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Homestead Plant Diversity at the Ship Breaking Areas of Bangladesh

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Authors' contributions

This work was carried out in collaboration between all authors. Author RN designed the study, guided the whole study both in field and in paper preparation including data sorting, analysis, writing the protocol and wrote the first draft of the manuscript. Author MAM carried out the field work physically, collected data, sorted data according to suggestions from author RN and author TKD helped to manage the literature collection and prepare the article according to reviewers' comments. All authors read and approved the final manuscript.

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ABSTRACT

Unplanned ship breaking at the Sitakund coast in Chittagong, Bangladesh is contaminating the surrounding vegetation mainly through the discharge of heavy metals from the discarded ship paints. Therefore, the present study was conducted with an aim to explore homestead plant diversity in ship breaking areas at Sitakunda sub-district in Bangladesh from where Salimpur and Kumira union was selected as ship breaking areas (SBA) whereas Bansbaria and Barabkunda as non-ship breaking areas (NSBA). In total 104 households were surveyed to ascertain plant diversity. Present study revealed that NSBA have more plant diversity than SBA. A total of 27 tree species including fruits, timber, fuel wood, aesthetics and medicinal were found in SBA while 30 species were found in NSBA. Shanon Winner index value was 2.5 in SBA whereas in NSBA it was 2.7. Agro-crop diversity in both areas was almost same. A total 15 agro-crop species were found in SBA and 16 species in NSBA. Average production of rice in SBA (2251.91 kg/yr/household) was quite higher compared to the NSBA (380.2 kg/yr/household).

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This study prioritizes the importance of soil properties analysis at the ship breaking areas and links it with the growth of plant vegetation to check if there is any significant relationship between them. Moreover, it is also very crucial to investigate the heavy metal concentration in plant including agro-crop and forest crop growing around this area. Based on findings from the analysis of soil properties and heavy metal concentration in soil and plant, farmers can be prescribed to plant site specific species for more production and sustainable homestead forest management at the ship breaking areas of Bangladesh.

Keywords: Diversity; index; household; agri-crop; tree species.

1. INTRODUCTION

From ecological and conservation point of view assessment of biodiversity of any habitat or locality has been regarded as one of the vital issue for careful preservation, promotion and management of the variety of life-forms [1]. Increased human population and associated development activities in the last few decades has resulted directly and indirectly in depletion of the natural vegetation which in turn increase the pressure on the homestead forest specially in the developing countries to meet various needs of the human beings. In this circumstances correct inventory and assessment of biodiversity in different habitats is necessary for evolving a long term strategy for conserving the endangered species and improvement of the existing species.

Bangladesh is situated at the complex interface of the Himalayan and the Southeast Asian Bio-geographic regions, and historically was well endowed with very diverse complements of terrestrial and aquatic flora and fauna [2]. Homestead forest in Bangladesh covers an area of 0.27 million ha. (Occupied by 15.4 million homesteads) while state owned forests cover 2.25 million ha [3]. Homestead is an operational unit in which a number of crops including trees are grown with livestock, poultry and fish production mainly for the purpose of satisfying the farmer's basic needs. It is the most prospective form of production site along with the seat/shelter of the family. Homestead fulfill basic needs of the people such as food, shelter, cash etc and high species diversity of the homestead help to reduce the environmental deterioration commonly associated with monoculture production system. Moreover, they have been producing sustained yields for a century in a most resources efficient way. To react with the recent scenario of rapidly growing population leading to over exploitation of natural resources and possible irreversible environment damage, homestead forest is now considered as the most alternative way for sustaining the natural resources [4].

Sitakunda is an administrative unit in the Chittagong District of Bangladesh. It is a seashore area situated a few kilometers north.

Chittagong where most of the ship breaking yards are concentrated. The Ship breaking area along the Chittagong sea shore is situated on 22° N Latitude and 91° E Longitude and at a stretched 14 kilometer form Fouzdarhat to Kumira under Sitakunda sub-district. The ship breaking industry has started its operation in Bangladesh in 60's and it was widely spread in 80's in Sitakunda, Chittagong, Bangladesh. In different years the industry broke the highest numbers of ships in the world. All the ship breaking industries of Bangladesh are located in this belt with more than 140 ship breaking yards in Salimpur, Kumira, Bhatiary, BarabKunda, Fouzdarhat zone in Chittagong showing the Bangladesh map as Fig. 1(a) locating the ship breaking area.

Ship breaking is the process of dismantling the obsolete vessel's structure for material recovery or disposal. Ship breaking is a challenging process, due to the structural complexity of ships and the many environmental, safety, and health issues involved [5]. It includes a wide range of activities from removal of all gears and equipment to cutting down the ship's infrastructure. Bangladesh (20°34′ and 26° 38′ N latitude and 88°01′ and 92°41′ E longitude) is a small South Asian country that borders India on the west, north, and northeast, Myanmar on the southeast, and the Bay of Bengal to the south. Bangladesh has repeatedly been blamed by many stake holders for exerting harmful impacts on the coastal and marine environment, particularly for causing soil contamination. The waste water that are discharged from the industries, passed through directly by the drains to the sea and partially fallen nearby soil and hence soil is contaminated for their indiscriminate

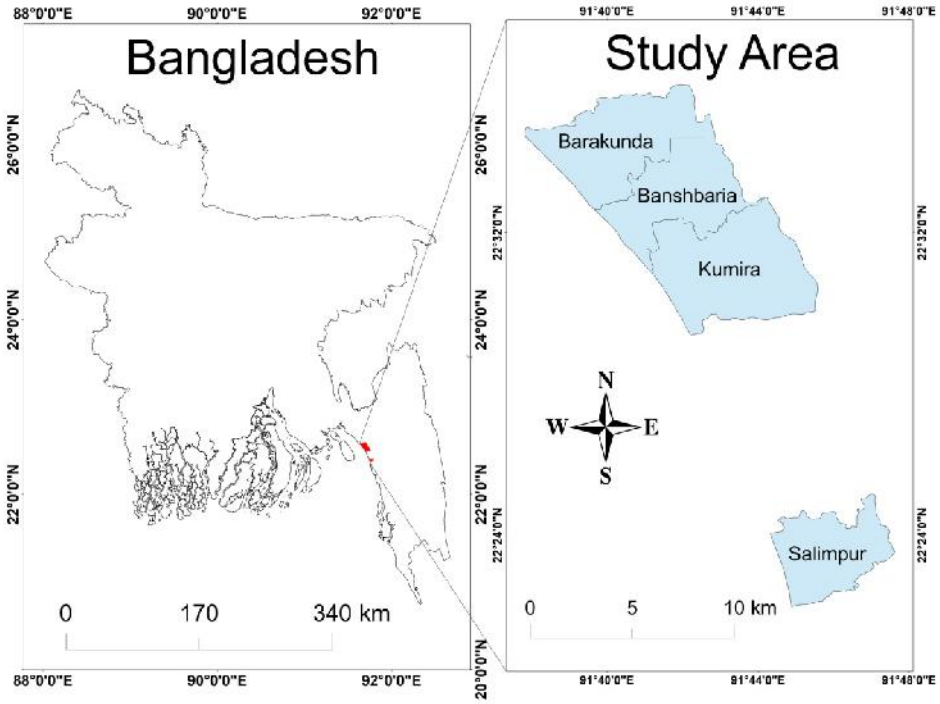
cutting of ship. These metals are leached out through the rain water to the ground and washed out by both heavy rainfall and tide and wave to the sea. On the other hand, while flowing through the open drains, the waste and foul waters also pollute its surrounding environments with its foul nature. These are very harmful for the people living nearby and also for the plants. Germination and initial growth of seedling are the stages of tree development that are often most sensitive to adverse environmental factors [6]. The physiological process of plant and crop are also affected and consequently their yield and production are reduced. There is also a chance of incorporation of pollutants into the food chain through the crops.

Various studies were carried out in different regions of Bangladesh on floristic composition (mainly trees) at the homestead areas of Bangladesh by different researchers [4,7,8]. Even there were many studies [9,10,11,12] on homegarden agroforestry, homegarden plantation and traditional use. But no study was carried out solely on the homestead plant diversity at the ship breaking areas of Bangladesh. Therefore, this study was carried out to investigate the homestead plant diversity specially tree and agro-crop species at the homestead areas surrounding the ship breaking and non-ship breaking areas of Sitakund sub-district mainly along the Chittagong Sea shore from Bhatiary to Kumira. The study will also investigate the contribution of homestead plant diversity in rural household economy. Furthermore, it will identify the management system and the problems faced by the households in the growing/cultivating plants to find out further research priority areas. Ship breaking industry covers an area of about 8 km^2. The study was conducted in Salimpur, Kumira, Bansbaria, Barabkunda unions under Sitakunda upazila (Fig. 1b).

2. MATERIALS AND METHODS

2.1 Study Area

The area is subtropical with a long dry season extending from September to April and an unpredictable period of rain storm from May to August. Mean annual rain fall in the study site is 3207 mm and mean annual temperature is 26.24°C. Southwest monsoon air provides about



1(a) 1(b)

Fig. 1(a). Bangladesh Map showing ship breaking yards (red color) and 1(b) showing (blue color) the study area

94% of the total rain fall. This lead to a period of saturation and gives rise to a phase of intense plant growth.

The information and relevant literature that were required for preparing this paper were collected from different books, journals and published papers of the library of Institute of Forestry and Environmental Sciences, University of Chittagong. Very recent and updated information and literature were collected from Internet.

2.2 Study Design

The study was based on the primary data collected directly from the field during June 2016 to September 2016 through physical measurement. During the study, multistage random sampling method was adopted for data collection. From a total of 20 upazila of Chittagong district (administrative unit), Sitakund upazila was selected purposively as this is the only upazila of Chittagong district where ship breaking yards are established. Out of 9 unions in Sitakund upazila, 4 unions (Salimpur, Kumira, Bansbaria and Barabkunda) were firstly selected randomly. Then two unions were selected randomly from ship breaking areas and two from non ship breaking areas. Then 2 villages from each union were randomly selected. The total number of villages was eight. The selected villages were Uttor Salimpur, Moddom Salimpur, Boro kumira, Alekdia, Kazipara, Nonabil, Moddhom Mahmudabad, Mandaritola respectively. 13 households from each village (total households 104) were selected for interview under this study. Total number of households in each village was obtained from the District census published by the Bangladesh Bureau of Statistics [13]. Before starting the actual survey, a reconnaissance survey was carried out at the study area. The objective of the survey was to get familiarized with the community, to get some idea of vegetation composition from the rural people of the study area.

2.3 Data Collection

2.3.1 Formal interview

In order to collect relevant information, interview schedule was carefully designed keeping the objectives of the study in view. The questionnaire contains both open ended and closed form of questions. All households were visited with the assistance of local student living at the study area. Most of the information were obtained through interview with household members. The distribution of plant species on the homestead was surveyed physically. Collected information was verified through discussion with the household respondent. Information on agro-crop production cost, consumption, sale value per year was also collected from the household member. Besides, information on particular issues like problems of home garden plantation, sources of seedlings, preferences of species selection, farmer's recommendation was also collected from the household level.

2.3.2 Vegetation survey

During taking interview, vegetation survey was conducted at each household compound to ascertain plant diversity. All plant species including tree species and agro-crops planted by the farmers at the ship breaking and non-ship breaking area were recorded with their botanical and local name. The number of plants and occurrence of that plant in number of homestead counted with the help of household member and local students. The local name of the plant in the homesteads was collected from the respondent. Seasonal crops like vegetables of herb category were also included in the study.

2.3.3 Secondary information collection

Secondary information and data were collected from different organizations such as IFESCU library and from various scientific journals, articles etc. The identification of the species was done with the help of specialist of Institute of Forestry and Environmental Sciences, University of Chittagong. Local name were collected from local people and from different books.

2.4 Data Analysis

Microsoft excel program was used to process all collected information and in preparing tables, charts and graphs. For the present study, one ecological index was used to analyze and to get a clear picture of the species diversity of the study areas, which is given below.

The Shannon-Winner diversity index was calculated following [14]:

$$\text{Shannon Index (H)} = -\sum (Pi \ln Pi)$$

Pi is the number of individuals of one species/total number of individuals in the samples.

3. RESULTS

3.1 Plant Diversity

A total 27 different species were found in ship breaking areas (SBA) Where *Cocos nucifera* (Coconut), *Eucalyptus camaldulensis* (Eucalyptus) and *Mangifera indica (*Mango) were found the most dominant (Table 1). On the contrary, a total 30 different plant species were found in non-ship breaking areas (NSBA) where *Eucalyptus camaldulensis* (Eucalyptus), *Cocos nucifera* (Coconut) and *Carica papaya* (Papaya) were found the most dominant (Table 1). Among the found species, 26 plant species were present at the both areas where only one species *Achras sapota* (Safeda*)* was found only in ship breaking areas and three (3) plant species e.g. *Psidium guajava* (Guava), *Averrhoea carambola* (Kamranga), *Bombax malabaricum* (Shimul tula) found in non-ship breaking areas. Shanon Winner index for ship breaking areas show the value of 2.5 whereas in non-ship breaking areas it is 2.7 which present that there is less variation in plant diversity in both the areas (Table 2).

3.2 Agriculture Crop Production Status

Agro-crop diversity in ship breaking and non-ship breaking areas were almost same. A total of 16 agri-crop species were found in non-ship breaking areas and 15 in ship breaking areas. Common species between these two areas were *Oryza sativa* (Rice), *Solanum melongena* (Eggplant), *Abelmoschus esculentus* (Okra), *Amaranthus gangeticus* (Red Amaranth), *Basella alba* (Spinach), *Phaseolus vulgaris* (Bean), *Solanum lycopersicum*(Tomato), *Brassica oleracea* (Cauliflower), *Lathyrus sativus* (Khesari dal), *Lens culinaris* (Mosur dal). Mean annual productions of rice per family among all crops grown in farms in ship breaking areas were the highest (2251.9kg/year) whereas it was (380.2 kg/year) in non-ship breaking areas. Production of rice in ship breaking areas was quite high compared to the non-ship breaking areas. Unique species for non-ship breaking areas were *Ipomoea batatas* (Sweet Potato), *Momordica charantia* (Bitter gourd) and *Trichosanthes cucumerina* (Snake gourd) while *Luffa cylindrica* (Sponge gourd) and *Brassica oleracea var capitata* (Badhakopi) for the ship breaking areas shown in (Table 3 and Table 4). Various agro-crops were found in the non-ship breaking areas such as *Oryza sativa* (Rice), *Solanum melongena* (Eggplant), *Trichosanthes cucumerina* (Snake gourd), *Abelmoschus esculentus* (Okra), *Momordica charantia* (Bitter gourd), *Cucurbita maxima* (Misti Kumra), *Amaranthus gangeticus* (Red Amaranth), *Lagenaria siceraria* (Bottle gourd), *Capsicum annuum* (Green Chili Pepper), *Basella alba* (Spinach), *Phaseolus vulgaris (*Bean), *Solanum lycopersicum* (Tomato), *Brassica oleracea* (Cauliflower), *Lathyrus sativus* (Khesari dal), and *Lens culinaris* (Moshur dal). Among them rice plays the most significant role in the rural economy of the non-ship breaking areas. Rice production in each family was 380 kg/yr where consumption was 344.2 kg/yr and production cost was 1908.6 BDT. Respondents got 835.3 BDT on an average by selling surplus rice. There were no surplus for Spinach and Cauliflower after own consumption. These crops were grown only for own consumption shown in (Table 4). Farmers were asked whether they find any impact of ship breaking activities on their agro-crop production but they responded that they are not aware on this issue. Furthermore, they suggested to carry on further research on ship breaking activities and it's impact on agro-crop production.

3.3 Sources of Seedlings

Three different sources of seedling were found in ship breaking areas. These are private source, own production and other sources i.e bringing from relative, neighbors. Major seedling sources was private sources (72%) followed by others (14%) and own (14%) respectively shown in Fig. 2(a). On the contrary, three different sources of seedling were found in non-ship breaking areas. These are private source, own production and other sources i.e. bringing from relative, neighbors. Major seedling sources was private sources (86%) followed by others (8%) and own (6%) respectively shown in Fig. 2(b).

3.4 Preference of Species Selection

Present choice of preference of species selection is confined to fruit, fuel and timber species for both ship breaking and non-ship breaking areas. Among them preference was given to the fruit tree species for both areas. However percentage varied from each other. In non-ship breaking areas 57% people chose fruit species while 73% people chose fruit tree species in ship breaking areas. After fruit species fuel species was given preference in non-ship breaking areas while timber was given preference in ship breaking areas (Fig. 3a). Past choice of species were confined to fruit, timber, aesthetics and medicinal

species for non-ship breaking areas and fruit, fuel, timber and aesthetics for ship breaking areas (Fig. 3b). Among them preference was given to the fruit tree species in non-ship breaking areas while timber species was given preference in ship breaking areas. In non-ship breaking areas 57% people chose fruit species while 43% people chose fruit tree species in ship breaking areas. In ship breaking areas 45% people chose timber species while 35% people chose timber species in non-ship breaking areas. Respondents of non-ship breaking areas were used to plant medicinal species, on the other hand respondents of ship breaking areas were used to plant fuel species (Fig. 3b).

Table 1. Plant diversity in both ship breaking and non-ship breaking areas

Species overlapped in both areas			
Local name	**Scientific name**	**Local name**	**Scientific name**
Acacia	*Acacia auriculiformis*	Kanthal	*Artocarpus heterophyllus*
Mango	*Mangifera indica*	Labu	*Citrus lemon*
Amra	*Spondia spinnata*	Litchi	*Litchi chinensis*
Banana	*Musa sapientum*	Mehegoni	*Swietenia mahagoni*
Bilimbi	*Averrhoa bilimbi*	Coconut	*Cocos nucifera*
Eucalyptus	*Eucalyptus camaldulensis*	Ata	*Annona squamosa*
Gab	*Diospyros perigrina*	Papaya	*Carica papaya*
Gamar	*Gmelina arborea*	Segun	*Tectona grandis*
Ganda	*Polygala vulgaris*	Silkoroi	*Albizia procera*
Jaba	*Hibiscus rosa-sinensis*	Supari	*Areca catechu*
Jam	*Syzygium cumini*	Tulsi	*Ocimum sanctum*
Jambura	*Citrus grandis*	Boroi	*Zyzyphus mauritiana*
Jhau	*Casuarina equisetifolia*	Khejur	*Phoenix sylvestris*
Species found only in non-ship breaking areas			
Local name	**Scientific name**		
Guava	*Psidium guajava*		
Kamranga	*Averrhoea carambola*		
Shimul tula	*Bombax malabaricum*		

Table 2. Shanon winner diversity index

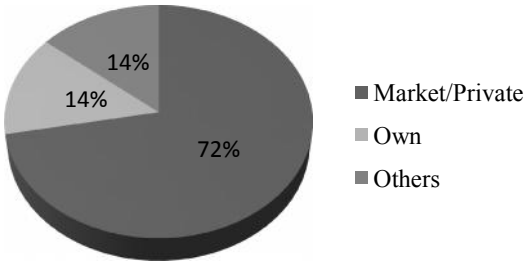
Areas	**Shanon winner index**
Ship breaking	2.5
Non-ship breaking	2.7

Table 3. Average production of agro-crop in ship breaking areas

Name of the crops	**Average production (kg/yr) in each family**	**Average consumption (kg/yr)**	**Average production cost (Tk)**	**Average sale value (Tk) for surplus crop)**
Badhakopi	4.6	2.32	174.4	1325.5
Eggplant	3.13	3.9	16.2	11.6
Okra	16.69	3.1	7.8	258.2
Sponge gourd	50	1.04	139.53	979.06
Cauliflower	46.51	4.65	162.79	1046.5
Misti Kumra	11.16	0.69	26.74	156.97
Red Amaranth	3.83	0.58	8.37	65.11
Bottle gourd	66.86	8.48	377.9	715.11
Green Chili	2.39	1.46	110.9	18.6
Musur dal	3.48	0.81	23.25	76.16
Spinach	0.81	0.58	2.32	3.48
Rice	2251.9	320	4546.51	2401.39
Bean	30.81	5	124.41	610.46
Tomato	27.67	3.37	111.62	400
Khesari dal	4.18	1.27	46.51	93.02

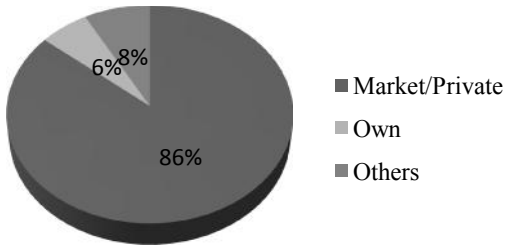
Table 4. Average production of agro-crop in non-ship breaking areas

Name of the crops	Average production (kg/yr)	Average consumption (kg/yr)	Average production cost(Tk)	Average sale value for surplus crop (Tk)
Rice	380.2	344.2	1908.16	835.3
Eggplant	2.65	2.14	28.77	10.2
Snake gourd	0.918	0.71	5.1	4.1
Okra	14.69	2.65	6.83	217.34
Bitter gourd	8.16	1.02	81.63	229.59
Misti Kumra	8.46	1.12	25.51	110.2
Red Amaranth	5	0.81	21.63	76
Bottle gourd	2.04	1.02	16.53	17.85
Green Chili	3.06	0.3	76.53	469.38
Spinach	0.61	0.61	2.04	0
Bean	23.46	6.02	105.1	348.9
Tomato	14.79	3.87	112.24	165.8
Cauliflower	1.63	0.51	10.2	0
Khesari dal	1.63	0.2	30.61	42.85
Sweet potato	6.12	0.61	20.4	82.65
Mosur dal	5.1	1.22	8.16	310.2



2(a)

Fig. 2(a). Seedling sources in ship breaking areas



2(b)

Fig. 2(b). Seedling sources in non-ship breaking areas

3.5 Purpose of Planting Trees in Home Garden

Major purpose of planting trees in home garden were deposit, house construction, fuel wood, furniture and cultural activities for both ship breaking and non-ship breaking areas. Among them the most dominant purpose was deposit for both areas. However percentage varied from each other. In ship breaking areas 26% people's purpose was deposit while 33% people's purpose was deposit in non-ship breaking areas followed by fuel wood and furniture (Fig. 4).

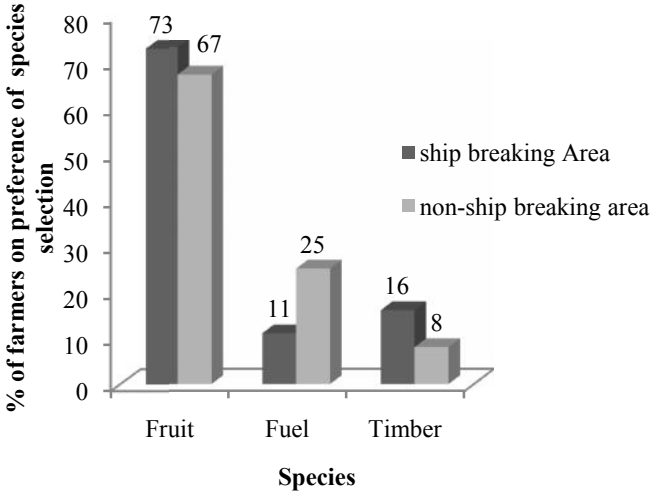
4. DISCUSSION

In tropical home gardens species diversity is generally believed to be very high [15]. Home gardens reached high levels of developments in terms of plant diversity, labor input and income derived from garden in region where population densities are high and create a forest like multistory canopy structure. Moreover, species diversity sue, shape and plant density also vary from place to place depending on cultural, ecological and socio economic factors which is consistent with the findings of present study where a total of 27 tree and 16 agri-crop species including fruits, timber, fuel wood, aesthetics and medicinal were found in ship breaking areas while 30 tree and 16 agri-crop species were found in non-ship breaking areas which support the study of [16] and [17] where our traditional agro-forestry practices support biodiversity through in situ conservation of tree species on farm level and there are many factors behind the selection

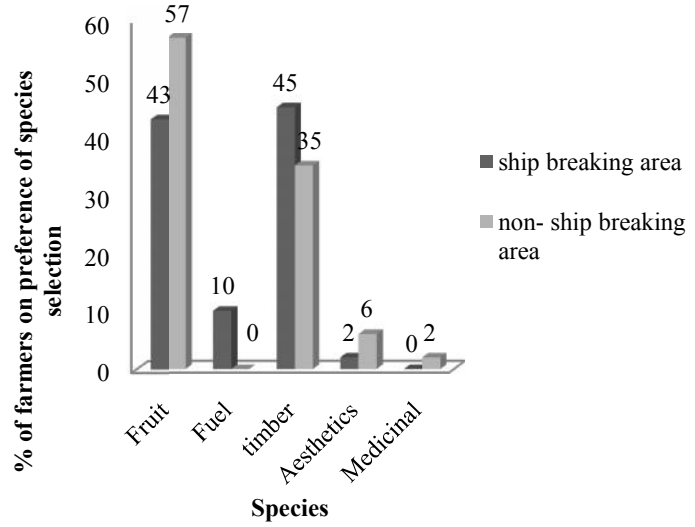
of integrated tree species in the farming system existed. This study has similar findings with [18] that documented more diverse crops in the home gardens in the South Andamans.

In this project, major seedling sources were found from private, own production and other sources e.g. relative, neighbors at both ship breaking and non-ship breaking areas. It is similar to the maximum findings [19] of homestead plantation seedling sources in Bangladesh. Surprisingly, relative and neighbors play an important role as seedling source, sometimes as seed or seedling.

For the majority of respondents surveyed, the selection criteria of tree species in the system were dependent on cash income as output followed by house construction, fuel wood, furniture and cultural activities for both the ship breaking and non-ship breaking areas.



3(a)



3(b)

Fig. 3(a) and 3(b). Percentage of farmers on present and past preference of tree species selection in both the areas

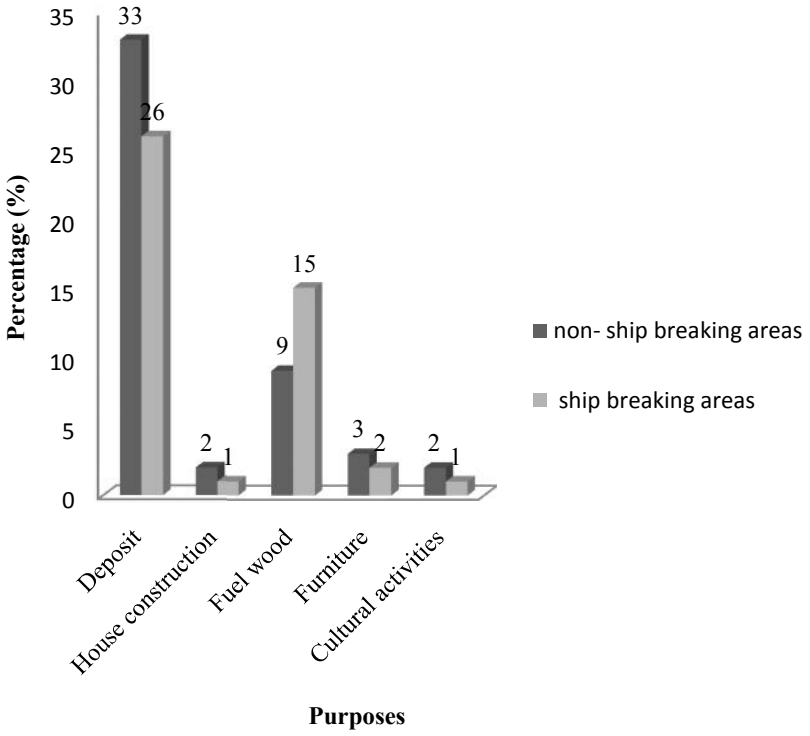


Fig. 4. Various purposes of planting trees in home garden

This study was found similar to the study conducted by [20] where they mentioned that farmers' decisions of whether or not to plant trees have been based primarily on economic rather than ecological concerns. Many of the farmers presently preferred fruit trees to plant in both the ship breaking (43%) and non-ship breaking (57%) as a source of income as well as their own consumption which is supported by findings of several researchers [21,22,8] across the country. [19] also found similar findings where farmers were very interested to grow timber and fruit trees for their economic return and family needs.

Homestead forestry can generate additional income to alleviate the poverty of rural people by increasing overall household income. Moreover, Shannon–Wiener index of this study was 2.5 in ship breaking and 2.7 in non-ship breaking areas, which is consistent with findings of a similar study [23] reported this index as 2.62–3.33, for different-sized home gardens of Bangladesh.

Homestead forest is acting a great role for biodiversity conservation but it is evident from the study that farmers have lack of knowledge on homestead forest species conservation through scientific way as they are planting following traditional management systems. Even farmers are not conscious whether ship breaking activities are affecting their homestead plant including tree and agro-crop production or not.

Several studies [24,25,26] were carried out at the ship breaking areas to check the soil properties and heavy metal concentration in soil and they explored that heavy metal pollution in the sediments of ship breaking areas is at alarming stage. Moreover, [27] reported the drastic expansion of ship yard from 3.45 km in 1989 to 12.78 km in 2010 which indicated an elongated pollution release zone which directly influencing the vegetation at the surrounding areas. Therefore, it is very much important to investigate the land use changing pattern due to ship breaking activities over time and its impact on soil properties and plant growth including agro-crop and forest crop growing around the ship breaking areas of Bangladesh. Moreover, it is also very urgent to investigate the heavy metal concentration in plant including

agro-crop and forest crop growing around this area. Based on findings from the analysis of soil properties and heavy metal concentration in soil and plant, farmers can be prescribed to plant site specific species for more production and sustainable homestead forest management at the ship breaking areas of Bangladesh.

5. PROBLEMS AND RECOMMENDATIONS

Household members mentioned oil leakage from ship breaking yards to the agri-land may cause soil infertility. Moreover, they also mentioned crops damaged animals, storm, children, lack of technical knowledge, and unavailability of space as major problems for cultivation of agri-crops and planting trees at the homestead level in both ship breaking and non-ship breaking areas. Household members suggested some measures against those problems which are mentioned below:

- Proper research on ship breaking activities and its impact on agro-crop production.
- Ship breaking industry should follow certain guidelines provided by Govt. so that it cannot effect negatively on cultivation and production of agri-crops and plantation of trees.
- Use of multipurpose trees should be encouraged considering the increasing demand of forest resources.
- To ensure safe and reliable source of planting materials i.e. establishment of Govt. nursery.
- Indigenous techniques practiced by the farmers should be modernized.
- Use of species that can withstand stormy weather for protection and can survive in ship breaking areas should be planted.
- Proper training and technical support should be made available by appropriate authority about home garden management to make home garden more productive.

6. CONCLUSIONS

Home garden is one of the most elaborate system of indigenous forestry, found most often in tropical and sub-tropical areas. It was found from the study that homestead people prefer fruit, fuel wood and timber species to plant which are a direct source of cash income as well as play role to fulfill their own demand. This preference of species selection should be considered while planning the homestead plantation program at the local level. Farmers should be provided incentives to plant their preferred tree species as well as endangered tree species for biodiversity conservation point of view. Moreover, agro-crop diversity was quite similar in both the ship breaking and non-ship breaking areas, even though there should be a depth research whether there is any impact of soil properties including heavy metals contamination on growth of agro-crop and tree species in ship breaking areas perhaps soil contamination due to ship cutting in the yard is happening there. In addition, farmers should be made conscious if there are any changes of production of agro-crop at the ship breaking areas and they should search the causes behind the changes. Moreover, strong co-ordination and linkage among different stakeholders from agriculture, forestry, land-use practitioners and finally the local people should be developed for sustainable homestead forest management.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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