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Agroforestry as it Pertains to Vegetable Production in Bangladesh

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Abstract: This study identified the diversity and distribution of tree species and which vegetable crops are grown beneath them, uses of different plants, to identify the problem faced by the farmer and to recommend a suitable small scale mixed production system. The study was conducted in three sub districts of the Gazipur district in Bangladesh. Questionnaires were used for the survey in which a total of 90 households were interviewed. Respondents for the survey were selected based on five different farm categories, i.e. tenant, marginal, small, medium and large farm. Among the different aspects, 80% of the respondents would like to have training on the proper management practices of trees followed by species selection (43%). A total of 43% useful tree plant species (fruit and timber) were identified from the home gardens of the study area. The most common species in the study area was jackfruit (*Artocarpus heterophyllus*, 26.3%) and mango (*Mangifera indica*, 22.5%) followed by mahogany (*Swietenia mahagoni*, 10.3%), coconut (*Cocos nucifera*, 10.0%), teak (*Tectona grandis*, 9.7%), while low prevalence species was minjiri (*Cassia siamea*, 0.03%), gora neem (*Melia azadirch*, 0.18%) and tamarind (*Tamarindus indica*, 0.19%). Based on diversified uses/services, the major fruit species were jackfruit, mango and coconut. The major timber species were koroi (*Albizia procera*), raintree (*Samanea saman*), neem (*Azadirachta indica*), teak (*Tectona grandis*) and eucalyptus (*Eucalyptus* spp.). Diversity and abundance of fruit species was found higher (Shannon's diversity index, H=7.25) in all farm categories followed by timber species (H=4.83). A total number of 43 plant species were identified in the homestead of the study area of which 28 were horticultural and 15 were timber and fuelwood producing species. Total income was found to increase with increase of farm size. A large number of vegetables (32 species) are cultivated in the study area, largely for local consumption. The study showed that stem amaranthus, indian spinach, aroids, sweet gourd, chili, turmeric, eggplant and radish were grown under shade of jackfruit, mango, date palm, litchi, mahogany and drumstick trees. Country bean, bitter gourd, sponge gourd and cowpea were found to grow as creeper on jackfruit, mango, litchi, mahogany and drumstick trees. Farmers earned cash income by selling trees and vegetables produced in the homestead. The total income from trees in the last five years was higher in the large farm category (BDT 22458) than that in the tenant category (BDT 6150). The total income was found to increase with increase of farm size. Among different tree species, jackfruit was identified as an important cash generating crop in the study area. Scopes for improvement of tree management practices were prevalent in the study area. Most of the farmers prefer fruit trees over fuel/timber species. The major problems faced by the farmers in tree establishment were damage caused by animals which was reported by 68% of the respondents. Insect pest was also another common constraint (27% respondents), they added.

Key words: Agroforestry, constraints, homegarden, sustainable agriculture, species diversity

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INTRODUCTION

Small scale agriculture plays an important role in the Bangladesh economy. It provides nearly 50% of cash flow to the rural poor[1,2]. Due to increasing population, the land holdings are being fragmented and areas devoted to small scale agriculture is decreasing[3]. It is important that small scale agriculture be maintained so that sustainable local vegetable production is continued in Bangladesh. Small scale production areas must be managed in sustainable manner.

There is rapidly growing recognition in both industrialized and developing nations of the need to concentrate on developing and maintaining sustainable agricultural systems aimed at meeting food requirements without causing further damage to the environment or the natural resource base on which agricultural depends. The goal of sustainable agriculture should be to maintain production at levels necessary to meet the increasing needs and aspirations of an expanding world population without degrading the environment[4].

Agroforestry can provide a sound ecological basis for increased crop and animal productivity, more dependable economic returns and greater diversity in social benefits on a sustained basis[5,6]. It helps to overcome shortcomings of traditional agriculture that are often characterized by low output at the cost of relatively high investment, resulting in a deteriorating of environment. Lundgren and Raintree[7] stated that agroforestry is a collective name for all land use systems and technologies where woody perennials 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[8-10].

Small scale vegetable production has been shown to be a source of additional income, because the household can sell a portion of the garden's produce[11,12]. Studies suggest that this additional income is generally utilized to purchase supplementary food items, further increasing the diversification of the family's diet. Small scale production of vegetables is especially important in overcoming seasonal availability of foods and promoting household self-sufficiency[13-15]. The objective of the study was to find out the structure and diversity of small scale agriculture in Bangladesh and determine how it applies to vegetable production.

MATERIALS AND METHODS

Geographical location of study area: Bangladesh is located between 20°34' and 26°3' North latitude and between 88°01' and 92°41' East latitude. It is boarded by the Bay of Bengal on the South and by India on all other sides and for a short distance in the south-east with Myanmar (Fig. 1).

The study was conducted in nine villages of Gazipur Sadar, Kapasia and Kaliakair sub-district in the Gazipur district (Fig. 2) where located in Bangladesh. The study is located in the central part of Bangladesh and covers a total area of 1762.72 km^2. The distances from district headquarter to the study villages are 11, 20 and 25 km, respectively. The total number of households, average size of household and literacy rate in the study district are 196, 169, 5 and 45%, respectively[16,17].

Site selection and sampling procedure: The research was carried out in the Gazipur district. There are five sub districts in the Gazipur district and three of there Gazipur Sadar, Kaliakor and Kapasia (Fig. 2) were selected as the study site. Nine villages were selected from each of the sub-districts using multistage sampling. All households of the nine villages were grouped into five farm categories i.e. tenant, marginal, small, medium and large according to Abedin and Quddus[18].

A sample of 90 households were selected, thirty from each sub-district, with equal assignment to each farm category by stratified random sampling.

Questionnaire development: In order to obtain relevant information a questionnaire containing both open and closed form of questions was administered through personal interviews.

Data collection: Data were collected with the help of inspectors of the Bangladesh Agricultural Development Corporation and Upazilla Agriculture Officer and of the Department of Agricultural Extension. To obtain valid and pertinent information all possible efforts were made to explain the purpose of the study to the respondents. Appointments with the interviewer were made in advance with the help of local leaders. Data were collected from January to June in 1998.

Data analysis: Data were coded for processing and analysis. Some statistical and mathematical analysis was

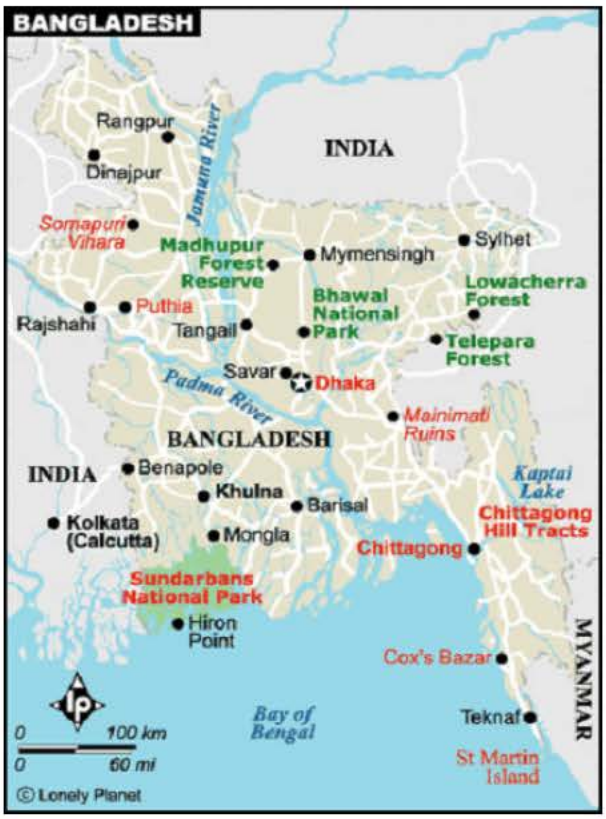

Fig. 1: Map of Bangladesh. Study area was in Gazipur District (former Dhaka district)

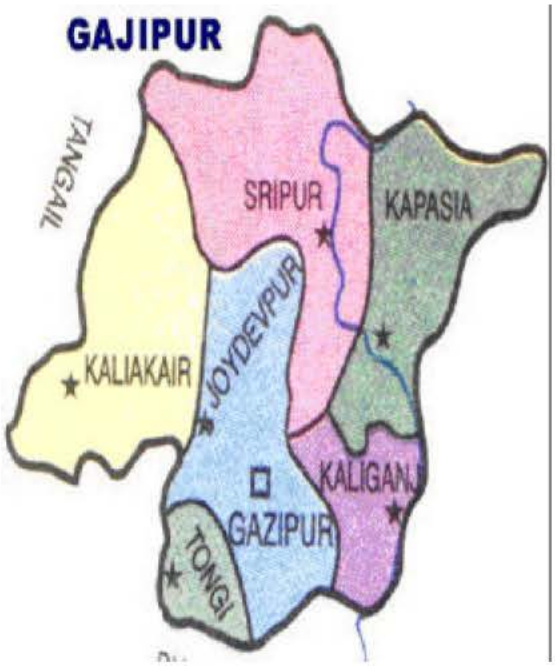

Fig. 2: Map of Gazipur district. Study area was in the Gazipur Sadar, Kapasia and Kaliakair sub-districts

done with ranking. Survey findings were compared on the basis of farm size categories. Relative Prevalence (RP) of tree species was determined by multiplying the number of trees per farm by the percentage of farm containing that species. It was calculated by the following statistics:

Relative Prevalence (RP) =Number of trees/farm x % farm with species

Species diversity was expressed by species diversity index according to Shannon-Wiener Index (H'). It was calculated as follows:

$$H' = -\sum_{i=1}^{3} (p_i)(\log_2 p_i)$$

where, H = information content of sample, index of species diversity, or Degree of Uncertainty, s = number of species pi = proportion of total sample belonging to ith species. Pi is the proportional abundance of the ith species such that Pi=n/N (n is the number of individuals in the ith species and N is the total number of individuals of all species in the community).

RESULTS AND DISCUSSION

Training needs: About nine different aspects in relation to homestead tree management have been identified where training are needed. Among the different aspects, 80% of the respondents would like to have training on the proper management practices of trees followed by species selection (43%), site selection (41%), disease identification (20%) and pest control (19%) (Table 1).

Table 1: Farmers responses for their training needed

Types of training needed	% respondent
Management practices	80
Species selection	43
Site selection	41
Disease identification	20
Pest and disease control	19
Seedling raising	18
Grafting technique	16
Time of planting	13
Fertilization	11

Table 2: Farmers planning to grow trees in future in Gazipur district to their homesteads

Farm category	Percent (%) of respondents			
	Gazipur Sadar	Kaliakair	Kapasia	Mean
Large	100	88	100	96.0
Medium	90	100	100	96.7
Small	100	98	95	97.7
Marginal	86	92	92	90.0
Tenant	55	66	63	61.3

Table 3: Problems/constraints faced by farmers in establishing and raising trees

Problems	Percent (%) of respondent			
	Gazipur Sadar	Kaliakair	Kapasia	Mean
Animals	65	71	68	68
Insect/pest	21	27	32	27
T. Storm	20	19	23	21
Children	13	16	19	16
Technical	18	13	15	15
Stolen	13	15	18	15
Strong wind	10	8	8	9
Postharvest ope	7	12	9	9
Conflict	11	9	8	9
Shade	9	7	8	8
No problem	6	9	7	7
Space	2	4	5	4

Planning to grow new trees in the homestead in future: Choice of tree species for planting in the homestead area is determined by values of the products, farmer's choice and perceptions. In this study, all farmers group opined to grow trees in their homesteads. On an average, 97.7% of farmers in small farm category was expressed their opinion to grow trees in their homestead followed by farmers in medium farm category (96.7%). Large farm category (96.0%), marginal farm category (90.0%) and landless farm category (61.3%) (Table 2).

Problems faced by the farmers in tree establishment: The major problem faced by the farmers in tree establishment was the damage caused by animals (Table 3). Animals, which are very essential for draft purpose and post harvest operations, damaged leaves and branches of trees and trample the seedlings are young trees. Seedlings are also damaged by children and by storm. Farmers reported more damage by animals and insect pest in the homesteads. Strom was also reported to cause damage to the trees. In the homesteads trees obstructed ventilation or fresh air, caused difficulties in post harvest operation of crops and were in some cases a source of conflict with neighbors. Trees also damaged roofs of houses during rain and storm. Seven percent of the farmers said that they had no problem in the homestead.

Use of homestead trees: The utilities or services of tree species grown in the homesteads are shown in Table 4. It was observed that every species of tree in homestead has multiple uses. The major uses of the tree grown on the homesteads were for fruit, timber, fuel, furniture and construction materials. The minor uses were for fodder, to make agricultural implements and support to creepers. Based on diversified uses/services, the major fruit species were jackfruit (*Artocarpus heterophyllus*), mango (*Mangifera indica*), coconut (*Cocos nucifera*), black berry (*Syzygium cumini*), jujube (*Zizyphus jujube*), tamarind (*Tamarindus indica*), etc. The major timber species were koroi (*Albizia procera*),

Table 4: Different uses of homestead tree species

	Uses							
Tree species	Fmit	Timber	Fuel	Fodder	Furniture	Implements	Creepers	Construction
Jackfruit	***	***	*	**	***	*	*	**
Mango	***	**	***	-	*	-	*	**
Coconut	***	-	**	-	-	-	*	**
Betelnut	***	-	*	-	-	-	*	**
Lemon	***	-	**	-	-	-	*	**
Palmyra palm	**	-	-	-	-	-	-	***
Jujube	***	*	*	*	-	*	**	-
Black berry	**	**	*	-	**	*	*	**
Wood apple	***	-	**	-	-	-	*	-
Litchi	***	-	**	-	-	-	*	-
Custard apple	**	-	**	*	-	-	*	-
Papaya	***	-	-	-	-	-	-	-
Sopeta	***	-	*	-	-	-	-	-
Tamarind	*	-	**	-	*	**	-	*
Pomegranate	***	-	*	-	-	-	-	-
Bey leaf	-	-	*	-	-	-	-	-
Pummelo	***	-	-	-	-	-	*	*
Guava	***	-	*	*	-	*	-	-
Carambola	**	-	*	-	-	-	-	-
Olive	**	-	*	-	-	-	-	-
Embilica	**	-	-	-	-	-	-	*
Elephant apple	***	-	*	-	-	-	-	-
Hog plum	**	-	*	*	-	-	*	*
Bullock's heart	***	-	-	-	-	-	-	-
Gab	*	-	*	-	-	-	-	***
Date palm	*	-	*	-	-	-	*	*
Bamboo	-	**	*	-	-	**	*	***
Banana	***	-	*	*	-	-	-	-
Babla	-	**	**	**	-	***	**	*
Koroi	-	***	**	-	***	-	-	***
Raintree	-	***	**	-	***	-	-	***
Neem	-	***	**	-	***	**	*	***
Teak	-	***	**	-	***	-	-	***
Eucalyptus	-	***	**	-	***	*	*	*
Sisso	-	***	**	-	***	*	*	*
Debdaru	-	*	*	*	*	*	*	*
Krishnachura	-	*	**	-	-	-	-	*
Minjiri	-	**	**	-	*	*	-	*
Akasmoni	-	**	**	-	*	*	-	*
Simul	-	**	**	-	**	*	-	**
Gozari	-	***	**	-	*	*	-	*
Mahagoni	-	***	**	*	***	**	-	*
Drumstick	***	-	*	*	-	-	**	-

***Very important use (>70%); **Moderate important use (50-69%); *Less important use (<50%)

Table 5: Types of homestead tree management

	Respondents	
Types of management	Number	Percentage (%)
Pruning	77	85
Weed control	53	59
Manure and fertilization	20	22
Mulching	20	22
Insecticide spray	4	4
Irrigation	3	3

Table 6: Total income from tree products during the last five years

	Farm		
Farm category	Number	Percentage (%)	Income (Taka/farm)*
Landless	10	56	6180
Marginal	13	72	6354
Small	13	72	8700
Medium	15	83	14560
Large	17	94	22458
Mean	14	77	11650

* 1 Bangladeshi Taka (BDT) = 0.01725 US Dollar (USD); subject to change

raintree (*Samanea saman*), neem (*Azadirachta indica*), teak (*Tectona grandis*), eucalyptus (*Eucalyptus* spp.), sisso (*Dalbergia sissoo*), mahagoni (*Swietenia mahagoni*) etc.

Tree management practices: Among tree management practices pruning (85%) was found to be an important tree management practices in the homestead (Table 5). The second management practice was weed control followed by 59% of the households mainly during seedling establishment. Application of manure and use of chemical fertilizer were also practiced by 22% household which were mostly limited to pit preparation, to seedling establishment. The tendency of using manures and fertilizers was relatively higher with rich farmers (medium and large) than with the poorer ones (landless, marginal and small). Irrigation was applied in a very limited scale

Table 7: Tree species found in the homestead and their Relative Prevalence (RP)

Scientific/botanical name	Local/common name	Relative Prevalence (RP)
Artocarpus heterophyllus	Jackfruit	26.28
Mangifera indica	Mango	22.53
Swietenia mahagoni	Mahagoni	10.35
Cocos nucifera	Coconut	9.93
Tectona grandis	Teak	9.68
Psidium guajava	Guava	8.19
Litchi cheneusis	Litchi	5.65
Borasus flabellifer	Palmyra palm	5.06
Aegle murmelos	Wood apple	5.06
Syzygium cumini	Black berry	4.63
Eucalyptus spp.	Eucalyptus	4.48
Phoenix sylvestris	Date palm	3.78
Bambusa spp.	Bamboo	3.69
Pnnica granatum	Pomegranante	3.66
Musa sapientum	Banana	2.86
Averrhoa carambola	Carambola	2.37
Zizyphus jujuba	Jujubi	2.00
Citrus limon	Lemon	1.93
Azadirachta indica	Neem	1.83
Achras sapota	Sapota	1.73
Elaeocarpus floribnndus	Olive	1.56
Albizia procera	Koroi	1.43
Moringa oleifera	Dmmstick	1.36
Areca catechu	Betelnut	1.31
Citrus grandis	Pummelo	1.09
Samanea saman	Raintree	1.08
Dalbergia sisso	Sissoo	0.86
Spondias mangifera	Hoghplum	0.75
Feronia limonia	Elephant apple	0.61
Acacia nilotica	Babla	0.58
Phyllanthus emblica	Embilica	0.54
Diospyros peregrina	Gab	0.49
Delonix regia	Krishnochura	0.48
Acacia anriculiformis	Akasmoni	0.43
Polyalthia longifolia	Debdaru	0.43
Shorea robusta	Gazari/Shal	0.43
Annona reticulata	Bullock's heart	0.41
Annona squamosa	Custard apple	0.38
Cinnamomem tamala	Bey leaf	0.30
Bombox ceiba	Shimul	0.21
Tamarinadus indica	Tamarind	0.19
Melia azadirch	Gora neem	0.18
Cassia siamea	Minjiri	0.03

(3%) during seedling establishment only. Therefore, immense scope and prospects do exits for increasing the productivity of the homestead area through improved practices such as manuring, fertilization, mulching, pruning, pollarding etc.

Tree products and income from trees: Trees in the homestead generate income to the farmers. The study showed that the average income generated during the last five years from homestead tress was 116,500 BDT (Bangladesh Taka) per farm. The income of the landless farmers from trees was much lower than the income of the other farm categories (Table 6). The lower income of the farmers from tree products was probably due to lower number of trees in the homestead.

Relative prevalence of tree species grown in homestead: A total of 43 tree species were identified in the surveyed homesteads. The Relative Prevalence (RP) of tree species found in the study area is shown in Table 7. The most common species in the study area was jackfruit (26.3) and mango (22.5) followed by mahogany (10.3), coconut (10.0), teak (9.68), guava (8.19), while low prevalence species was minjiri (0.03), gora neem (0.18), tamarind (0.19), shimul (0.21) and beyleaf (0.30). The dominance of jackfruit (*Artocarpus heterophyllus*) and mango (*Mangifera indica*) was found in almost all the farm categories. The dominance of jackfruit and mango in the study area was probably due to ecological and socio-economic advantages. There were minor differences in relative prevalence of less common species.

Tree crop association: In the study area, different combinations of tree-vegetable associates were recorded (Table 8). A total 32 of vegetables were found to grow in association with trees either under direct shade or as

Table 8: Horticultural crops associated with major tree species in the homesteads

Tree species	Vegetable grown under trees		Creeper vegetables grown using trees as trellis	
	Major	Minor	Major	Minor
Jackfruits	Aroids, Chili, Turmeric, Sweet gourd	Indian spinach, cowpea	Sponge gourd, Ribbed gourd	Country bean
Mango	Amaranthus, Spinach, Turmeric, Aroids, Country bean	Bitter gourd, Cowpea, Zinger	Sponge gourd	Bitter gourd, Ribbed gourd
Date palm	Spinach, Amaranthus	Turmeric, Aroids, Bitter gourd	-	-
Coconut	Amaranthus, spinach, turmeric, aroids, radish	Egg plant	-	Sponge gourd
Jujube	Amaranthus	Spinach, Turmeric	Country bean	Sweet gourd
Litchi	-	Amaranthus, Spinach, Radish	-	-
Mahogany	-	Amaranthus, turmeric	-	Country bean
Koroi	-	Amaranthus, Egg plant	-	-
Sisso	Amaranthus	Sweet gourd, Egg plant, Ribbed gourd	-	-
Babla	-	-	-	Country bean
Drumstick	-	Amaranth, Pointed gourd	-	Country bean

Table 9: Vegetables grown in the study area and their uses

Common name	Scientific name	Family	Plant type	Uses
Lal shak	*Amaranthus gangeticus*	Amaranthaceae	Herb	Vegetable and fodder
Danta	*Amaranthus gangeticus*	Amaranthaceae	Herb	Vegetable and fodder
Taro	*Colocasia antiquorum*	Araceae	Herb	Vegetable
Mukhi Kachu	*Colocasia esculenta*	Araceae	Herb	Vegetable
Papaya	*Carica papaya*	Caricaceae	Herb	Vegetable, medicinal and fruit
Spinach	*Beta vulgaris*	Chenopodiace	Herb	Vegetable
Indian spinach	*Basella rubra*	Chenopodiace	Herb	Vegetable
Helencha	*Enhydra fluctuans*	Compositae	Herb	Vegetable
Kang kong	*Impomoea replans*	Convolvulaceae	Herb	Vegetable fodder
Radish	*Raphanus sativus*	Criciferae	Herb	Vegetable
Cabbage	*Brassica oleraceae* Var. *capitata*	Cruciferae	Herb	Vegetable, salad and fodder
Cauliflower	*Brassica oleraceae* Var. *botrytis*	Cruciferae	Herb	Vegetable and salad
Knolkhol	*Brassica oleraceae* Var. *canorapa*	Cruciferae	Herb	Vegetable
Pumkin	*Curcurbita moschata*	Cucurbitaceae	Herb	Vegetable
White gouard	*Benincasa hishida*	Cucurbitaceae	Herb	Vegetable
Snake gouard	*Trichosanthes anguina*	Cucurbitaceae	Herb	Vegetable
Ribbed gouard	*Luffa acutangula*	Cucurbitaceae	Herb	Vegetable
Cucumber	*Cucumis sativus*	Cucurbitaceae	Herb	Vegetable and salad
Pointed gouard	*Trichosanthes dioica*	Cucurbitaceae	Herb	Vegetable
Bitter gouard	*Momordica charantia*	Cucurbitaceae	Herb	Vegetable
Kankrol	*Momordica dioica*	Cucurbitaceae	Herb	Vegetable
Bath Sponge	*Luffa cylindrica*	Cucurbitaceae	Herb	Vegetable
Bottle Gourd	*Lagenaria siceraria*	Curcurbitaceae	Herb	Vegetable
String bean	*Vigna sineusis*	Leguminosae	Herb	Vegetable
Country bean	*Lablab* sp.	Leguminosae	Herb	Vegetable
Okra	*Abelmoschus esculeutus*	Malvaceae	Herb	Vegetable
Drumstick	*Moringa oleifera*	Moringaceae	Herb	Vegetable and fuelwood
Plantain	*Musa paradisiaca*	Musaceae	Herb	Vegetable, fruit and medicinal plants
Eggplant	*Solanum melongena*	Solanaceae	Herb	Vegetable
Tomato	*Lycopersicon esculentum*	Solanaceae	Herb	Vegetable and salad
Potato	*Solanum tuberosum*	Solanaceae	Herb	Vegetable
Jute leaf	*Corchorus capsularis*	Tiliaceae	Herb	Vegetable and fuelwood

creeper. The vegetables grown under direct shade were food and cash generating plants and the associated trees were jackfruit, mango, date palm, coconut, jujube, litchi, mahogany, koroi, sissoo, babla, drumstick etc. It was reported that growing vegetables under trees have been benefited the associated trees.

Vegetable species of the traditional homestead in Gazipur District: A total 32 species of vegetables were found to grow in the study area but largely for their own consumption (Table 9). Most of the vegetables were uses as vegetable and salad. Some vegetables were also used as medicinal plant and fruit crops (i.e. Papaya and plantain). Cabbage, cauliflower, tomato, bottle gourd, pumpkin and cucumber were the most important vegetables which were grown in the study area (personal communication with farmers, data not shown).

RECOMMENDATIONS

In spite of the immense scope and prospects of the homegardens, no systematic program has so far been under taken to improve their productivity of the homegarden. In order to bring in a positive change in the productivity of the homegardens, the following recommendations are made on the basis of the findings of

the current study: The homegarden system can be improved by proper care management practices, more research performance, cooperative and extension services etc. and replace the low economic value crops by high economic value crops. This will ensure sustainable production for the poor farmers of Bangladesh. Efforts should be made to make the rural farmers aware of the appropriate planning and management of the homesteads and to provide them necessary training and other technical supports for these purposes. Agro based industry should be built for more income generating activities. Since jackfruit (*Artocarphus heterophyllus*) is a multi purpose fruit tree commonly found in all locations, a food process industry can be made on the basis of jackfruit production and utilization. The efforts should be made to identify different shade tolerant vegetables and to motivate and train the farmers to increase the vegetable production of the study area and to cultivate them under the trees in the homestead. Women work efficiency should be increased by training, education and extension supports since they are mainly involved in home gardening. Future research must address many factors which constrain or limit the achievement of sustainability objectives. Addressing such constraints will require efforts in such areas as:

1. The conservation, evaluation and use of germplasm in genetic improvement efforts with crops and livestock.
2. Crop management, including fertilizer use, pest control and various cultural practices.
3. The development of improved and more intensive systems that might evolve from traditional, indigenous systems.
4. Soil and water management, effective and efficient use of irrigation water, etc.
5. The management of homestead gardens, animal systems, including animal health and nutrition.

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