 8% respectively in the existing agroforestry system of Sitakunda upazila, Bangladesh, but in the same region *Eucalyptus* below 5 years old had insignificant or very little effect on the crop yield. Prakash (1989) reported the results of study conducted in Haryona and it was observed that *Eucalyptus* grown on all sides of fields' bunds at 1.8 m spacing between trees had negligible negative effect on associated agricultural corps in first two

years. In an 8 years rotation *Eucalyptus* under agroforestry is the optimum rotation for higher internal rate of return with minimum loss to crops. it was reported that *Eucalyptus* planted as windbreaks in Gujrat helped in increasing the atmospheric humidity and thus resulted in an increase in the yield of wheat and mustard by 23 and 24 percent respectively (Kumar, 1984). It has been debated internationally whether the fast-growing Eucalyptus plantations cause local biodiversity to increase or decrease (IFS, 1989; Tang et al., 2007). Eucalyptus is well accepted as a productive species by wood producers due to its very high rate of growth. For example, the area covered by eucalyptus plantations has tripled over the last decade in the province of Biscay, Spain (Ascasibar, 1997). In Bangladesh *Eucalyptus camaldulensis* experimental plantations showed excellent yield to 69 m^3 $ha^{-1}yr^{-1}$ in a closed spaced plantation, but in hilly areas the production reduced to as low as 14 m^3 $ha^{-1}yr^{-1}$ (Davidson and Das, 1985). Although the genus has wide range of adaptability and despite its wide range use in many countries of the world, there are controversies about its performance especially in water use, soil nutrient depletion, soil erosion, chemical impacts, allelopathic effect and biodiversity loss. Most of the controversies came from mass media supported by environmentalists, social activists and some NGO's rather than from scientific world (Ahmed and Akter, 1995).

There is scarce information on the performance of *Eucalyptus* as agroforestry component in Bangladesh. Local peoples' who are planting different species of *Eucalyptus* their perception regarding performance of the species was not assessed round the country. Hence, the study is conducted to depict the status of *Eucalyptus* species, people's consciousness and knowledge about performance of *Eucalyptus* species as an agroforestry component. Comparing growth performance of *Eucalyptus* in various types of practices was another objective of the study.

Materials and methods

To design an appropriate questionnaire, the researchers first conducted a reconnaissance survey in June 2011 for report building and identifying potential households for the study. The existing agroforestry systems were categorized into homegarden, trees in boundary of crop field and fallow land for the purpose of collecting better primary data, later Homegardens were categorized into three age group viz. <15 year, 15-30 year, >30 year then field survey was conducted throughout Mirsharai and Sitakundaa upazila of Chittagong district, Bangladesh.

The study area is located between 22°30' and 22°54' north' latitude and 91°27' and 91°45' east longitude. The area is bounded on the north by Tripura state of India, Chagalnaiya and Feni upazilas of Feni district, on the east by Fatikchari and Hathazari upazilas, on the south by Pahartali upazila, on the west Swandip channel of the Bay of Bengal. There might be some variation in microclimate round the year. Usually high rainfall concentrates during the monsoon in June to September. Dry period prevails from November to March for about 4-5 months. Relative humidity is high, usually 73-88%, with only minor variation and the average annual temperature ranges from 22.44°C to 30°C (Banglapedia, 2008). From each upazila 15 plots were selected following simple random sampling irrespective of location and age of the agroforestry systems. Separate plot sizes were determined for the three categories to facilitate data collection viz. 5m × 0.5m plot for trees in crop field boundary , 10m × 10m plot for fallow land and complete enumeration in case of homestead agroforestry system. Spiegel relaskope, measuring tape and diameter tape were used to collect different variables to facilitate volume calculation from standing trees.

Equation used for volume calculation

Volume of the *Eucalyptus* trees using height (m) and girth at breast height (cm) is calculated following (Table 1) the Latif and Islam (2004) and Latif et al., (1999). The regression equations which

showed maximum value of regression square were chosen for volume calculation.

Table 1. Equations for volume calculation.

Plantation type	Selected models	N	R^2	SE
Woodlot (≥5 years)	V_t = - 0.062939 + 0.00458384 × H + 0.000025752 × G^2 + 0.00000176593 × G^2H	131	0.982	0.039
Cropland	Log (V) = - 11.523307 + 1.911628 log (G) + 0.738982 log (H)	151	0.955	0.039

Here, V= Volume (m^3); V_t = Total volume over bark (m^3); H = Height (m); G = Girth at breast height (cm); R^2 = Regression square; SE = Standard Error; N = Number of sample trees.

Results and discussion

Socio-economic and demographical categorization of respondents

Considering demography of the study area male domination was found (92.22%) among agroforestry practitioners' (Table 2), from this study it also found that 12.22% of the agroforestry practitioners were illiterate and 44.44% of the respondents were educated up to primary level followed by secondary education (28.89%) and higher education (14.44%) irrespective of age and sex. Agriculture was the major occupation (43.33%) of the respondent followed by business (34.44%), day labor (14.44%) and service (7.78%).

Farmers' perceptions towards Eucalyptus planting

Plantation of different varieties of *Eucalyptus* was observed to a large extent as a component of agroforestry in the studied area. Farmers used to plant *Eucalyptus* varieties on the boundary of agricultural crop field, and raising mono-plantation on agricultural land and fallow lands adjacent to their homesteads. Three species of *Eucalyptus* was used in their plantation, e.g. *Eucalyptus camaldulensis*, *Eucalyptus brassiana* and *Eucalyptus tererticornis*. But, *Eucalyptus camaldulensis* is widely planted in comparison to other two species. *Eucalyptus* was planted intensively as a component of agroforestry practices amid controversies. 55.56% of respondents favor *Eucalyptus* as a component of agroforestry because it is fast growing timber species and it can resist itself under adverse environmental conditions (Table 3).

Table 2. Socio-economic and demographic categorization of respondents.

Demographical category		Percentage (%) (N= 90)
Gender	Male	92.22
	Female	7.78
Level of education	Illiterate	12.22
	Primary education	44.44
	Secondary education	28.89
	Higher education	14.44
Occupation	Agriculture	43.33
	Business	34.44
	Service (Government, Private and NGO)	7.78
	Day labor	14.44

Table 3. Farmer's perceptions towards *Eucalyptus* planting.

Topic of the questions asked to the farmers	Farmer's Perceptions	Percentage (%) (N= 90)
Introduction of *Eucalyptus* in Bangladesh: A controversial decision	Yes	35.55
	No	55.56
	Not sure	8.89
Is Eucalyptus in agroforestry system reducing agricultural crop production?	Yes	100
	No	0.0
Do Eucalyptus consume more water from subsurface soil?	Yes	87.78
	No	0.0
	Not sure	12.22
Are intensive plantations of eucalyptus causing loss of biodiversity?	Yes	57.78
	No	0.0
	Not idea	42.22
Do you have any knowledge on provenance trial or improved genetic resources?	Yes	0.0
	No	100
Level of technology input and management of *Eucalyptus* is required intensively	Yes	43.33
	No	56.67
Is productivity of eucalyptus decreasing in Bangladesh?	Yes	32.22
	No	10
	No idea	57.78
Main purpose of planting *Eucalyptus* as a component of agroforestry	Timber production	33.33
	Pole and post	15.56
	Fuel wood	12.22
	Multipurpose	38.89

However, 35.55% respondents argued against its introduction because they argued that it is harmful to the environment. 100% respondents believed that *Eucalyptus* in association with agricultural crop is responsible for reducing the crops production. Rate of water consumption from subsurface soil is another controversial issue in *Eucalyptus* based agroforestry system and 87.78% of the respondents think that *Eucalyptus* consumes more water from subsurface soil in comparison to other species. They also observed that when *Eucalyptus* are cut into lumber it shows more shrinkage and swelling than that's of other species. 57.78% of the respondents think that intensive plantation of Eucalyptus cause to decrease local biodiversity and others do not possess any idea in this regard. It is also notable that no farmers were found familiar with provenance trial or improved genetic resources. 56.67% of the respondent believed that it requires less technological input and management. The respondents who thought productivity of *Eucalyptus* is declining are 32.22% where 57.78% of the respondents do not possess any knowledge on productivity of *Eucalyptus*. However, 10% respondent did not think productivity of *Eucalyptus* is declining. In the study area 33.33% farmer plant *Eucalyptus* mainly for timber production followed by pole and post making (15.56%) and fuel wood (12.22%). It was also found that 38.89% of respondents are accustomed to multiple use of *Eucalyptus* such as shade, windbreaks, soil rehabilitation, fencing and protection.

Eucalyptus based agroforestry considering the age of the Homegardens

From this study it was found that *Eucalyptus* is getting preferences in new households in comparison to older households.

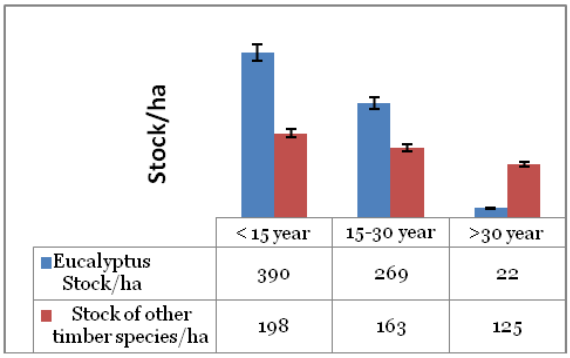

Fig. 1. Categorization of home garden based on age.

Homegardens aged bellow 15 years contains highest (390 stock ha^{-1}) number of *Eucalyptus* on the other hand old households (age >30 years) contains only 22 individuals of Eucalypts ha^{-1} (Fig. 1).

Averages mean annual increment (MAI) of Eucalyptus at different agroforestry system

Average MAI of *Eucalyptus* tree species at homegardens was found very low (10.681 $m^3h^{-1}yr^{-1}$) compared to other existing agroforestry system, because homegardens encompasses many plant species in limited space other than *Eucalyptus* and has to compete with other homestead plants. The value is quiet lower in than the expected yield (19 $m^3ha^{-1}yr^1$) from Eucalyptus plantations in Bangladesh reported by Davidson and Das (1985). On the other hand, *Eucalyptus* was planted on the boundary of crop field and on fallow lands as a practice of monoculture which ensures less competition for sunlight, space and nutrient. Probably that is why trees in crop field boundaries and fallow land shown greater average MAI (48.618 $m^3h^{-1}yr^{-1}$and 45.181$m^3h^{-1}yr^{-1}$ respectively) compared to homegardens (Table 4).

These values are much higher than that's reported from various trial plantations of *Eucalyptus* round the world. Evans (1992) reported 5-10 $m^3ha^{-1}yr^1$ on 10-20 year rotations in the drier tropics, whereas in moist regions yield may be up to 30 $m^3ha^{-1}yr^1$ on 7-20 year rotations. But, In Bangladesh closed spacing (1m×1m) plantation reported to produce 69 $m^3ha^{-1}yr^1$ in 5.5 years (Davidson and Das, 1985). However, the yield variation largely depends on plantation spacing.

Table 4. Relation between average age and average MAI at different site

Agroforestry system	Average age (year)	Average MAI ($m^3h^{-1}yr^{-1}$)
Homegardens	8.9	10.681
Trees in crop field boundary	6.0	48.618
Fallow land	6.3	45.181

Management of Eucalyptus in different agroforestry system

Eucalyptus camaldulensis was planted as tree component in most of the studied agroforestry systems of Sitakunda and Mirsharai upazila. Agroforestry practitioners collect seedlings of this species from nursery. In Sitakunda and Mirsharai it is found to be propagated from seed by the nursery owners. Management practices of *Eucalyptus* followed in the study areas can be discussed under plantation management, tending operation, coppice management and harvesting.

Plantation management

All the farmers of the study area collect *Eucalyptus* seedlings from privately owned nursery. During rainy season seedlings are found to be sold in the local markets. Polybag seedlings height of ≤ 90 cm are sold at 3 - 4 Taka/seedling and height ≥ 90 cm are sold at 5 – 7 Taka/seedling. Traditional planting technique (planting seedling digging a small hole) is very common in the studied area. Seedlings are tied with a stick buried near the seedling to provide mechanical support during the seedling stage. *Eucalyptus camaldulensis* is susceptible to a diverse range of fungi causing damping-off, collar rot and leaf diseases. Insects (termites and aphids) and rodents become sometimes troublesome in the young stage of this species. *Colleototrichum gloeosporioides* has been found responsible for leaf spot and twig blight

diseases of young *E. camaldulensis* plantations in Bangladesh (Begum, 1995). But no protective measures were reported to be taken by the farmers in Sitakunda and Mirsharai upazila. Planted seedlings protect themselves from all these only by their natural resistance capability. Sometimes domestic animals cause harm to the agricultural crops and planted tree seedlings.

Tending operation

Practitioners' remove climbers and weeds from agroforestry plots at irregular intervals. Weeding operation twice in a year is followed up to 3 years of the plantation in most of the plots. No chemical fertilizer was found to be used by any respondents, but 70% of the farmers use bio-fertilizer in their plots specially for better crop yield. Use of fertilizer varied in three categories of agroforestry system. Amount of fertilizer is used in trees in crop land boundary and homegardens is higher comparatively than that's of fellow land. In general, *Eucalyptus* produces fewer branches and crown spreading is lower than many other plant species. Its bole grows straightly upwards and become longer naturally. Probably, for that reasons respondent conduct pruning at several years interval. 90% of the farmer never thinned their plantation site or homegarden may be because of its less space demand for growth along with little timber and fuel wood production at the young stage.

Coppice management

Eucalyptus stumps were found to produce notable number shoots in the study area. But most of the shoots were of low quality as they break easily by moderate wind and vary much vulnerable to pests. 70% farmers of the Eucalyptus practitioner do not possess any knowledge to manage the coppice of the Eucalyptus. None of them retained and managed *Eucalyptus* coppice previously.

Conclusion

As *Eucalyptus* is planted as agroforestry component to a large extent in the studied area, it was convenient for the researchers to perceive the attitude of the agroforestry practitioners regarding *Eucalyptus*. Though people have no scientific knowledge about agroforestry technology and potentiality of *Eucalyptus* species as an agroforestry component, they are planting the species unconsciously because of its high growth rate and wide site suitability. Moreover, *Eucalyptus* is more capitalistic and requires low cost technology input and management, all classes of farmers are planting it. Role of *Eucalyptus* species as a agroforestry component associated with different agricultural crops need to be properly determined to assist the practitioners in adopting proper combination of agricultural and tree components in their agroforestry plots.

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