

Research paper

Diversity and management of homestead resources: The case of Sandwip Upazila, Chittagong, Bangladesh

Mahmuda Jahan¹, Md. Arif Chowdhury^{2*} and Shahpara Nawaz¹

Jahan, M., Chowdhury, M.A., Nawaz, S. 2022. Diversity and management of homestead resources: The case of Sandwip Upazila, Chittagong, Bangladesh. – Forestry Studies | Metsanduslikud Uurimused 77, 38–55, ISSN 1406-9954. Journal homepage: <http://mi.emu.ee/forestry.studies>

Abstract. Homestead resource utilization is widespread in Asia, while centuries of traditional approaches have been increasing throughout South Asia. Homestead resources are vital to maintaining sustainable life and livelihood of local people in Bangladesh and people in remote areas as coastal zones are mostly engaged with their homestead resources. The study was conducted in Sandwip Upazila (sub-district) of Chittagong district to assess the diversity of plant species, species richness, homestead management practices, and their contribution to the socio-economic condition of the rural households. Ninety household interviews were conducted using a semi-structured questionnaire following stratified sampling to fulfill objectives. A total of 57 tree species under 28 families, including timber, fruits, fuel wood, and multi-purpose tree species were found in the study area. Among the identified 57 tree species under 28 families, 49% are fruit species, while the mean value of Shannon-Wiener Index and evenness of species were 3.32 and 1.89, respectively. Also, the Species Richness Index for Maitbhanga and Sarikait unions was 15.20 and 15.36, respectively, while 52% of the respondents identified market or private nurseries as their source of planting materials. Besides, 71.11% of the respondents replied that protection measures are taken for protecting planting seedlings, while seedlings were used mostly for a better survival rate. Damaged by animals, storms, and pests were identified as most problems faced by households in homestead resource management. This study may help policymakers, including local communities to take proper necessary actions to ensure sustainable management of diversity of homestead resources in local areas of Bangladesh.

Key words: Bangladesh, diversity, homestead forest, management, resources.

Authors' addresses: ¹Institute of Forestry and Environmental Sciences, University of Chittagong, Chittagong-4331, Bangladesh; ²Department of Climate and Disaster Management, Jashore University of Science and Technology, Jashore 7408, Bangladesh; *e-mail: arifchowdhury065@gmail.com

Introduction

Homestead is an area adjoining a household, where a diversified combination of perennial and annual plant species are

cultivated, often in association with livestock farming, and mostly maintained by household members for the sustenance of food supply and livelihood (Mekonen *et al.*, 2015). Homesteads comprise several

DOI: 10.2478/fsmu-2022-0011



© 2022 by the authors. Licensee Estonian University of Life Sciences, Tartu, Estonia. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

layers of vegetation, ranging from herbs and vegetables to shrubs and large trees, and typically include domestic and wild animal components (Castañeda-Navarrete, 2021). In addition, homesteads involve a traditional method of land use and are considered one of the socially accepted and sustainable local solutions that have been extensively implemented by communities with limited resources (Jegora *et al.*, 2019). Also, the homestead forest is one of the significant components of rural economies in the tropical regions of the world (Foysal *et al.*, 2013), and understanding species composition and diversity is one of the prerequisites to ensuring sustainable management of forest resources.

The homestead resources management and utilization approach are widespread in Asia, particularly in India, Sri Lanka, Nepal, and Bangladesh (Kumar *et al.*, 2012; Rahman *et al.*, 2017) through the carefully managed combination of annual and perennial farm crops and livestock within the courtyard of the households. The homesteads meet several social, cultural, and ecological demands, while plant species composition of homesteads varies depending on the meteorological and edaphic conditions of the location and the household's income (Vibhuti *et al.*, 2018). Homestead forests are significant sources of timber, fruits, fodder, fuelwood, and medicinal tree species in South-Asian countries such as Bangladesh (Baul *et al.*, 2021), they help household members to maintain a balanced diet with additional food, fuel, and fodder (Mekonen *et al.*, 2015).

Furthermore, over two-thirds of the total land of Bangladesh is suitable for agricultural activities and homestead areas account for more than three-quarters of all agroforestry activities (Zaman *et al.*, 2010). Around 20 million homestead forests cover 0.27 million hectares amounting to 2% of the total land area and 10% of the natural forest area of the country (Baul *et al.*, 2021; Kabir & Webb, 2008; Rahman *et al.*, 2017). The diverse species of homesteads in Ban-

gladesh fulfill approximately 70% of timber, 70% of fruit, 40% of vegetables, 90% of fuel, 48% of sawn and veneer logs, and over 90% of bamboo requirements of the country (Rahman *et al.*, 2017; Roy *et al.*, 2013). However, as a result of population pressure and the conversion of land for other uses, these homesteads are being overexploited and degraded, resulting in fragmentation (Baul *et al.*, 2021). Additionally, Kabir *et al.* (2016) mentioned that the species composition and diversity of homestead plants in Bangladesh depend on household land area and economic conditions, the household head's expertise, and time spent in management. Studying homestead plant species composition and diversity is necessary to align homestead management with these factors. Besides, improved systematic management of homesteads is needed to prevent exploitation and fragmentation (Baul *et al.*, 2021), thus the homestead resources can be maintained for the betterment of health and economic benefits of the rural communities in Bangladesh.

Sandwip is Chittagong's sole offshore island, which is frequently hit by tropical cyclones and storm surges of varied strengths, as well as abnormally high tides, and saltwater intrusion (Paul & Rahman, 2006). Households are shrinking in size and shape as a result of land erosion caused by rivers, population expansion, and industrialization. Thus, it is vital to understand the present status of homestead resource diversity and management practices of Sandwip. Here, each household's primary livestock component was poultry, followed by goats, cattle, buffalo, and sheep (Alam & Masum, 2005). In addition, because of transportation difficulties with the mainland, people of the offshore island heavily depend on their homestead products. Although several studies were conducted in Bangladesh on homestead forests (Alam & Sarker, 2011; Alam *et al.*, 1996; Das, 1990; Zaman *et al.*, 2010), traditional uses of homestead agroforest (Alam *et al.*, 1990; Millat-e-Mustafa, 1997b; Momin

et al., 1990), and natural forest biodiversity (Chowdhury *et al.*, 2018; Chowdhury *et al.*, 2019; Alam *et al.*, 2019; Rahman *et al.*, 2020; Rahman *et al.*, 2019), no study has been done on homestead forest resource management yet on Sandwip Upazila (sub-district) of Chittagong district, while there is a considerable possibility for developing homestead resources management approaches for conserving biodiversity and ensuring food and livelihood security. Following the background, this study was conducted to understand the diversity of homestead trees or vegetation species. This study also tried to assess the various aspects of the raising and management of different kinds of species in the rural homestead forest or area of the offshore island of Bangladesh. Here, the general objective is to understand the status and diversity of homestead resources along with practice and associated problems in homestead forest management in Sandwip Upazila, Chittagong. In addition, specific objectives are to understand the diversity and distribution of the tree species of the homestead area, including species composition, homestead agroforestry pattern, and problems associated with homestead resources management.

Methodology

Study area

The study was conducted at Sandwip Upazila of Chittagong district in Bangladesh (Figure 1). Sandwip Upazila is an island with an area of 762.42 square kilometers and a total population of 292,773 (BBS, 2012).

The soil is composed of newly formed Meghna estuary floodplain alluvial soil. The maximum and minimum mean temperature is 31.6°C and 25.4°C, respectively, and the average annual rainfall of 3600 mm (Alam & Masum, 2005). Also, the main crops of this area are paddy, potato betel leaf, sugarcane, coconut, nut, palm, and different forms of vegetables.

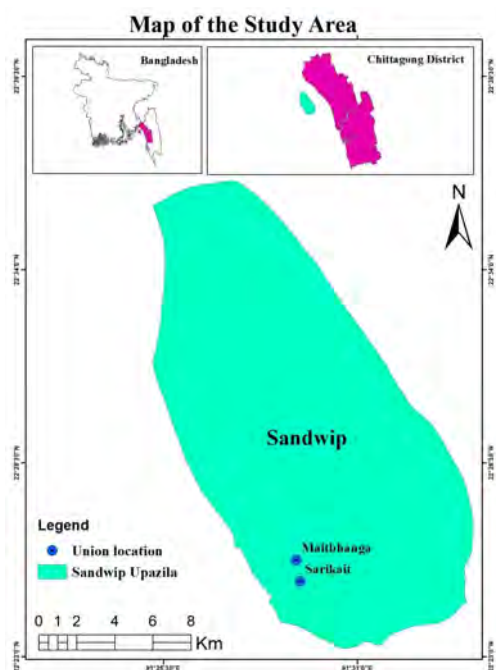


Figure 1. Location of Sandwip Upazila, Chittagong, Bangladesh (study area).

Sampling procedure

Out of 15 unions in Sandwip Upazilla, two unions named Maitbhanga and Sarikait were selected using stratified sampling. From each union, one village was chosen following the same sampling procedure, resulting in a total of two villages: Sarikait and Maitbhanga. Here, due to restrictions on movement during COVID-19, collection of the data was limited within two unions and this study design was prepared accordingly. Also, from the reconnaissance survey, it was understood that the species pattern of the Upazila is somehow the same for the homestead area. Here, one union Sarikait is comparatively close to the sea compared to another union Maitbhanga. The size of a household's homestead was utilized as the basis for stratification. The homestead sizes of the study area were classified into three groups: small, medium, and large. The sizes of small, medium and large homesteads were 0.05–0.14 ha, 0.15–0.20 ha, and >0.20 ha, respectively.

Data collection

A reconnaissance survey was conducted to understand the overall situation of different homestead resources of the study area before the collection of final data. The survey was carried out through a well-defined semi-structured questionnaire. Data or information about the demography of the respondent, income from the household, the status of present homestead resources, and their management of the selected sites were recorded. The data collection was done from December 2020 to February 2021.

A total of 90 households were surveyed, and 45 from each group (i.e. 20 small, 15 medium, and 10 large household groups from each village) were selected to represent the existing scenario. Here, random sampling was followed to conduct the household surveys. All field data were gathered through in-person interviews with household heads specifically from each family. After interviewing the respondents, a physical observation was done by visiting the plots and counting tree species at each homestead, attempting to relate and corroborate with the responses of respondents about the names and number of species.

Data analysis

The collected data were organized by using Microsoft Excel 2013. Before analyzing data, a double check was done to ensure the accuracy of the data. After that, both Microsoft Excel and SPSS (Statistical Package for Social Sciences) software were used to analyze the data following the objectives of this study. Here, species composition, relative density, occurrence frequency, diversity index, and distribution evenness are important attributes for determining the diversity status. The structural characteristics of a tree stand in a homestead were analyzed using various formulae in terms of relative density, the occurrence of tree species, and tree density (Alam & Sarker, 2011). Tree species diversity in the selected homesteads was calculated through the Shannon-Wie-

ner Index of Diversity (Michael, 1990) and Index of Evenness, (E) (Magurran, 1988). Equations of indices are given below,

$$1. \text{Occurrence of a tree species (Frequency)} = \frac{\text{Total number of farms in which the species occur}}{\text{Total number of farms studied}} \times 100$$

$$2. \text{Relative density of a species} = \frac{\text{Total number of individuals of a species in all farms}}{\text{Total number of individuals of all species}} \times 100$$

$$3. \text{The Shannon-Wiener Index of Diversity, } H = -\sum P_i \ln P_i$$

Where, H = Index of species diversity, P_i = No. of individuals of one species / Total no. of individuals in the samples.

$$4. \text{Species Diversity Index, } D = S/N$$

Where, D = Diversity index, S = Total number of species, N = Total number of individuals.

$$5. \text{Species Richness Index, } R = (S-1) / \log N$$

Where, R = Species richness index, S = Total no. of species, N = Total no. of individuals of all the species.

$$6. \text{Species Evenness Index, } E = H / \log S$$

Where, E = Species evenness index, H = Shannon-Wiener index for diversity, S = Total no. of species.

Results

Diversity and Dominance Index of fruit and timber species in homesteads

In the case of the diversity and dominance index of tree species in homesteads, it is observed that the data obtained from the Shannon-Wiener Diversity Index (3.32) showed a higher value which represents more diversity (Table 1). But the index of dominance value for the fruit and timber

Table 1. Diversity and density analysis of the fruit and timber species in Sandwip Upazila.

Parameters	Total	Based on union	
		Maitbhanga	Sarikait
No. of species (S)	57	57	57
No. of individuals (N)	9255	4833	4422
Shannon-Wiener Index of Diversity (H)	3.32	3.30	3.32
Diversity Index (D)	0.006	0.011	0.012
Index of Dominance (ID)	0.06	0.06	0.06
Species Richness Index (R)	14.12	15.20	15.36
Species Evenness Index (E)	1.89	1.88	1.89

Table 2. Vegetable species found in the homesteads of Sandwip Upazila.

All year	Summer vegetable	Winter vegetable	Spices
<i>Carica papaya</i>	<i>Trichosanthes anguina</i>	<i>Dolichos lablab</i>	<i>Capsicum annum</i>
<i>Colocasia indica</i>	<i>Abelmoschuses culentus</i>	<i>Vigna sinensis</i>	<i>Curcuma longa</i>
<i>Dioscorea alata</i>	<i>Basella rubra</i>	<i>Legenaria siceraria</i>	<i>Zingiber officinalis</i>
-	<i>Luffa acutangula</i>	<i>Cucurbita maxima</i>	-
-	<i>Cucumis sativus</i>	-	-
-	<i>Momordica charantea</i>	-	-
-	<i>M. cochinchinensis</i>	-	-

species of the study area was 0.06 which represents less dominancy of the tree species. The calculated value of the Species Richness Index was 14.12 which represents more richness of tree species and the total number of individuals distributed among all possible tree species.

In addition, a similar number of species (57) was found in both the Maithbhanga and Sarikait unions, while a higher number of total individuals was found in the Maitbhanga union than in Sarikait. In the case of the Shannon-Wiener Diversity Index, Diversity Index, Species Richness, and Evenness Index the associated value was higher for the Sarikait union, representing more diversity than in the Maitbhanga union.

A total of 17 vegetable species were found to be grown on a homestead several times around the year of which 3 species (*Carica papaya* L., *Colocasia indica* (Lour.) Kunth, *Dioscorea alata* L.) were grown around the year (Table 2). Also, three species e.g. *Capsicum annum* L., *Curcuma lon-*

ga L., and *Zingiber officinalis* Roscoe were identified as spices in the homesteads of Sandwip Upazila. In addition, there were seven and four vegetables identified as summer and winter vegetable spices, respectively in the homesteads of Sandwip Upazila.

Besides, three exotic timber species i.e. akashmoni (*Acacia auriculiformis* A. Cunn. ex Benth.), mahogany (*Swietenia mahagoni* (L.) Jacq), and gamar (*Gmelina arborea* Roxb.) were found in the study area. Akashmoni was the most abundant species (Relative Density 3.77, Table 4), while gamar was the least abundant species.

Homestead resources and diversity Types of fruit and timber species

In terms of tree species in the homesteads, 57 tree species under 28 different families consisting of timber, fruits, fuel wood, and multi-purpose tree species were identified, while multi-purpose tree species provide different kinds of resources like timber,

Table 3. Families with number of Species observed in the study area.

SI.	Family name	No. of species (n)	SI.	Family name	No. of species (n)
1	Anacardiaceae	3	15	Lythraceae	1
2	Annonaceae	4	16	Malvaceae	1
3	Arecaceae	2	17	Meliaceae	2
4	Averrhoaceae	1	18	Mimosaceae	1
5	Caricaceae	1	19	Moraceae	3
6	Casuarinaceae	1	20	Moringaceae	1
7	Combretaceae	2	21	Musaceae	1
8	Dilleniaceae	1	22	Myrtaceae	4
9	Ebenaceae	1	23	Oxalidaceae	1
10	Elaeocarpaceae	1	24	Rhamnaceae	1
11	Euphorbiaceae	2	25	Rosaceae	1
12	Leguminosae	9	26	Rubiaceae	1
13	Guttiferae	1	27	Rutaceae	5
14	Lamiaceae	1	28	Sapindaceae	1

fruits, fuel wood, etc. (Table 3). Among all of the families, the majority (n=9) of the tree species were from the Leguminosae family, and the identified second largest (n=5) family was Rutaceae.

On the other hand, among 57 tree species, 49% were fruit species (Figure 2). Most of the homestead respondents concentrate on fruit species because of their subsistence and cash need. Next to fruit species people focus on fuel wood (18%) for their daily basis cooking purposes. The least percentage of species were observed as medicinal species (3%).

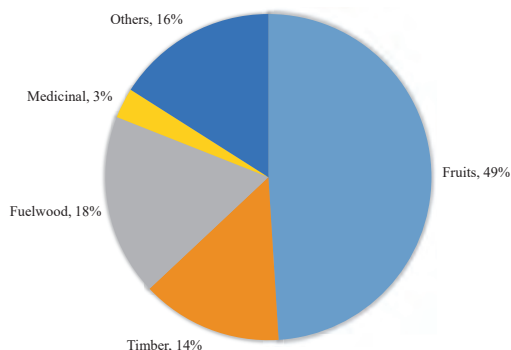


Figure 2. Percentage distribution of fruit and timber species based on their types.

The category of large farms contained the greatest number of fruit and timber species (n=49), while the category of small farms contained the lowest number of species (n=36).

Frequency and relative density of fruit and timber species

Among the different kinds of fruit tree species, the frequency of fruit species supari (*Areca catechu* L.), narikel (*Cocos nucifera* L.), and am (*Mangifera indica* L.) is higher in both unions. In the Matibhanga union, the frequency of supari, narikel, and raintree (*Albizia saman* (Jacq.) F. Muell.) was 100%, 95.56%, and 97.78%, respectively (Table 4), while in the case of the Sarikait union, the frequency of both narikel and supari was found to be 97.78%. Besides the Matibhanga union, the least amount of fruit species were apples (6.67%) and golabjams (8.89%), while in Sarikait, the same species were identified as the least frequency species concentrating 8.89% and 4.44% for apples and golabjam, respectively. In the case of the relative density, the highest value was observed for supari in Matibhanga (15.64%) and Sarikait (12.5%) followed by narikel (9.21%) in Matibhanga and 10.20% in Sarikait.

Table 4. Fruit and timber species of homesteads and their uses, occurrence, and density.

Local name	Scientific name	Family	Major uses	Total	Based on union				
					Matibhanga (%)		Sarikaik (%)		
				F (%)	RD (%)	F	RD	F	RD
Supari	<i>Areca catechu</i>	Annonaceae	Fruit	98.89	14.18	100	15.64	97.78	12.57
Narikel	<i>Cocos nucifera</i>	Arecaceae	Fruit, fuel wood	96.67	9.68	95.56	9.21	97.78	10.20
Raintree/ fulkori	<i>Albizia saman</i>	Leguminosae	Timber, fuel wood	93.33	9.11	97.78	9.00	86.67	9.23
Am	<i>Mangifera indica</i>	Anacardiaceae	Fruit, timber	93.33	6.85	93.33	6.52	93.33	7.21
Silkoroi/ sadakoroi	<i>Albizia procera</i>	Leguminosae	Timber, fuel wood	72.22	6.14	73.33	5.94	71.11	6.35
Kala koroij/ sherish	<i>Albizia lebbeck</i>	Leguminosae	Timber	62.22	4.04	51.11	3.91	73.33	4.18
Akashmoni	<i>Acacia auriculiformis</i>	Leguminosae	Timber	74.44	3.77	71.11	3.41	77.78	4.16
Mahagoni	<i>Swietenia mahagoni</i>	Meliaceae	Timber	84.44	3.37	84.44	3.50	84.44	3.23
Kathal	<i>Artocarpus heterophyllus</i>	Moraceae	Fruit, fodder, Timber	78.89	3.12	77.78	2.67	80.00	3.62
Papaya	<i>Carica papaya</i>	Caricaceae	Fruit	84.44	3.10	84.44	2.79	84.44	3.44
Kola	<i>Musa sapientum</i>	Musaceae	Fruit	48.89	2.27	48.89	2.23	48.89	2.31
Peyara	<i>Psidium guajava</i>	Myrtaceae	Fruit	82.22	2.19	84.00	1.97	82.80	2.44
Tentul	<i>Tamarindus indica</i>	Leguminosae	Fruit, fuel wood	84.44	2.00	82.22	1.97	86.67	2.04
Kafla	-	-	Fuel wood, fence	74.44	1.84	77.78	1.90	71.11	1.76
Mandar	<i>Erythrina indica</i>	Leguminosae	Fuel wood, fence	75.55	1.78	75.56	1.68	75.56	1.90
Gojom	-	-	Fuel wood	66.67	1.73	62.22	1.76	71.11	1.70
Boroi	<i>Ziziphus jujuba</i> Mill.	Rhamnaceae	Fruit, fuel wood, fence	75.56	1.69	77.78	2.69	73.33	0.59
Pundal	-	-	Fuel wood	66.66	1.62	66.67	1.63	66.67	1.61
Gab	<i>Diospyros peregrina</i>	Ebenaceae	Fruit, pole	62.22	1.55	53.33	1.78	71.11	1.29

Local name	Scientific name	Family	Major uses	Total	Based on union				
					Maithbhang (%)		Sarikait (%)		
					F (%)	RD (%)	F	RD	
Amra	<i>Spondias pinnata</i>	Anacardiaceae	Fruit	52.22	1.38	53.33	1.34	51.11	1.42
Gamar	<i>Gmelina arborea</i>	Lamiaceae	Timber	28.89	1.33	31.11	1.37	26.67	1.29
Jam	<i>Syzygium cumini</i>	Myrtaceae	Fruit, timber	66.67	1.24	75.56	1.20	57.78	1.29
Lebu	<i>Citrus limon</i>	Rutaceae	Fruit	74.44	1.21	75.56	1.43	73.33	0.97
Dumur	<i>Ficus hispida</i>	Moraceae	Fruit, fuel wood	74.44	1.21	73.33	1.34	75.56	1.06
Badam	<i>Terminalia catappa</i>	Combretaceae	Fruit, fuel wood	74.44	1.06	75.56	1.03	73.33	1.09
Tal	<i>Borassus flabellifer</i>	Annonaceae	Fruit, pole	51.11	0.95	53.33	0.97	48.89	0.93
Simul	<i>Bombax ceiba</i>	Malvaceae	Cotton, fuel wood, timber	53.33	0.95	53.33	0.95	53.33	0.95
Bhadi	<i>Lannea coromandelica</i>	Anacardiaceae	Fuelwood	36.67	0.93	37.78	0.93	35.56	0.93
Khejur	<i>Phoenix dactylifera</i>	Arecaceae	Fruit, fence	35.56	0.80	35.56	0.72	35.56	0.88
Kamranga	<i>Averrhoa carambola</i> L.	Oxalidaceae	Fruit	42.22	0.76	46.67	0.79	37.78	0.72
Jambura	<i>Citrus maxima</i>	Rutaceae	Fruit	35.56	0.68	37.78	0.62	33.33	0.75
Dewa	<i>Artocarpus lacucha</i>	Moraceae	Fruit	26.67	0.61	28.89	0.46	24.44	0.77
Litchi	<i>Litchi chinensis</i>	Sapindaceae	Fruit	38.89	0.57	40.00	0.54	37.78	0.61
Neem	<i>Azadirachta Indica</i>	Meliaceae	Medicinal	51.11	0.53	51.11	0.56	51.11	0.50
Bandarlathi	<i>Cassia fistula</i>	Leguminosae	Timber, fuel wood	15.56	0.43	17.78	0.41	13.33	0.45
Amloki	<i>Phyllanthus emblica</i> L.	Euphorbiaceae	Fruit	31.11	0.42	31.11	0.43	31.11	0.41
Jamrul	<i>Syzygium samarangense</i>	Myrtaceae	Fruit	33.33	0.41	35.56	0.39	31.11	0.43
Jhau	<i>Casuarina equisetifolia</i>	Casuarinaceae	Fuel wood	13.33	0.38	11.11	0.29	15.56	0.47
Kodom	<i>Neolamarckia cadamba</i>	Rubiaceae	Fuel wood	26.67	0.37	24.44	0.35	28.89	0.38

Local name	Scientific name	Family	Major uses	Total	Based on union				
					Maithbhang (%)		Sarikaik (%)		
				F (%)	RD (%)	F	RD	F	RD
Belumbo	<i>Averrhoa bilimbi</i>	Averrhoaceae	Fruit	32.22	0.35	33.33	0.33	31.11	0.36
Jalpai	<i>Elaeocarpus floribundus</i>	Elaeocarpaceae	Fruit	28.89	0.30	31.11	0.31	26.67	0.30
Bel	<i>Aegle marmelos</i>	Rutaceae	Fruit	26.67	0.30	26.67	0.29	26.67	0.32
Arboroi	<i>Cicca acida</i>	Euphorbiaceae	Fruit, fuel wood	28.89	0.30	26.67	0.29	31.11	0.32
Babla	<i>Acacia nilotica</i> .	Mimosaceae	Fuel wood, fence	18.89	0.30	20.00	0.31	17.78	0.29
Krishnochura	<i>Delonix regia</i>	Leguminosae	Fuelwood	24.44	0.27	24.44	0.27	24.44	0.27
Dalim	<i>Punica granatum</i>	Lythraceae	Fruit	21.11	0.26	22.22	0.25	20.00	0.27
Sofeda	<i>Annona squamosa</i> L.	Annonaceae	Fruit	17.78	0.22	17.78	0.27	17.78	0.23
Ata	<i>Annona reticulata</i>	Annonaceae	Fruit	18.89	0.22	17.78	0.21	20.00	0.23
Sajna	<i>Moringa leifera</i>	Moringaceae	Fruit, fuel wood	11.11	0.18	11.11	0.21	11.11	0.16
Arjun	<i>Terminalia arjuna</i>	Combretaceae	Medicinal	13.33	0.17	13.33	0.17	13.33	0.18
Kau	<i>Garcinia cowa</i> Roxb.	Guttiferae	Fruit	16.67	0.16	17.78	0.17	15.56	0.16
Sissoo	<i>Dalbergia sissoo</i>	Leguminosae	Timber, fodder	14.44	0.16	15.56	0.17	13.33	0.16
Chalta	<i>Dillenia indica</i>	Dilleniaceae	Fruit	15.56	0.15	13.33	0.12	17.78	0.18
Kodbel	<i>Feronia limonia</i>	Rutaceae	Fruit	13.33	0.13	8.89	0.10	17.78	0.16
Malta	<i>Citrus limetta</i>	Rutaceae	Fruit	11.11	0.13	11.11	0.12	11.11	0.14
Apple	<i>Malus domestica</i>	Rosaceae	Fruit	7.78	0.08	6.67	0.06	8.89	0.09
Golabjam	<i>Eugenia jambos</i> L.	Myrtaceae	Fruit	6.67	0.08	8.89	0.08	4.44	0.07

Furthermore, among the identified 10 medicinal species in homestead, leaf, oil, and seed of neem (*Azadirachta Indica* A. Juss.) are used to get cures for liver and blood diseases (Table 5). Local people also use arjun (*Terminalia arjuna* (Roxb.) Wight & Arn.), thankuni (*Centella asiatica* (L.) Urban), basok (*Justicia adhatoda* L.), tulsi (*Ocimum tenuiflorum* L.), pudina (*Mentha spicata* L.), etc. for their daily purposes as medicinal plants.

Moreover, am (*Mangifera indica*), kathal (*Artocarpus heterophyllus* Lam.), koroï (*Albizia saman*), narikel (*Cocos nucifera*), mahogany (*Swietenia mahagoni*), and supari (*Areca catechu*) were found in addition to a variety of tree-vegetable associations in the study area (Table 6). In addition, eleven vegetables that can grow in direct shadow or as a creeper beside trees were found.

Table 5. Medicinal species found in the homesteads of Sandwip Upazila.

Name	Scientific name	Use
Neem	<i>Azadirachta Indica</i>	Leaf, oil, seeds relieve skin problems; liver tonic, blood purifier
Arjun	<i>Terminalia arjuna</i>	Bark as heart tonic
Thankuni	<i>Centella asiatica</i>	Whole plant as memory booster, blood purifier
Basok	<i>Justicia adhatoda</i>	Leaf as cough remover
Tulsi	<i>Ocimum tenuiflorum</i>	Leaf, flower good for heart, blood, lungs, and cough
Pudina	<i>Mentha spicata</i>	Leaf for increasing digestion, preventing cold
Sajna	<i>Moringa oleifera</i>	Fruit, leaf for controlling blood pressure, preventing stroke
Papaya	<i>Carica papaya</i>	Fruit for curing ulcers, preventing cancer
Lemon	<i>Citrus limon</i>	Fruit, leaf for reducing cholesterol, as blood purifier, and for reducing vomiting
Ginger	<i>Zingiber officinale</i>	Rhizome, leaf for reducing nausea, sickness and vomiting

Table 6. Types of crops with major tree species in Sandwip Upazila.

Tree species	Vegetables grown under trees	Creeper Vegetables Grown Using Trees as Trails
Am	Aroids, amaranthus, spinach, turmeric, ginger	Bitter guard, sponge gourd
Kathal	Pineapple, chili, turmeric, aroids	Country bean, ribbed gourd
Koroï	Aroids	-
Narikel	Aroids, spinach, turmeric	-
Mahogany	Spinach, ginger	Country bean, yam
Supari	Turmeric, pineapple	Yam, country bean

Table 7. Distribution of income of homestead (BDT/ year) according to farm category.

Category of household	Timber species (BDT)	Fuel (BDT)	Fruit (BDT)	Bamboo (BDT)	Fish (BDT)	Total (BDT)
Small	4287	1183.66	2533.34	1149	4304	13457
Medium	5313	2179	3750	1940	4375	17557
Large	7750	3489	4500	2465	6500	24700
Average (Tk)	5783.33	2283.88	3594.45	1851.33	5059.66	55714

Here, BDT= Bangladeshi Taka

Income from homestead resources

The total annual average income of the small households was 13,457 Bangladeshi taka (BDT) and the large households' total annual average income was 24,700 BDT (Table 7). The maximum income of the households came from selling timber, while the second highest income of different farm categories was generated from selling the fishes.

Purpose of tree plantation, choice, and value of home garden species

Among the entire respondents, the majority of the households (45.56%) addressed getting timber, fuel, and fruit as their purpose, while 42.23% of the households planted trees to get timber and fruit (Figure 3).

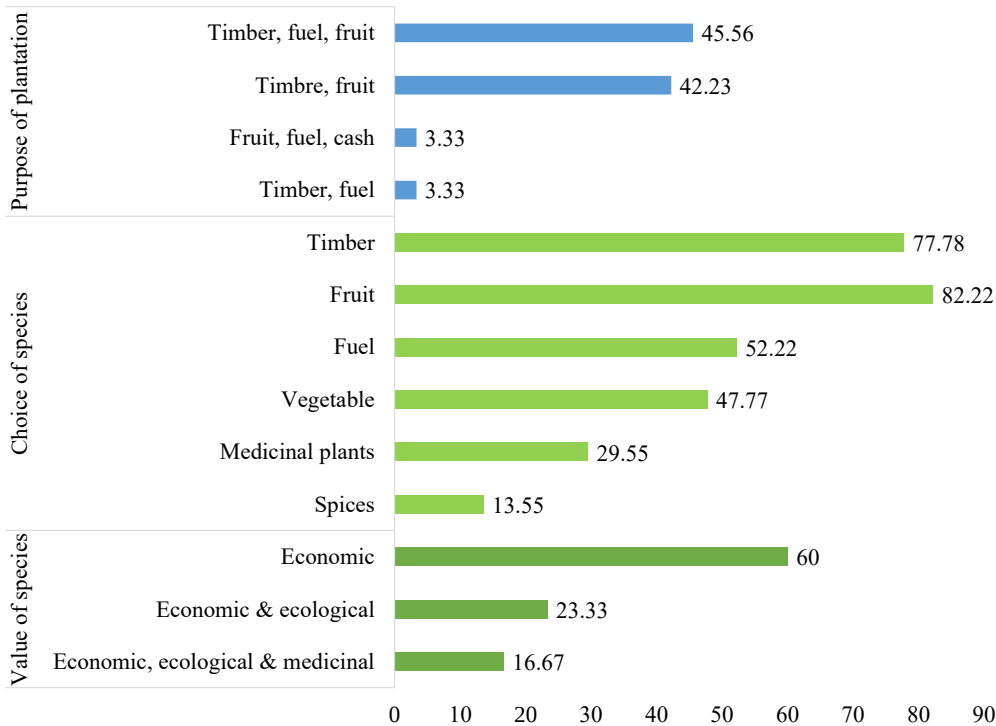


Figure 3. Perception of respondents on the purpose of the plantation, choice of species, and value of species.

In the case of interest of respondents to plant new trees in their homestead, it was observed that the majority of the people prioritized fruit species (82.22%) as a top priority, while timber (77.78%), fuel (52.22%) vegetables (47.77%), medicinal plant (29.55%), spice (13.5%) were considered based on their choice.

Management practice of homestead

The majority of the site selection decisions are taken by females (34%) for planting

purposes. Moreover, 27% and 39% of site selection decisions were taken by male and female participants, respectively. Also, plantation (31.11%) and fertilization (50%) were done by the male (Table 8).

Most of the respondents (52%) purchased their planting materials from the market (Table 9). The common planting materials were seeds, seedlings, and vegetative propagules, while the farmers prefer seedlings mostly because of their availability and better survivability.

Table 8. List of activities for management of homesteads by people.

Activities	Gender involvement (%)					Children	Others
	Male	Female	Both (male & female)	Both (male & children)	Both (female & children)		
Seedling collection	30	13.33	40	16.66	-	-	-
Planting	31.11	22.22	20	17.77	8.88	-	-
Watering	22.22	38.88	33.33	5.55	-	-	-
Weeding	20	33.33	16.66	8.88	13.33	7.77	-
Fertilizing	50	11.11	13.33	15.55	10	-	-
Thinning	13.33	11.11	16.66	17.77	13.33	15.55	12.23
Pruning	12.23	10	13.33	20	14.44	8.88	22.22
Harvesting	23.23	13.33	15.55	38.8	5.55	3.33	-

Table 9. Source of planting materials/ seedlings.

Aspects	Response (%)	
Sources	Market/private nursery	52%
	Govt. nursery	14%
	Homestead forest	22%
	Neighbours, relatives, and others	12%
Types of planting materials/ Knowledge on reasons for use and non-use		
Item	Reason for use	Reason for non-use
Seed	Easy to grow, easily available	Lower survival rate, more damage, prone to insect attack
Seedlings	Better survival rate, less damage, costly	Not readily available
Vegetative propagules	Better survivability, easily available, Growth is fast	Costly
Protection measures of trees in homestead		
Protection measures are taken for protecting planting seedlings	Yes	71.11%
	No	28.89%

Moreover, 71.11% of the household took various measures such as fencing, binding with a hard stick, regular observation, etc. to protect seedlings planted in the homestead, while 28.89% of the household were reported to take no measures for protecting the planted seedling.

In the case of the fertilizer used in homesteads, 32% of the respondents said that they have used a chemical fertilizer in their homestead to improve soil fertility followed by cow dung (27%), household

residue (27%), and a small amount used (14%) all the fertilizer.

Problems associated with home gardening

On the other hand, the study revealed some common problems faced by the house owners in home gardening. Damages caused by animals were the most significant obstacle for farmers while planting and growing trees (50%) (Figure 4).

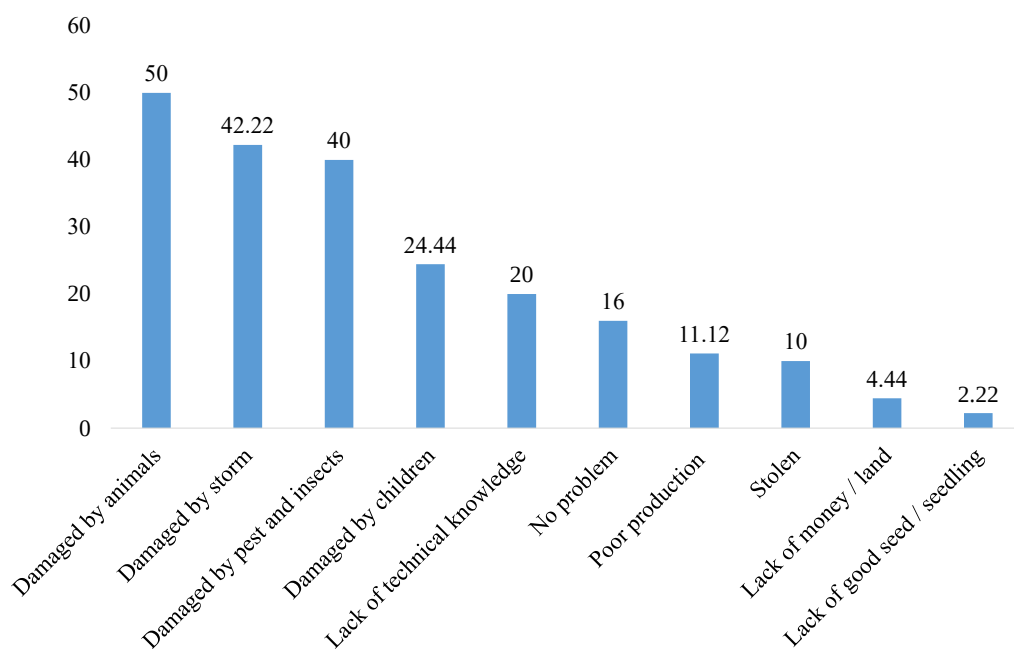


Figure 4. Problems faced by the households in homestead resources management.

Discussion

Homestead depicts the combination of different groups or species of trees, shrubs, including vegetables within the periphery of an individual house, which is fully managed by the family members (Fernandes & Nair, 1986). Homestead is one of the most important production areas of different resources in Bangladesh, which provides a significant contribution to the group of people with low economic status (Miah & Hussain, 2010). Following the aspects of the importance of homestead resources, this study covered the diversity and management of homestead resources in Sandwip Upazila, Chittagong, Bangladesh. The findings revealed that the number of plant species (excluding vegetable species) in this study area was 57 under 28 families, which indicates the homestead has a moderately high diversity and species richness, which is higher than the findings of Abedin & Quddus (1990). They were found in homesteads of Tangail district (52 spp.), Ishurdi (34 spp.), Jessore (28 spp.), Patu-

akhali (20 spp.), Rajshahi (28 spp.), and Rangpur (21 spp.), respectively. Besides, in a study conducted in different regions of the country, Millat-e-Mustafa (1997a) found 92 species of perennial plants.

Furthermore, in the case of diversity and density of fruit and timber species, the Shannon-Wiener Diversity Index is higher than the Index of Dominance, indicating less dominance of the tree species with greater diversity in the home garden. The computed value of the Species Richness Index also specifies a greater diversity of tree species and a more even distribution of the total number of individual trees across all tree species. This result is consistent with those of a few studies with similar objectives. This index was reported to be 3.33 by Millat-e-Mustafa (1997a) and 3.16 by Nath *et al.* (2015) for homesteads of varying sizes in Bangladesh. On the contrary, it was found that the tree species in this study (Evenness Index = 1.89) were more evenly distributed than the distribution. Nath *et al.* (2015) found homestead forests in ecologically critical areas in Bangladesh (Evenness

Index = 0.84). Shannon-Wiener's Diversity Index values range between 1.5 and 3.5 in the majority of ecological studies, and rarely exceed 4.0. The Shannon Index rises when both the diversity and uniformity of a plant community increase. Besides, a total of 17 vegetable species were found to grow on a homestead several times a year of which 3 grew round the year. The number was higher than in another study (14 spp.) conducted by Momen *et al.* (2006) in Sandwip Upazila.

Moreover, eleven vegetables were found under the direct shade of trees or as a creeper in association with trees. Under the trees, various shade-tolerant and/or shade-requiring plants, such as ginger (*Zingiber officinale*), turmeric (*Curcuma longa* L.), aroids (*Colocasia indica*), etc. were identified growing in homesteads. Few large and medium-sized farms were growing vegetables using horticultural and forest species, which is an additional source of income for those farms. Typically, farmers did not cultivate crops beneath the canopy of trees, although some of the mentioned species required shade. Lack of adequate knowledge, provision of inputs, and technology were identified as the primary reasons for its non-practice. In addition, the insufficiency of labor to plant and care for the vegetables was also a factor for those who do not cultivate them. Similar to the findings of Zaman *et al.* (2010) the present study discovered that some shade-loving plants thrive beneath and close to tree canopies. Among them, *Zingiber officinale*, *Curcuma longa*, *Ananas comosus* (L.) Merr., *Colocasia indica*, *Capsicum frutescens* L., *Amorphophallus* Blume ex Decne, and *Dioscorea* L. were found in homestead forests.

Furthermore, among all species, fruit species comprised the highest percentage (42%). Here, supari (*Areca catechu*), narikel (*Cocos nucifera*), and am (*Mangifera indica*) were the most frequent fruit tree species as these trees provided economic return and fulfilled a portion of the nutritional requirement. In timber and fuel wood

species, raintree (*Albizia saman*), mahogani (*Swietenia mahagoni*), and mandar (*Erythrina indica* L.) have the highest frequencies. On the other hand, the present study revealed that traditional fruits of low economic value, such as chalta (*Dillenia indica* L.), kodbel (*Feronia limonia* L. Swingle), and golabjam (*Eugenia jambos* L.) are gradually decreasing from the homestead. Exotic timber species, such as *Swietenia mahagoni*, and *Acacia auriculiformis* are increasing in terms of relative density and frequency in the homestead. On the other hand, Ahmed & Islam (1994) indicated that about 31 minor fruit species have reached a stage of near extinction from their home in Bangladesh. Malta (*Citrus limetta* Risso) and apple (*Malus domestica* Borkh.) species were found in small amounts in very few homesteads which were provided by the government under the "Ekti Bari Ekti Khamar (One House One Farm)" project.

Farmers derive benefits from homesteads in various ways as they use homestead resources as a "reserve bank" for food and income. It was discovered that the annual average income of the small households was 13457 BDT and the large households' annual average income was 24700 BDT. The maximum income of the households comes from selling timber. The income from trees for the small farm categories was substantially lower than the income from trees for the other farm categories. Smaller farms had fewer trees and less land devoted to tree production, which contributed to a lower income from tree products. This observation conforms with Zaman *et al.* (2010) homesteads study. The second highest income of different farm categories came from selling fish.

Most households (82.2%) preferred largely food or fruit species for planting due to monetary incentives and family demands, and this conclusion is supported by the findings of Masum *et al.* (2008) and Siddiqui & Khan (1999) and in various parts of the country. Fruit trees were preferred by farmers due to their numerous

applications and consumption. According to Bashar (1999), farmers prefer fruit trees in their homesteads. The study revealed that geographical location, better financial condition, availability of planting materials, commercial values, and more so the local tradition are identified as the factors affecting people's species preference in a different region. These findings are corroborated by the research of Millat-e-Mustafa (1997a) on home gardens in four regions of Bangladesh.

The respondents were found to use cow dung, household residue, and chemical fertilizer on their land to maintain soil fertility. In tree planting and management work male participation was (52.08%) slightly higher than that of females, however, females actively took part in the development and care of home gardens. As the area of homesteads was near female working areas it was easy for them to look after it compared to men. The site selection decision for planting purposes was mostly taken by female (34%) members and less by male members (27%). Women play the most active role in maintaining homesteads. Although men performed heavier tasks at home gardens, such as planting, thinning, and fertilization in homestead management, women and children performed lighter work, such as weeding and watering.

The majority of the respondents (60%) had given an emphasized economic value. Here, 23.33% of the respondents mentioned combined economic and ecological value and only 16.67% of the respondents were aware of the economic, ecological, and medicinal value of what home garden should be conserved. As a strategy for maintaining ecological balance and a source of medicinal plants, the majority of the respondents assessed the home garden as "least significant". Consequently, it appears that there is still a shortage of understanding in these two areas since Roy *et al.* (2013) obtained similar findings.

Due to the lack of better management techniques and high-quality varieties, the

traditional maintenance system of homestead gardens in the study area was characterized by a low level of cultural practices. Typically, farmers rely on plants that grow naturally inside their homestead's perimeter. In addition, a review of the present management regime revealed that cultivators lack scientific knowledge. The vast majority of household owners still adhere to traditional homestead management approaches, while just a few have adopted modern practices. Agriculturalists, ecologists, biologists, and economists must communicate and interact across disciplines to protect homestead resources, identify and implement appropriate evaluation methodologies for sustainable management, and increase profits from the homestead. A greater understanding of agro-biodiversity as natural capital for delivering ecosystem goods and services is required. This knowledge will assist in increasing agricultural output and encouraging forestry (Swift *et al.*, 2004; Wood & Lenné, 2005) in the least forested regions by building human-managed farm forestry.

Conclusion

In terms of plant management and utilization, Bangladesh homestead forestry practices are following conventional methods and need improvement. Findings reveal that homesteads provide tangible benefits, such as fruit, fuel wood, and food materials with some income. There was enough unused land in the homesteads, which were relatively safe from flood and other threats. The land can be used for tree-growing purposes with desirable species. Producing various nutritious foods around the house may be a sensible way to provide adequate food to the household members. Thus, selective plantation of fruit species around the home garden can greatly influence the promotion of proper nutrition. It is evident from the study that farmers possess extensive indigenous

knowledge related to several aspects of homestead forestry management. Farmers are mostly concerned about improving the growth of fruit trees in their home gardens. There is still immense scope to improve technologies for species selection, clonal propagation, species interaction, soil management, etc. To achieve a stable ecological balance and sustainable productivity of the homesteads, the proper initiative should be reintroduced along with the rare indigenous fruit trees and careful management of homesteads.

Recommendations

The following recommendations may be made to improve the status of homestead biodiversity:

- 1) Proper training and motivation of both male and female members of the family for better management of homestead forestry.
- 2) Distribute seedlings that have the potential to grow in homestead conditions.
- 3) Promoting awareness on the need for community forestry and planting of more indigenous tree species on homestead land.
- 4) Detail analysis of the tree crop interaction is needed for the selection of appropriate species.
- 5) Combined application of indigenous and scientific knowledge.
- 6) Identifying and introducing shade-tolerant crops and vegetables for growing under trees.

Acknowledgements. Authors are thankful to community members of Sandwip Upazila, Chittagong, Bangladesh for their support during data collection for this study.

References

- Abedin, M.Z., Quddus, M.A. 1990. Household fuel situation, home gardens and agroforestry practices at six agro-ecologically different locations of Bangladesh. – Abedin, M.Z., Lai, C.K., Ali, M.O. (eds.). *Homestead Plantation and Agroforestry in Bangladesh*. Joydebpur, Bangladesh, Bangladesh Agricultural Research Institute (BARI), 19–53.
- Ahmed, M., Islam, A. 1994. People's choice and attitudes towards growing multipurpose tree species. – *Chittagong University Studies*, Part II: Science, 18(1), 31–39.
- Alam, M.S., Haque, M.F., Abedin, M.Z., Akter, S. 1990. Homestead trees and household fuel uses in and around the farming system research site, Jessore. – Abedin, M.Z., Lai, C.K., Ali, M.O. (eds.). *Homestead Plantation and Agroforestry in Bangladesh*. Joydebpur, Bangladesh, BARI, 106–119.
- Alam, M., Sarker, S.K. 2011. Homestead agroforestry in Bangladesh: dynamics of stand structure and biodiversity. – *Journal of Sustainable Forestry*, 30(6), 584–599.
- Alam, M.K., Mohiuddin, M., Basak, S.R. 1996. Village trees of Bangladesh: diversity and economic aspects. – *Bangladesh Journal of Forest Science*, 25(1–2), 21–36.
- Alam, M.S., Masum, K.M. 2005. Status of homestead biodiversity in the offshore island of Bangladesh. – *Research Journal of Agriculture and Biological Sciences*, 1(3), 246–253.
- Alam, M., Rahman, M.R., Chowdhury, M.A., Alam, M.S. 2019. Community dependency and conservation practices in Khagrachari, Bangladesh: a study on management of village common forests (VCFs). – *Asian Journal of Research in Agriculture and Forestry*, 4(2), 1–13. <https://doi.org/10.9734/ajraf/2019/v4i230060>.
- Bashar, M.A. 1999. Homegarden Agroforestry: Impact on biodiversity conservation and household food security. (A case study of Gazipur District, Bangladesh). – MSc thesis. Oslo, Agricultural University of Norway. 110 pp.
- Baul, T.K., Peuly, T.A., Nandi, R., Kar, S., Mohiuddin, M. 2021. Composition of homestead forests and their contribution to local livelihoods and environment: a study focused on Bandarban hill district, Bangladesh. – *Trees, Forests and People*, 5, 100117. <https://www.sciencedirect.com/science/article/pii/S266671932100056X>.
- BBS (Bangladesh Bureau of Statistics). 2012. *Statistical Year Book of Bangladesh-2011*. Dhaka, Ministry of Planning, BBS.
- Castañeda-Navarrete, J. 2021. Homegarden diversity and food security in southern Mexico. – *Food Security*, 13, 669–683. <https://doi.org/10.1007/s12571-021-01148-w>.

- Chowdhury, M.A., Islam, K.N., Hafiz, N., Islam, K. 2019. Diversity of trees in a community managed forest: The case of Komolchori VCF, Khagrachari, Bangladesh. – *Geology, Ecology, and Landscapes*, 3(2), 95–103.
- Chowdhury, M.A., Zahra, F.-T., Rahman, M.F., Islam, K. 2018. Village common forest management in Komolchori, Chittagong Hill Tracts, Bangladesh: an example of community based natural resources management. – *Small-scale Forestry*, 17(4), 535–553.
- Das, D.K. 1990. List of Bangladesh village tree species. Chittagong, Bangladesh Forest Research Institute, 11 pp.
- Fernandes, E.C.M., Nair, P.K.R. 1986. An evaluation of the structure and function of tropical homegardens. – *Agricultural Systems*, 21(4), 279–310. <https://www.sciencedirect.com/science/article/pii/0308521X86901046>.
- Foysal, M.A., Hossain, M.L., Rubaiyat, A., Hasan, M.B. 2013. Economics of homestead forestry and their management activities at Fatikchhari Upazila of Chittagong District, Bangladesh. – *Agriculture, Forestry and Fisheries*, 2(4), 161–176.
- Jegara, T., Asfaw, Z., Anjulo, A. 2019. Woody species diversity and management in homegarden agroforestry: the case of Shashemene District, Ethiopia. – *International Journal of Forestry Research*, 2019, 3697047. <https://doi.org/10.1155/2019/3697047>.
- Kabir, M.E., Rahman, M.M., Rahman, M.A.U., Ando, K. 2016. Effects of household characteristics on homegarden characteristics in Kalaroa Upazila, Satkhira District, Bangladesh. – *Small-scale Forestry*, 15(4), 443–461.
- Kabir, M.E., Webb, E.L. 2008. Can homegardens conserve biodiversity in Bangladesh? – *Biotropica*, 40(1), 95–103.
- Kumar, B.M., Singh, A.K., Dhyani, S.K. 2012. South Asian agroforestry: traditions, transformations, and prospects. – Nair, P.K.R., Garrity, D. (eds.). *Agroforestry - The Future of Global Land Use*. Dordrecht, Springer, 359–389.
- Magurran, A.E. 1988. *Ecological Diversity and Its Measurement*. Princeton, New Jersey, Princeton University Press. 179 pp.
- Masum, K.M., Alam, M.S., Abdullah-Al-Mamun, M.M. 2008. Ecological and economical significance of homestead forest to the household of the offshore island in Bangladesh. – *Journal of Forestry Research*, 19(4), 307–310.
- Mekonen, T., Giday, M., Kelbessa, E. 2015. Ethnobotanical study of homegarden plants in Sebeta-Awas District of the Oromia Region of Ethiopia to assess use, species diversity and management practices. – *Journal of Ethnobiology and Ethnomedicine*, 11, 64. <https://doi.org/10.1186/s13002-015-0049-8>.
- Miah, M.G., Hussain, M.J. 2010. Homestead agroforestry: a potential resource in Bangladesh. – Lichtfouse, E. (ed.). *Sociology, Organic Farming, Climate Change and Soil Science*. Dordrecht, Springer, 437–463. https://doi.org/10.1007/978-90-481-3333-8_16.
- Michael, P. 1990. *Ecological Methods for Field and Laboratory Investigations*. New Delhi, Tata McGraw-Hill Publishing Co. Ltd. 404 pp.
- Millat-e-Mustafa, M. 1997a. Floristic and indigenous management techniques of homegardens in Bangladesh. – Alam, M.K., Ahmed, F.U., Amin, S.M.R. (eds.). *Agroforestry: Bangladesh Perspective*. Dhaka, Bangladesh, Bangladesh Agricultural Research Council (BARC), 34–67.
- Millat-e-Mustafa, M. 1997b. Tropical homegardens: an overview. – Alam, M.K., Ahmed, F.U., Amin, S.M.R. (eds.). *Agroforestry: Bangladesh Perspective*. Dhaka, Bangladesh, BARC, 18–33.
- Momen, R.U., Huda, S.M.S., Hossain, M.K., Khan, B.M. 2006. Economics of the plant species used in homestead agroforestry on an off-shore Sandwip Island of Chittagong District, Bangladesh. – *Journal of Forestry Research*, 17(4), 285–288.
- Momin, M.A., Abedin, M.Z., Amin, M.R., Islam, Q.M.S., Haque M.M. 1990. Existing homestead plantation and household fuel use pattern in the flood prone Tangail region of Bangladesh. – Abedin, M.Z., Lai, C.K., Ali, M.O. (eds.). *Homestead Plantation and Agroforestry in Bangladesh*. Joydebpur, Bangladesh, BARI, 136–145.
- Nath, T.K., Aziz, N., Inoue, M. 2015. Contribution of homestead forests to rural economy and climate change mitigation: a study from the ecologically critical area of Cox's Bazar – Teknaf Peninsula, Bangladesh. – *Small-scale Forestry*, 14(1), 1–18. <https://doi.org/10.1007/s11842-014-9270-x>.
- Paul, A., Rahman, M.M. 2006. Cyclone mitigation perspectives in the islands of Bangladesh: a case of Sandwip and Hatia Islands. – *Coastal Management*, 34(2), 199–215. <https://doi.org/10.1080/08920750500531371>.
- Rahman, M.A., Tani, M., Asahiro, K., Asik Ullah, S.M. 2017. Species composition, diversity and productivity of homesteads in southeastern Bangladesh. – *Small-scale Forestry*, 16, 295–309.
- Rahman, M.R., Rahman, M.M., Chowdhury, M.A. 2020. Assessment of natural regeneration status: the case of Durgapur hill forest, Netrokona, Bangladesh. – *Geology, Ecology, and Landscapes*, 4(2), 121–130.
- Rahman, M.R., Rahman, M.M., Chowdhury, M.A., Akhter, J. 2019. Tree species diversity and structural composition: The case of Durgapur Hill Forest, Netrokona, Bangladesh. – *Asian Journal of Forestry*, 3(1), 10–19.

- Roy, B., Rahman, M.H., Fardusi, M.J. 2013. Status, diversity, and traditional uses of homestead gardens in Northern Bangladesh: a means of sustainable biodiversity conservation. - International Scholarly Research Notices, 2013, 124103. <https://doi.org/10.1155/2013/124103>.
- Siddiqui, M.A., Khan, N.A. 1999. Floristic composition and socio-economic aspects of rural homestead forestry in Chittagong: a case study. - Bangladesh Journal of Forest Science, 28(2), 94-101.
- Swift, M.J., Izac, A.-M.N., van Noordwijk, M. 2004. Biodiversity and ecosystem services in agricultural landscapes—are we asking the right questions? - Agriculture, Ecosystems & Environment, 104(1), 113-134.
- Vibhuti, Bargali, K., Bargali, S.S. 2018. Effects of homegarden size on floristic composition and diversity along an altitudinal gradient in Central Himalaya, India. - Current Science, 114(12), 2494-2503. <http://www.jstor.org/stable/26495762>.
- Wood, D., Lenné, J.M. 2005. 'Received Wisdom' in agricultural land use policy: 10 years on from Rio. - Land Use Policy, 22(2), 75-93.
- Zaman, S., Siddiquee, S.U., Katoh, M. 2010. Structure and diversity of homegarden agroforestry in Thakurgaon District, Bangladesh. - The Open Forest Science Journal, 3, 38-44.

Received November 11, 2022, revised December 28, 2022, accepted December 30, 2022