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# Farmers Preference and Perception towards Cropland Agroforestry in Bangladesh

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## Abstract

This study attempts to examine farmers' preference and perception towards cropland agroforestry (CAF) and its economic benefits in Bangladesh. It surveys 84 farmers of two sub-districts named Manirampur and Bagherpara under Jessore district of Bangladesh to address the study objectives with the help of a questionnaire during the period of June to July 2013. We follow a multistage random sampling procedure for selecting respondents of the survey. A total of 27 plant species under 19 families are identified in the surveyed crop fields, among which 11 are tree species and 1 is shrub from 8 families and 15 species are agricultural crops from 11 families. According to the survey findings, most of the farmers prefer multipurpose tree species like *Swietenia macrophylla* (67 percent), *Phoenix sylvestris* (48 percent), *Mangifera indica* (48 percent) and *Cocos nucifera* (43 percent). We also find that *Curcuma longa* (92 percent), *Oryza spp.* (56 percent), *Solanum melongena* (43 percent) *and Amorphophallus campanulatus* (33 percent) are the available agriculture crops which are grown in association with trees in the study area. The surveyed farmers report that they practice CAF to get fuel wood, fodder, juice, fruit and food for family consumption and revenue earnings. About 76 percent of the surveyed farmers endorse the existence of a positive interaction between trees and agriculture crops, while the rest 24 percent endorse the existence of a negative interaction between trees and agriculture crops. This study finds that CAF farmers on an average earn US$ 1,410 per farm per year and the yearly average revenue difference between CAF and non-cropland agroforestry (NCAF) farmers is US$ 214. Overall, CAF needs to develop through scientific intervention in the study area to conserve the biodiversity and to enhance farmers' sustainable livelihood.

**Key Words:** agroforestry, cropland, preference, perception, multipurpose, livelihood

## Introduction

Agroforestry is an age-old practice in traditional farming system of Bangladesh that we find in homesteads since long ago (Karim and Savill 1991). It is a collective name of land-use systems and technologies where woody perennials, such as, trees, shrubs, palms, bamboos, etc. are deliberately used on the same land as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence (Lundgren and Raintree 1982). Agroforestry is a land management system which increases the yield of the land. In the latter part of 1970s agroforestry policies were officially initiated in Bangladesh (Hasanuzzaman et al. 2014a) when the energy crisis was felt and food and fodder crisis also appeared, whereas the forest started disappearing (BARC 1993). However, cropland agroforestry (CAF) practice has started by the introduction of forestry extension service in early eighties of the last century by Bangladesh

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Forest Department to overcome the crisis. This practice has been extended successfully later on by SWIS Development Cooperation (SDC) through Village and Farm forestry Project (VFFP) at 16 districts of North Bengal (Rahman and Alam 2007). The efforts of VFPP have triggered the adoption of planned cropland agroforestry practices by the farmers (Quddus 2001). According to Rahman et al. (2011), cropland agroforestry practice has been practiced in different regions of Bangladesh and gained popularity during the last couple of decades.

Cropland agroforestry, a systematic land-use system of Bangladesh, is a combined cropping practice where trees are grown in crop fields in association with agricultural crops (FAO 2004). Generally, trees are planted on the borders or within the crop fields (Hocking and Islam 1994) usually with agricultural crops such as rice, wheat, pulses, jute, oilseed, sugarcane, vegetables and others. It is a distinct form of agroforestry which is primarily used for managing lands classified as agricultural lands. This system aims at production of enough food grain, timber, fodder, fruit, fuelwood and other products (Abedin et al. 1987; Hasan et al. 1997; Rahman 2011; BARC 1993). Agriculture in Bangladesh is facing various natural hazards due to climate change and farmers loose large amount of crops almost in every year, whereas, woody perennials are capable of tolerating adverse climate (Hasanuzzaman et al. 2014a). Therefore, farmers plant suitable trees in crop fields as an insurance crop in case of a sudden crop failure or to support crops against environmental hazards and also to provide additional income from trees (Rahman and Alam 2007; BARC 1993).

The cropping pattern and choice of species varies in different agro-ecological zones of the country. Farmers willingly prefer to practice multipurpose tree species such as *Mangifera indica*, *Acacia* spp., *Swietenia macrophylla*, *Artocarpus heterophyllus*, *Eucalyptus* spp., *Litchi chinensis*, *Albizia* spp. *Dalbergia sissoo*, *Borassus flabellifer* and *Phoenix sylvestris* both in the boundaries and in the entire crop land (Abedin et al. 1987; BARC 1993; Hasan et al. 1997; FAO 2004; Quddus 2001; Hasanuzzaman et al. 2014a). *Borassus flabellifer* and *Phoenix sylvestris* based system are extensively practiced in Jessore, the study district (Abedin and Quddus 1990; Bhuiyan 1994; BARC 1993; Hasan et al. 1997; Tejwani and Lai 1992). *Mangifera indica* based agroforestry has been practiced since the 1990s in the northern part of Bangladesh (Rahman 2011). *Litchi chinensis* based agroforestry is also widely practiced by small land holders in northern Bangladesh (Rahman et al. 2008). *Artocarpus heterophyllus* based agroforestry system is particularly popular in the Bhawl and Modhupur tracts regions of Dhaka and Mymensing districts as well as in the Tangail district, which is planted as both boundary plantation and in-field plantations like an orchard with intercropping of agricultural crops (Bhuiyan 1994).

The overall forest quality in Bangladesh is poor. The actual forest coverage is only 6 to 7 percent due to overpopulation (Islam and Sato 2010). This has made the country as a whole ecologically critical (Jacalne 1984; FD 1981). The demand and supply of fuel wood are 310 and 125 million cubic feet (cft) respectively, and those for timber are 115 and 44 million cft respectively (Hossain 1999). Thus, the shortages of timber and fuel wood are 62 percent and 60 percent respectively (Uddin et al. 2010). This large demand of wood has created a tremendous pressure on the reserved forests. It is very difficult to create forests in new crop lands due to the dearth of land and other scarce resources. Conversely, people need not only forest products but also the agricultural products and animals for meeting their increasing demand to sustain their livelihoods. Approximately three-fourth of the entire population of the country is engaged in agriculture which is the major land-use pattern in the country (Singh and Tewari 1996).

The forest in the south-west region of Bangladesh is under tremendous pressure originated from increasing population for meeting their livelihood demands of both land and forest products. Under the said situation, the CAF practice in this region has immense potentials to address the problem by providing its multi-dimensional products and services (Hasanuzzaman et al. 2014a). In addition, CAF might be an important tool to address poverty reduction as well as to minimize the pressure on natural forest to a great extent. It might be a potential land-use system for sustainable livelihood in Bangladesh.

Several studies have been conducted on CAF practice from various perspectives. However, a study to ascertain the farmers' preferences and perceptions towards different CAF and its economic benefits is hardly available in the literature. Therefore, this study aims to observe the farmers

preferences and perceptions towards different CAF in the study area and to estimate the economic benefits of it in the Jessore district of Bangladesh. It also intends to better understand the local peoples' socio-economic characteristics and their self-motivated CAF system that will act as baseline information for the policy makers to institutionalize CAF and subsequently to assist farmers in receiving support to adopt CAF.

## Materials and Methods

### *Study area*

This study considers Jessore district of Bangladesh as the study site. Geographically, the area is located at an elevation of 4.8 meters above mean sea level and extends from $23^{o}10'12''$N to $23^{o}17'0''$N and $89^{o}12'0''$E to $89^{o}20'0''$E covering an area of 2,567 $km^2$ with a population of 2.74 million (BBS 2011). The area falls under high Ganges river floodplain agro-ecological region (BARC 2012). High lands (flood-free) comprise about 48 percent (Hasan et al. 1997) of total area in the district. The soil of the district is calcareous in nature with pH ranging from 7.0 to 8.5 (SRDI 1977). The climate of the area is tropical monsoon. Annual average temperature is maximum $37.10^{o}$C and minimum $11.20^{o}$C; and annual rainfall is 1,537 mm (Banglapedia 2014).

Jessore district consists of 8 sub-districts (locally called upazilas), 92 unions, 1,434 villages and 0.66 million households. On an average two persons per household are economically active in the district. Common crops in the area include direct seeded rice (Aus), transplanted rice (Aman), winter transplanted rice (Boro), wheat, jute, pulse, tuberose, sugarcane and vegetables. It is also famous for date molasses. Therefore, the authors purposively select Jessore district (Fig. 1) as the study site for its better bio-physical resources of CAF (Hasanuzzaman et al. 2014b) and diversified livelihood patterns of the people. We also consider the easy accessibility and communication facilities in of the study area and the cooperation of local people in case of study area selection.

### *Sampling design*

A multistage random sampling procedure is followed in this study. Firstly, Jessore district (locally called zila) is purposively selected from the south-west region of Bangladesh. Consequently, two upazilas (sub-districts) named Manirampur and Bagherpara are randomly selected out of 8 upazilas in the district. Out of 9 unions of Bagherpara and 17 unions of Manirampur upazila, a total of four unions are randomly selected taking two from each upazila. A total of twelve villages are selected randomly taking three villages from each union (Table 1). A total of 84 farm families are randomly selected as samples from these twelve villages containing total 625 households. A control was imposed in selecting samples to ensure that half of the sampled households are CAF practitioners and the rest half are NCAF (monoculture) practitioners.

### *Data collection and analysis*

Farm level primary information is collected using a questionnaire through an intensive household survey during June to July 2013. Besides, physical observations of the farms are carried out to observe the biophysical condition

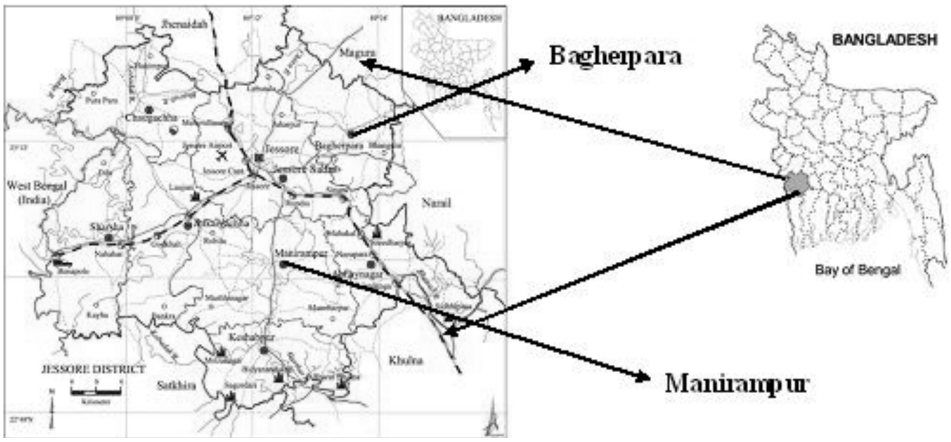


**Fig. 1.** Study Area of Jessore District, Bangladesh.

**Table 1.** Distribution of Sample Respondents

| Name of District | Name of Upazila | Name of Union | Name of Village | Sample HHs | |
|---|---|---|---|---|---|
| | | | | CAF | NCAF |
| Jessore | Manirampur | Dhakuria | Gabokhali | 3 | 4 |
| | | | Chapakona | 4 | 3 |
| | | | Brahammandanga | 3 | 4 |
| | | Haridaskati | Samaskati | 4 | 3 |
| | | | Kajipara | 3 | 4 |
| | | | Vomordah | 4 | 3 |
| | | Narikelbaria | Bolorampur | 4 | 3 |
| | | | Dayarampur | 3 | 4 |
| | Bagherpara | Dhalgram | Ketropala | 4 | 4 |
| | | | Bollamukh | 4 | 3 |
| | | | Agra | 3 | 3 |
| | | | Dhalga | 3 | 4 |
| Total | 2 | 4 | 12 | 42 | 42 |

Source: Authors' compilation.

and to analyze the actual practices in the natural settings. Collected data are initially entered in computer carefully using Microsoft Excel and crosschecked randomly against original completed questionnaires to detect entry errors. Accordingly, the detected errors are corrected before analysis. Descriptive statistical analysis including frequency distribution, percentage and simple ranking procedures are used for the data analysis to summarize farmers' socio-economic characteristics and farm specific characteristics.

This study classified surveyed farms into three categories: small (< 0.20 hectare), medium (between 0.20 to 0.40 hectare) and large (> 0.40 hectare) following Millat-e-Mustafa (1997) and Kibria and Anik (2010) for the analysis of tree density and economic benefits. Income approach is the commonly used technique for valuing agriculture and tree crops where all products are valued using actual market prices (Chakraborty et al. 2015). The monetary value of each product is calculated considering the market price in the nearest local market of the study site. Quantity of the products supplied or sold to the market from each respondent and other sources of income in the year prior to survey i.e. 2012 is recorded through personal interview. In addition, standing timber value of trees is also considered to calculate yearly income of tree crops. Hereunder, a likert scale of five points is used to measure the farmers' preference level (Chakraborty et al. 2015) where 5 for 'Mostly preferred', 4 for 'Very preferred', 3 for 'Preferred', 2 for 'Less preferred' and 1 for 'Least preferred' is considered. Farmer's total preference rate (TPR) is calculated as,

$$TPR = \frac{\sum X_i P_i}{n} \quad \cdots\cdots(1)$$

Where, $TPR$=Total Preference Rate

$X_i$=Percentage of farmers' preference towards a particular species at specific preference level

$P_i$=Points of preference level under likert scale

$n$=No. of class or scale

## Results and Discussion

### *Farmers' socio-economic characteristics*

All of the surveyed respondents are male. They are directly practicing farming activities. Traditionally Bangladesh is a male dominated society. It is perceived that male has a good knowledge about their land and cultivation technique. The collected data indicate that most of the farmers are middle aged with mean age of 50 years. The middle-aged farmers are likely to be more active in applying farming experiences and considered as economically active members in rural economy. The study findings reveal that about three-fourth of the respondents have nuclear family and the

rest have extended family. More than 90 percent of the respondents are married. A majority of the farmers has completed secondary school education. Average household size in the study area is 4.8, whereas the national average is 4.4 (BBS 2011). The mean landholding size per household is 0.79 hectare ranging from 0.07 hectare to 4.21 hectare. It is evident that majority of the farmer's (61 percent) annual income is between US$ 1,400 to 3,900 (Field Survey 2013).

### *Species Composition of CAF*

Various types of tree species are found growing in association with agriculture crops into the CAF farms in the study area. It is observed that cropping pattern in the study area varies mostly with land, soil and socioeconomic factors. A total of 27 plant species are recorded from the crop fields, of which 11 are tree species and 1 is shrub from 8 families and 15 species are agricultural crops (4 shrubs, 7 herbs and 4 climbers) from 11 families (Appendix 1 of Annex and Table 2). Alternatively, a total of 11 exotic species and 16 native species are identified in the study area (Table 2). Moreover, the number of species is also higher in the study area compared to some other areas of Bangladesh. For example, Yasmin et al. (2010) find 16 tree species in cropland areas of Madhupur upazila under Tangail district, Hasan et al. (1997) find 15 tree species in crop field at Bagherpara FSR Site of Jessore and Abedin et al. (1987) find 8 tree species at Bagherpara of Jessore. Hasanuzzaman et al. (2014a) find a total of 18 forest tree species and 59 agricultural species in Jessore, Khulna and Satkhira district. In our study the number of agriculture species is comparatively low because we only consider the existing species in the crop field during the survey period which was carried out in the rainy season.

Agriculture crops which are grown in association with

**Table 2.** Species Composition of CAF in the Study Area

| Origin | Number of Species | | | | | Number of Family | Species (%) |
|---|---|---|---|---|---|---|---|
| | Tree | Shrubs | Herbs | Climber | Total | | |
| Exotic | 4 | 3 | 1 | 3 | 11 | 7 | 41 |
| Native | 7 | 2 | 6 | 1 | 16 | 12 | 59 |
| Total | 11 | 5 | 7 | 4 | 27 | 19 | 100 |

Source: Authors' compilation based on field survey (2013).

**Table 3.** Tree - Crop Combination in Cropland Agroforests in the Study Area

| Trees | Agricultural Crops | Agroforestry Systems |
|---|---|---|
| *P.* sylvestris | Paddy, Brinjal, Turmeric, Banana, Jute | STP |
| *S. macrophylla* | Paddy, Brinjal, Turmeric, Chili, Banana, Giant taro, Eddoe ,Elephant foot aroid, Jute, Papaya | BP, STP, SP |
| *M. indica* | Paddy, Brinjal, Turmeric, Elephant foot aroid, Stem amaranth, Cucumber | STP, SP,CP |
| *C. nucifera* | Paddy, Brinjal, Papaya, Cucumber, Banana, Jute, String bean | BP, STP, SP,CP |
| *A. heterophyllus* | Turmeric, Banana, Eddoe | BP, STP |
| *Z. nummularia* | Brinjal, Turmeric, Giant taro, Eddoe, Elephant foot aroid, Cucumber, Bitter gourd, String bean | STP, SP, CP |
| *L. cinensis* | Turmeric, Cucumber, Brinjal, Chili | STP, SP,CP |
| *S. saman* | Paddy, Turmeric, Banana, Giant taro, Eddoe, Elephant foot aroid, Jute | BP |
| *A. catechu* | Turmeric, Banana, Giant taro, Eddoe, Elephant foot aroid, Brinjal, Papaya, Cucumber | BP, STP |
| *B. flabellifer* | Paddy, Jute | STP |
| *K. anthotheca* | Paddy, Brinjal, Papaya, Cucumber | BP, STP, SP |
| *Albizia* spp. | Turmeric, Banana, Giant taro, Brinjal, Jute | BP |

N.B.: Agroforestry Systems are denoted with STP, Scattered tree plantation; BP, Boundary Plantation; SP, Strip Plantation; CP, Composite plantation.
Source: Authors' compilation based on field survey (2013).

trees are listed in Table 3. Tree and agricultural crop combinations of CAF are much higher than traditional farming (Hasanuzzaman et al. 2014a). The highest tree-crop combination in cropland agroforests are *S. macrophylla*, *M. indica*, *C. nucifera*, *Z. nummularia*, *S. saman* and *A. catechu* based system. On the other hand, various agroforestry systems are found in crop fields of the study area (Table 3). These are scattered tree plantation, boundary plantation, strip plantation and composite plantation. Rahman and Alam (2007) also find the similar agroforestry systems in their study and define these systems. Our study finds that farmers practice *C. nucifera* with agriculture crops in four different agroforestry systems. In the same way, *S. macrophylla* and *K. anthotheca* are practiced through boundary plantation, strip plantation and scattered tree plantation based agroforestry systems. Moreover, scattered tree plantation, strip plantation and composite plantation are found in case of *M. indica*, *Z. nummularia* and *L. cinensis*.

### Tree density in CAF farmland

The primary data reveal that *M. indica*, *P. sylvestris*, *L. cinensis* and *S. macrophylla* are the major tree species in the crop field, while the minor tree species include *A. heterophyllus*, *Ziziphus nummularia*, *Cocos nucifera* and *Samanea saman* (Table 4). The literature also endorses the existence of many of the reported species in some other areas of Bangladesh. For example, Quddus (2001) finds that five species namely *S. macrophylla*, *Dalbergia sissoo*, *Eucalyptus* spp. *Melia azedarach* and *S. saman* are mainly adopted by farmers, whereas *Acacia auriculiformis*, *Azadirachta indica*, *Leucaena leucocephala*, *Albizia procera*, *Albizia lebbeck*, *Gmelina arborea*, *Terminalia arjuna*, *Acacia nilotica* and *Acacia mangium* are limited adopted species in cropland agroforestry action research plots by VFFP in Northwest Bangladesh (Appendix 2 of Annex). Yasmin et al. (2010) find *A. auriculiformis*, *A. heterophyllus*, *A. indica*, *Eucalyptus* spp. and *M. azedarach* as dominant species in the cropland areas of Madhupur upazila under Tangail district. Whereas, Hasan et al. (1997) find *A. heterophyllus*, *P. sylvestris*, *S. macrophylla* and *S. saman* as the major tree species in the crop field while the minor species include *M. indica*, *B. flabellifer*, *Syzygium cumini*, *A. nilotica*, *Bombax ceiba*, *Tectona grandis*, *Albizia* spp., *Trema orientalis* and *Leucaena leucocephala* in the crop fields at Bagherpara FSR Site of Jessore. Abedin et al. (1987) find *P. sylvestris*, *B. flabellifer* and *A. heterophyllus* as major species and *Magnifera indica*, *A. indica*, *Albizia* spp., *B. ceiba* and *Areca catechu* as minor species at Bagherpara under Jessore district. However, *P. sylvestris*, *B. flabellifer*, *C. nucifera*, *Dalbergia sissoo*, *A. heterophyllus*, *Albizia* spp and *A. nilotica* are found growing as 'sole species' in the crop fields (BARC 1993; Tejwani and Lai 1992). In addition, *S. macrophylla*, *M. indica*, *C. nucifera*, *P. sylvestris*, *B. flabellifer*, *Ziziphus spp.*, *L. chinensis* and *A. catechu* are identified as major tree species in Jessore, Khulna and Satkhira districts (Hasanuzzaman et al. 2014a).

Tree species are categorized into horticultural species and forest species in the study area (Table 4). Among various horticultural species in the surveyed crop fields, the density of *M. indica* is the highest (85 per farm) followed by *L. cinensis* (42 per farm) and *P. sylvestris* (36 per farm). In case of forest species, *S. macrophylla* (42 per farm), *K. anthotheca* (30 per farm) and *S. saman* (14 per farm) are remarkable. Small farms have the highest number and the highest density of trees in the crop fields. In contrast, the density of trees per hectare is smaller in large farms than the medium farms. On an average, a total of 319 trees of both horticultural and forest species are available in the crop field per

**Table 4.** Distribution of Trees in CAF Farm

| Tree species | No. of trees per farm | | | |
|---|---|---|---|---|
| | Small | Medium | Large | Average |
| Horticulture species | | | | |
| *P. sylvestris* | 33 | 30 | 47 | 36 |
| *B. flabellifer* | 5 | 4 | - | 3 |
| *M. indica* | 71 | 58 | 125 | 85 |
| *A. heterophyllus* | 42 | - | - | 14 |
| *L. cinensis* | 42 | 83 | - | 42 |
| *Z. nummularia* | 24 | 45 | - | 23 |
| *C. nucifera* | 24 | 28 | - | 17 |
| *A. catechu* | 25 | - | - | 8 |
| Forest species | | | | |
| *S. macrophylla* | 58 | 25 | 42 | 42 |
| *S. saman* | 42 | - | - | 14 |
| *Khaya anthotheca* | 35 | 28 | 26 | 30 |
| *Albizia* spp. | 16 | - | - | 5 |
| Total | 417 | 301 | 240 | 319 |

N.B.: The data is rounded.
Source: Authors' compilation based on field survey (2013).

farm. This data clearly demonstrate higher species density in the study area compared to other areas of Bangladesh. For example, Hasan et al. (1997) find that *P. sylvestris* is the highest (17 per farm) followed by *A. heterophyllus* (3 per farm) and in case of forest species, *S. saman* (2 per farm) and *S. macrophylla* (1 per farm) are remarkable in the crop fields at Bagherpara FSR Site of Jessore. Abedin et al. (1987) find *P. sylvestris* (102/ha), *B. flabellifer* (62/ha), *A. heterophyllus* (30/ha) and *M. indica* (10/ha) on highland sites at Bagherpara under Jessore district. Moreover, the relative prevalence rate (RP) of tree species in the crop fields are *P. sylvestris* (RP=37), *D. sissoo* (RP=8), *A. nilotica* (RP=5), *A. heterophyllus* (RP=3), *M. indica* (RP=2) and *C. nucifera* (RP=2) in the south-western part of Bangladesh (BARC 1993). In contrast, Hasanuzzaman et al. (2014a) find that the most prevalent species are *S. macrophylla* (RP=20.83), *M. indica* (RP=15.57), *C. nucifera* (RP=7.08), *Ziziphus* spp. (RP=4.14) and *P. sylvestris* (RP=1.92) in cropland agroforest areas of Jessore, Khulna and Satkhira districts. Our estimates are different because of variation in farm size categories and unit of measurement. Moreover, people intensively practice CAF in the study area in a systemic way with different arrangements for getting multiple products. Such a practice might be the main reason to increase the tree density into the surveyed crop fields over time.

### *Uses of CAF tree species*

The surveyed farmers report that most of the grown trees in the crop fields have multiple uses (Table 5). The respondents also mention that *S. macrophylla*, *A. heterophyllus* leaves and *S. saman* fruits are used as animal feed. Trees like *S. macrophylla*, *S. saman*, *A. heterophyllus*, *B. flabellifer*, *K. anthotheca* and *Albizia* spp. are used to make construction material and furniture along with other uses like fuel wood and cash income. The respondents also state that *M. indica*, *C. nucifera*, *Z. nummularia*, *L. cinensis*, *P. sylvestris* and *B. flabellifer* fruits are used as nutritious food for family consumption along with cash income. The juice collected from *B. flabellifer* and *P. sylvestris* is a major source of cash income to the farmers in addition to contributing in family consumption. During the taping season, 200-250 liters of juice and 25-30 kg molasses can be obtained from each *P. sylvestris* tree and about 20-25 percent more juice and molasses than *P. sylvestris* are secured from *B. flabellifer* that offers a good employment opportunity to the rural people (Abedin and Quddus 1990; Bhuiyan 1994). Leaves of the *P. sylvestris* and *B. flabellifer* trees are used for making mats, bags, fans and baskets by women that help them to generate income. At Bagherpara, income from *P. sylvestris* secures in-

**Table 5.** Uses of Tree Species

| Tree species | Percentages of CAF farmers | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | G | H | I |
| *P. sylvestris* | 75 | - | 75 | 75 | - | 65 | - | - | 100 |
| *S. macrophylla* | 85 | 45 | - | 70 | 100 | 100 | - | 82 | - |
| *M. indica* | 25 | - | 100 | 90 | 80 | 85 | 85 | 80 | - |
| *C. nucifera* | 100 | - | 100 | 50 | - | 95 | 95 | 12 | - |
| *A. heterophyllus* | 55 | 100 | 100 | 64 | 82 | 75 | 75 | 73 | - |
| *Z. nummularia* | - | - | 65 | 75 | - | 20 | 55 | - | - |
| *L. cinensis* | - | - | 55 | 40 | - | 65 | 65 | - | - |
| *S. saman* | 85 | - | - | 100 | 100 | 100 | - | 100 | - |
| *A. catechu* | 55 | - | 65 | - | - | 65 | - | - | - |
| *B. flabellifer* | 25 | - | 85 | 45 | - | 55 | 25 | 55 | 100 |
| *K. anthotheca* | 85 | - | - | 65 | 75 | 75 | - | 65 | - |
| *Albizia* spp. | 65 | - | - | 100 | 85 | 100 | - | 100 | - |

N.B.: A=Leaf as fuel, B=Leaf as fodder, C=Fruit, D=Fuel wood, E=Furniture, F=Cash income, G=Food for family consumption, H=Construction materials, I=Juice.
Source: Authors' compilation based on field survey (2013).

come of poor families for 5-6 months in a year (Aktar and Haque 1986). Moreover, Hasanuzzaman et al. (2014a), Hasan et al. (1997) and BARC (1993) also find the multipurpose uses of cropland agroforest tree species. Cash from trees are also used to purchase land and bullock, to meet cultivation costs and household needs and as a part of meeting expenditure of arranging social ceremonies (Abedin et al. 1987). Above all, the CAF practice plays a vital role to enhance the sustainable livelihood of rural people.

### *Farmers' preferences of tree and agriculture species in CAF farmland*

Farmers in the study area consider the biophysical and socio-economic attributes of tree species before incorporation into crop fields. During the interviews, farmers mention that trees are easily decomposed to increase the soil fertility and give quick return. Tree species with low crown density, little branches, high growth rate and multipurpose usage are considered as most preferred. We also observe that most of the farmers prefer fruit species; however few farmers prefer timber species in the farmland except *S. macrophylla*. Aladi and John (2014) find the same trend in their study. However, appropriate selection of tree species depends on the fulfillment of local market demand and achievement of environmental sustainability (Hasanuzzaman et al. 2014a).

In terms of species preference, most of the farmers prefer *S. macrophylla* (67 percent), *P. sylvestris* (48 percent), *M. indica* (48 percent) and *C. nucifera* (43 percent) as tree crops and *Curcuma longa* (92 percent), *Oryza spp.* (56 percent), *Solanum melongena* (43 percent), *Amorphophallus campanulatus* (33 percent) as agriculture crops in their CAF farms (Table 6 and Table 7). Our findings are fairly similar with Hasanuzzaman et al. (2014a) in terms of tree species preference. In addition, Hasanuzzaman et al. (2014a) also find that 57 percent farmers prefer *S. macrophylla* for timber production because of high market value of timber, small crown with thin branches, straight single stem with a long clear bole, and fast growing characteristics. On the other hand, *P. sylvestris* continue to maintain its dominance in the crop fields in the north-west and south-western regions (BARC 1993). In our study area about 48 percent cropland agroforest farmers prefer *P. sylvestris* for molasses production because of its high market demand, its multipurpose usage, naturally grown in the study area, control soil erosion, no management cost with least shade effect on the crops. Generally, *P. sylvestris* is not usually planted, rather it is naturally grown in the cropland and found abun-

**Table 6.** Farmers' Preferences of Tree species in CAF Farm

| Tree species | Percentage of CAF farmers | | | | | |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | TPR |
| *P. sylvestris* | 15 | 17 | 12 | 7 | - | 48 |
| *S. macrophylla* | 21 | 24 | 21 | 2 | - | 67 |
| *M. indica* | 17 | 15 | 12 | 5 | - | 48 |
| *C. nucifera* | 14 | 14 | 15 | 1 | - | 43 |
| *A. heterophyllus* | 1 | 1 | - | 14 | - | 09 |
| *Z. nummularia* | 12 | 12 | 10 | 5 | - | 37 |
| *L. cinensis* | 7 | 8 | 12 | 15 | - | 33 |
| *K. anthotheca* | 3 | 7 | 5 | 7 | - | 18 |
| *S. saman* | 1 | 1 | 2 | 17 | - | 12 |
| *A. catechu* | 3 | - | 1 | 12 | - | 11 |
| *B. flabellifer* | 3 | - | 7 | 10 | - | 14 |
| *Albizia spp.* | 3 | 1 | 3 | 5 | - | 10 |
| Total | 100 | 100 | 100 | 100 | - | 350 |

N.B.: A=Mostly preferred, B=Very preferred, C=Preferred, D=Less preferred, E=Least preferred.
Source: Authors' compilation based on field survey (2013).

**Table 7.** Farmers' Preferences of Agriculture Crops in CAF Farm

| Agriculture Crops | Percentage of CAF farmers | | | | | |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | TPR |
| *Oryza spp.* | 15 | 12 | 17 | 24 | - | 56 |
| *C. longa* | 32 | 36 | 22 | - | - | 92 |
| *S. melongena* | 12 | 8 | 15 | 17 | - | 43 |
| *Colocasia esculenta* | 6 | 10 | 8 | 5 | - | 26 |
| *A. campanulatus* | 10 | 12 | 10 | 3 | - | 33 |
| *Momordica charantia* | 4 | 7 | 3 | 12 | - | 20 |
| *Carica papaya* | 7 | 5 | 12 | 6 | - | 26 |
| *Musa paradisica* | - | - | 5 | 8 | - | 08 |
| *Capsicum species* | 1 | - | 3 | 12 | - | 09 |
| *Abelmoschus esculentus* | 3 | 5 | 1 | 3 | - | 11 |
| *Amaranthus lividus* | 5 | 3 | 1 | 5 | - | 13 |
| *Others vegetables* | 5 | 2 | 3 | 5 | - | 13 |
| Total | 100 | 100 | 100 | 100 | - | 350 |

N.B.: A=Mostly preferred, B=Very preferred, C=Preferred, D=Less preferred, E=Least preferred.
Source: Authors' compilation based on field survey (2013).

dantly in the survey area. Most of the farmers just have kept it in their field with other crops and nursing the naturally growing trees for future benefits. Abedin et al. (1987) also found that *P. sylvestris* grows abundantly in the crop fields of both highland and mid-elevation sites in Bangladesh. Similarly, *M. indica* (48 percent) and *C. nucifera* (43 percent) are also preferred by cropland agroforest farmers because of its multipurpose usage and economic profitability. However, in case of agriculture crops, Hasanuzzaman et al. (2014b) finds that 95 percent preferred *Oryza spp*, 42 percent preferred *S. melongena*, 52 percent preferred *Lens culinaris*, 42 percent preferred *Capsicum frutescens* and 66 percent preferred *Musa* spp. in their study area. The purpose of preference of the identified agriculture crops in our study is that these are well grown in association with trees in the same land and require low management cost.

### *Farmers' perception towards different components of CAF*

Farmers in the study area have good knowledge concerning the relationship that exists between various CAF components when they are grown together. Such knowledge and experience guide them in deciding which tree species to grow or where to plant. In addition, they gain clear ideas of the positive and negative interactions of components in various CAF practices based on their accumulated experience and knowledge. According to the survey, about 76 percent of the respondents have confirmed the existence of a positive interaction between trees and agriculture crops. In contrast, about 24 percent of the respondents have recognized the existence of a negative interaction between trees and agriculture crops. Similarly, Zeleke (2009) finds that 88 percent farmers have confirmed the existence of a positive interaction between trees and agriculture crops, whereas 51 percent of the respondents recognized the existence of a negative interaction between trees and agriculture crops.

According to the responses obtained from the farmers, water and soil conservation is the most positive interaction between trees and crops followed by biomass production (Fig. 2). On the contrary, water competition and providing shade are identified as the important negative interactions between trees and agriculture crops (Fig. 3). Most of the surveyed farmers report that CAF farming system helps to control pests and increase crop production. In contrast, some of the surveyed farmers think that crop yields are reduced when trees are grown in the fields. However, the reduction in crop yield might not be significant up to certain age of the trees. The effects of trees on the crops depend on many factors like density, age and planting configuration of the tree species (BARC 1993). However, such yield loss is supplemented by the yield of fruit, fuel wood, juice and wood. Some respondents think that tree crops in the field act as a habitat of birds and other animals. Moreover, some agriculture crops like *C. longa*, *Alocasia indica* and *A. campanulatus* are well grown under trees and that's why farmers are willing to adopt these mixing land-use systems for maximizing the production and to sustain their livelihood.

### *Economic benefits of CAF farm*

This study finds that the CAF farmers on an average earn more than three times higher income per farm in year 2012, in comparison to that of trees only (Table 8). Specifically, the farmers earn on an average only US$ 415 per farm from trees, whereas they earn on an average US$ 1,459 for practicing trees and agriculture crops together in year 2012 (Table 8). The farmers' income mainly comes

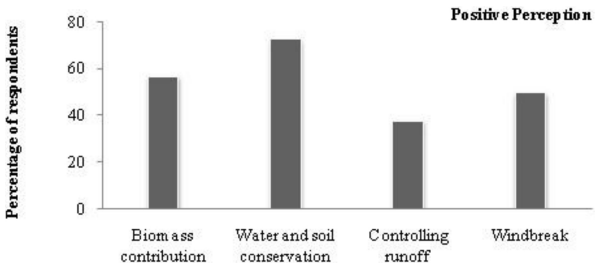


**Fig. 2.** Positive Interaction between Tree and Crop.

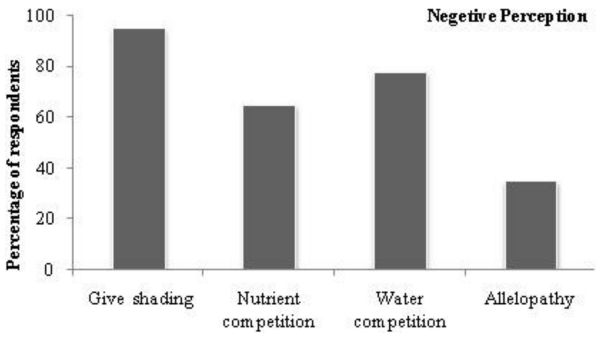


**Fig. 3.** Negative Interaction between Tree and Crop.

**Table 8.** Annual Cash Income from the CAF and NCAF Farm

| Farm type | Item | Income (US$/Year/Farm) | | | |
|---|---|---|---|---|---|
| | | Small | Medium | Large | Average |
| CAF farm (N=42) | Trees | 226 | 382 | 637 | 415 |
| | Agriculture crops | 770 | 868 | 1,493 | 1,044 |
| | Total (a) | 996 | 1,250 | 2,130 | 1,459 |
| NCAF farm (N=42) | Agriculture crops | 943 | 1,027 | 1,766 | 1,245 |
| | Total (b) | 943 | 1,027 | 1,766 | 1,245 |
| Differences (a-b) | | 53 | 223 | 364 | 214 |

Source: Authors' compilation based on field survey (2013).

from selling fruits, juice, trees and agriculture products. Abedin et al. (1987) find that farmers on an average earn US$ 67 per year from the trees in CAF farms.

Table 8 also illustrates that the NCAF farmers earn on an average US$ 1,245 per farm in year 2012. Selling agriculture products is the main source of generating such income. While considering all farms together, this study finds that the yearly cash income difference between CAF and NCAF farmers is US$ 214 on average.

Moreover, most of the CAF farmers report that they require fewer amounts of manure, irrigation and pesticide, because trees itself supply biomass nutrient, protect harmful pests and conserve the soil and water in the farmland. As a result, CAF farmers could maximize their production with lower cost than NCAF farmers. In addition, CAF farmers get more economic benefits than NCAF farmers. Such finding is also supported by the prevailing literature. For example, Chakraborty et al. (2015), Islam (2013), Rahman (2011), Rahman et al. (2007), Rahman and Alam (2007) and Hossain et al. (2005) find that CAF has a good economic rate of return.

## Conclusion

The respondents practice CAF both in traditional and systematic way in the study area. Small land size is the dominant land holding types followed by high elevated land in most cases of the study area. According to the study findings, most of the farmers prefer multipurpose tree species. The surveyed farmers report that they practice CAF to get fuel wood, fodder, juice, fruit and food for family consumption and revenue earnings. About three-fourth of the surveyed farmers endorse the existence of a positive interaction between trees and agriculture crops, while the rest endorse the existence of a negative interaction between trees and agriculture crops. This study finds that CAF farmers on an average earn US$ 214 more per farm per year than the NCAF farmers.

Systematic approach with multipurpose tree species in CAF farm is getting popularity day by day in this region to get the diverse products and services from the integrated land-use system. Moreover, there is a lack of scientific intervention into this growing land-use system until now in the study area. Along with, there is also a great scope of improvement in these land-use systems through scientific research and government intervention, so that farmers can allocate their limited resources in a judicious way to get the best possible returns from their land use system.

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**Appendix 1.** List of Important Cropland Species found in the Study Area

| Local Name | English Name | Scientific Name | Family Name | Types | Origin |
|---|---|---|---|---|---|
| Tree Species | | | | | |
| Mahogany | Mahogany | *Swietenia macrophylla* | Meliaceae | Tree | Exotic |
| Raintree | Raintree | *Samanea saman* | Leguminosae | Tree | Exotic |
| Sil Koroi | Koroi | *Albizia procera* | Leguminosae | Tree | Native |
| Lombu | Nyasaland mahogany | *Khaya anthotheca* | Meliaceae | Tree | Exotic |
| Aam | Mango | *Magnifera indica L.* | Anacardiaceae | Tree | Native |
| Kanthal | Jackfruit | *Artocarpus heterophyllus L.* | Moraceae | Tree | Exotic |
| Kul | Indian Jujube | *Ziziphus nummularia* | Rhamnaceae | Shrubs | Native |
| Khejur | Date palm | *Phoenix sylvestris Roxb.* | Palmae | Tree | Native |
| Lichu | Litchi | *Lichi cinensis Sonn.* | Sapindaceae | Tree | Native |
| Narikel | Coconut | *Cocos nucifera L.* | Palmae | Tree | Native |
| Supari | Betel nut | *Areca catechu L.* | Arecaceae | Tree | Native |
| Tal | Palmyra palm | *Borassus flabellifer L.* | Palmae | Tree | Native |
| Agriculture Crops | | | | | |
| Aman | Paddy | *Oryza spp.* | Graminae | Herbs | Native |
| Begun | Brinjal | *Solanum melongena* | Solanaceae | Shrubs | Exotic |
| Barbati | String bean | *Vigna sesquipedalis* | Leguminosae | Climber | Exotic |
| Chal kumra | Wax gourd | *Benincasa hispida* | Cucurbitaceae | Climber | Exotic |
| Dantashak | Stem amaranth | *Amaranthus lividus* | Amaranthaceae | Herbs | Native |
| Holud | Turmeric | *Curcuma longa* | Zingiberaceae | Herbs | Native |
| Jhal marich | Chili | *Capsicum species* | Solanaceae | Shrubs | Exotic |
| Kola | Banana | *Musa paradisica* | Musaceae | Shrubs | Exotic |
| Mankachu | Giant taro | *Alocasia indica* | Araceae | Herbs | Native |
| Mukhikachu | Eddoe | *Colocasia esculenta (L.)* | Araceae | Herbs | Native |
| Olkachu | Elephant foot aroid | *Amorphophallus campanulatus* | Araceae | Herbs | Native |
| Pat | Jute | *Corchorus capsularis L.* | Tiliaceae | Shrubs | Native |
| Pepe | Papaya | *Carica papaya L.* | Caricaceae | Herbs | Exotic |
| Shasa | Cucumber | *Cucumis sativus* | Cucurbitaceae | Climber | Exotic |
| Karala | Bitter gourd | *Momordica charantia L.* | Cucurbitaceae | Climber | Native |

Source: Authors' Compilation based on Field Survey (2013).

**Appendix 2.** List of Tree Species Planted in Cropland Agroforestry Action Research Plots by VFFP in Northwest Bangladesh and their Survival and Status of Adoption

| Local Name | Scientific Name | Main Observations |
|---|---|---|
| Mahogany | *Swietenia macrophylla* | Survived on SL; good adoption |
| Raintree | *Samanea saman* | Survived on SL; fairly good adoption |
| Sil Koroi | *Albizia procera* | Survival and good growth observed, preferred by farmers but limited option so far, NR observed |
| Kala Koroi | *Albizia lebbeck* | Survival and good growth observed; limited adoption |
| Akashmoni | *Acacia auriculiformis* | Survived on SL & ML; limited adoption |
| Khoir | *Acacia catechu* | No record of survival |
| Mangium | *Acacia mangium* | Survived on SL & ML; limited adoption |
| Babla | *Acacia nilotica* | Survived on SL & ML; limited adoption |
| Tarul | *Albizia chinensis* | No record of survival |
| Neem | *Azadirachta indica* | Survived on SL; limited adoption |
| Shimul | *Bombax ceiba* | No record of survival; NR found |
| Hizal | *Barringtonia acutangula* | No record of survival |
| Minjiri | *Cassia siamea* | Survived on SL; no adoption |
| Jhau | *Casuarina equisetifolia* | Survived on ML; limited adoption |
| Narikel | *Cocos nucifera* | No record of survival |
| Sisso | *Dalbergia sisso* | Survived on SL; good adoption but declining for diseases |
| Eucalyptus | *Eucalyptus camaldulensis* | Survived on SL & ML; good adoption in Bogra |
| Bot | *Ficus bengalensis* | No record of survival |
| Pakur | *Ficus religiosa* | No record of survival |
| Gliricidia | Gliricidia sepium | No record of survival |
| Gamar | *Gmelina arborea* | Survived on SL; limited adoption in Jessore |
| Jarul | *Lagestreomia speciosa* | Survived on SL & ML; no adoption |
| Ipil-ipil | *Leucaena leucocephala* | Survived on SL & ML; limited adoption |
| Bokain | *Melia azedarach* | Survived on SL; good adoption in Dinajpur |
| Bokphul | *Sesbania grandiflora* | No record of survival |
| Jam | *Syzigium cumini* | No record of survival |
| Tetul | *Tamarindus indica* | Survived on ML; no adoption |
| Bohera | *Terminalia bellirica* | No record of survival |
| Arjun | *Terminalia arjuna* | Survived on ML; limited adoption |
| Pituli | *Trewia nudiflora* | Survived on ML; no adoption |
| Albida | *Acacia albida* | Survived on SL & ML; no adoption |
| Moluccana | *Albizia falcataria* | Survived on ML; brittle, no adoption |
| Calliandra | *Calliandra callothyrsus* | Survived on SL; no adoption |
| Barun | *Craeteva religiosa* | No record of survival |
| Ambar | *Liquidambar styracifolia* | No record of survival |
| Asal | *Terminalia alata* | No record of survival |
| Asan | *Terminalia tomentosa* | No record of survival |
| Jigni | *Trema orientalis* | No record of survival |
| Parkinsonia | *Parkinsonia aculeata* | No record of survival |
| Pawlonia | *Paulownia elongata* | No record of survival |

Source: Quddus (2001).

[For Appendix 2, HL=High Land, ML=Medium Land, NR= Natural Regeneration].