



The Role of NGOs Activities with forest conservation for sustainable development: Experiences from Bangladesh

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Abstract:

The study assessed the capability of NGOs ongoing programs towards species richness and biodiversity conservation in a sustainable way of rural households in Chattogram and Moulavibazar during 2014 to 2019. Data were collected from 330 IGA participating forest-dependent farmers, who were the member of different NGOs. The assessment was done using multistage random sampling. A total of 131 plant species were identified adjacent twenty villages of evergreen and semi-evergreen forest, Sal forest and Mangrove forest areas of which 43 species were fruit-producing, 41 timber species, 29 fuel wood and ornamental species, 18 medicinal and species of spices. Most of the farmers (33%) preferred to plant fruit tree species for future plantation followed by timber species (31%). Diversity and abundance of fruit species were found higher in all homesteads. Seven livestock, seven poultry, and two pet animal species were recorded. A total of 46 species of cultured fish species were recorded. Besides, analysis of existing management period indicates that farmers lack scientific information, almost every household presently follows traditional management systems. Finally, a homestead forest management plan, conservation of homestead species diversity through scientific management and obtaining training and support from government and NGOs, was found highly demandable by this study.

Keywords: Role of NGOs Activities, Forest Conservation, Sustainable Development, Bangladesh

1. Introduction

Bangladesh is situated at the complex interface of the Himalayan and Southeast Asian Biogeographic Regions, and historically was well endowed with very diverse complements of terrestrial and aquatic flora and fauna. The tropical forest is regarded as the richest in Plant Diversity. But Bangladesh has only 5 to 6% forest area (Bashar, 1999). It has 15.4 million homesteads occupying 0.3 million hectares of land and is providing major requirements of food, fruit, vegetables, timber, and fuel wood (Abedin & Quddus, 1990). Wide ranges of plant biodiversity for timber and food crops were found in the homesteads (Bashar, 1999).

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The Government of Bangladesh has been implementing wider programs including Afforestation, cattle, goat, poultry rearing, fish farming, handicrafts, small and cottage industries, etc. The government has been paying much attention and channeling more money towards the community programs since the early 1980s, taken as an approach to poverty alleviation and environmental amelioration. Along with the government programs more than 100 national and international NGOs are also engaged in homestead/community forestry programs as part of their strategy for environmental development and poverty reductions.

The NGOs sector has grown to serve the rural poor, especially after the respective governments adopted the economic reform policies. Most of the NGOs have proved themselves capable of interacting with rural poor and this has been well recognized by the government. However, only some of the NGOs adopt a holistic approach to poverty alleviation programs for forest dependant people. The Caritas Bangladesh, BRAC, World Vision Bangladesh, Arannak Foundation, and Bangladesh Palli Daridro Bimochan Foundation and several other NGOs have been working with the government as a development partner in a different sector. Both GO and NGOs activities have been playing a significant role in engaging forest dependant farmers in income generation activities, which were considered to assist them in having a more significant role in the family, especially with regards to improving the livelihood and homestead/forest resource conservation.

2. Materials and Methods

Chattogram and Moulavibazar covered by evergreen and semi-evergreen forest area, Tangail and Sherpur covered by Sal forest area and Sathkhira covered by mangrove forest area were the locales of this study. The study was conducted among forest dependant farmers of the study area and was considered as the population of the study. Multistage purposive and random sampling procedures were followed to obtain the desired sample. Having a minimum of three years of membership in different NGOs and took facilities to implement IGAs from aforesaid organizations. A sample from 330 forest dependant farmers constituted the actual sample of the study IGAs participation out of 3,330 poor households was selected following a random sampling procedure. Data were collected through a pre-tested interview schedule. In addition, focus group discussion (FGD), scored causal diagrams (SCDs), key informant interview (KII), interview schedule, and direct field observation were also employed to obtain necessary information. Data were collected from forest dependant farmers, who were the member of different NGOs (Caritas Bangladesh, BRAC, World Vision Bangladesh, Arannak Foundation and Palli Daridro Bimochan Foundation) selected by multistage random sampling procedure during May 2015 to July 2017. The collected data were cross-checked finally in a group meeting at every village involving people at various levels. In the present study, homestead biodiversity was evaluated considering mainly the plants, domestic animals, and fishes. The following measures were used in determining biodiversity.

- i. Species richness (S) = The number of species within a homestead

- ii. Relative Prevalence (RP) = Population of the species per homestead X % homesteads with the species.
- iii. Interspecies diversity: Simpson's Species Diversity Index (D)

$$D=1-\sum(pi)^2$$

Where Pi is the proportion of total individuals in the ith species.

Pi=n/N, n is the number of individuals in the ith species and N is the total number of the individuals of all species in the community, D=Diversity index number, \sum = is a summation sign, S=Total number of species, D can range from 0 to 1.

- i. Species evenness: The most frequently used measures, which covers large samples (Peet, 1974) are:

$$E = I - I_{\min} / I_{\max} - I_{\min}$$

and

$$E=I/I_{\max}$$

Where, E = Species Evenness Index, I = Diversity Index and I_{min}=Lowest value of this index and I_{max}= Highest values of this index for the given number of species and sample size.

3. Results and Discussion

The existing biodiversity in the rural homesteads of evergreen and semi-evergreen, sal forest and mangrove forest areas are described under – i) Species richness, ii) interspecies diversity and iii) Species evenness as follows:

Species richness in the rural homesteads

Almost all the homesteads of the study areas contained mixed vegetation of various annual and perennial plants including trees and shrubs. There were different types of domestic and pet animals and also fishes in the ponds. The findings of the study showed that there was a wide variety of plant and animal species in homesteads and their number varied from one homestead to another and also varied among the three study areas.

Plant species richness in the homesteads

A total of 131 plant species were identified in the three study areas. Among the 131 plant species, 33% fruit species, 31% timber species, 22% fuelwood and ornamental plant species, and 14% medicinal species. The highest number (110) of species were found in hill forest area and lowest (105) in the Sal forest area (Table 1). Alam and Masum (2005) identified 142 plant species in the Offshore Island of Bangladesh.

Table 1. Species Richness of Plant Groups in the Homesteads of Different Study Areas

Study area	No of species				Total
	Fruit	Timber	Medicinal and spices	Fuelwood and ornamental	
Hill forest	42	31	16	21	110
Sal forest	42	26	16	21	105
Mangrove	41	26	17	25	109

forest					
Average	42	28	16	22	108
All	43 (33)	41 (31)	18 (14)	29 (22)	131 (100)

Figure 1. in parentheses indicate percentages of each category

Fruits: Findings presented in Table 1 show that the number of fruit species was higher in the homesteads compared to other categories of plant species. Fruit species covered about 33% of the total vegetation of a rural homestead. A total of 42 fruit species was recorded in Sal forest and hill forest areas and 41 in the mangrove forest area. Bashar (1999) identified 44 fruit species while Mannan (2000) recorded 36 fruit species in the homestead of Gazipur districts.

Timber: The plant group 'timber' occupied the second position concerning the average number of species and covered 31% of the total vegetation of rural homesteads (Table 1). A total of 31 timber species was recorded in the hill forest area. The Equal number of timber species (26) was recorded both Sal and mangrove forest areas. Mannan (2000) recorded 30 timber species in the homestead of Gazipur districts.

Fuel and Ornamental plants: The plant group 'fuel and ornamental' occupied the third position concerning the average number of species and covered 22% of the total vegetation of rural homesteads (Table 1). A total of 25 fuel and ornamental plant species was recorded in the mangrove forest area while there were 21 species in the Sal forest area and 20 in the mangrove forest area. These were mainly trees and shrubs such as wider, banyan tree, royal poinciana, night flowering jasmine, coral tree, china rose, bamboo, mangrove date palm, kankra, ipil-ipil, nipa palm, cape jasmine, cynometra, medlar, chandon, kasava, shimul, cane, debdaru, henna, portia tree, china box, parrot tree, goran, baen, camel's foot tree, payra, and rubber. Hossain *et al.* 2009 found that 19.77% ornamental species at the horticultural farm of BAU, Mymensingh.

Medicinal and spices: The plant group 'medicinal and spices' occupied the fourth position concerning the average number of species and covered 14% of the total vegetation of rural homesteads (Table 1). A total of 17 medicinal and spices plant species were recorded in the mangrove forest area. The Equal number of medicinal and spices (16) was recorded both Sal and hill forest areas. Hossain *et al.* 2009 found that 4.36% medicinal species and 0.04% spices species at the horticultural farm of BAU, Mymensingh.

The richness of animal species

Seven livestock species i.e cow, buffalo, goat, horse, sheep, rabbit, and pig were found in the homesteads of all three study areas. In the case of cattle, the exotic or crossbreed was found in many cases along with local breed. Black Bengal was the only species of goat (Table 2). Seven poultry species as chicken, duck, goose, Japanese quail, guinea fowl, turkey, and pigeon were available in the study villages (Table 2). Only two pet animals e.g. dog and cat of the local breed were found in homesteads of all study areas.

Table 2. Species Richness of different animal groups in the Homestead of Different Study Areas

Study area	No of species					Total
	Livestock	Poultry	Pet animals	Birds	Fish	

Hill forest	7	7	2	32	37	85
Sal forest	7	7	2	32	40	88
Mangrove forest	7	7	2	26	37	79
Average	7	7	2	30	38	84
All	7 (7)	7 (7)	2 (2)	40 (39)	46 (45)	102 (100)

Figure 2. in parentheses indicate percentages of each category

Among the animals found in the homesteads, species richness was high in the case of fishes. A total of 40 fish species were mentioned by the respondents which they observed recently in their ponds while catching fish. The highest number (40) of species was recorded at the Sal forest area and lowest (37) at mangrove and hill forest area. In this case, respondents were asked to mention different birds as they observed in their homesteads during the last one year. The highest number (32) of species was recorded at hill and Sal forest area and lowest (26) at mangrove forest area Table 2. Islam et al. 2017 found that 2 livestock species, 3 poultry species, 2 pet animal species, 28 fish species, and 21 bird species in the homestead of Gazipur district. Alam and Masum (2005) found that poultry was the major livestock component followed by goat and cattle as occurred respectively at 63.7%, 11.6%, and 10.6% of the households in Sandip Upazila.

Relative prevalence of species

A total of 131 plant species and 14 animal species were identified in the surveyed homesteads (Table 3). The relative prevalence of different species was determined with species found in all the three study areas. However, the relative prevalence (RP) of species of fruits, timber, medicinal, fuel and ornamental spices, and domestic animals are as follows.

Table 3. Relative Prevalence of Different Species in the Homesteads of the Study Areas

Common Name/English Name	Scientific Name	Hill forest	Sal forest	Mangrove forest	All	R
Mango	<i>Mangifera indica</i>	50.853	40.755	13.790	35.621	1
Jackfruit	<i>Artocarpus heterophyllus</i>	13.571	37.454	2.480	17.835	3
Betelnut	<i>Areca catechu</i>	19.216	6.620	2.781	9.540	8
Guava	<i>Psidium guajava</i>	17.588	21.745	9.972	16.554	4
Pineapple	<i>Ananas sativus</i>	8.457	19.456	1.045	10.037	7
Blackberry	<i>Syzygium cumini</i>	2.177	1.429	1.512	1.716	19
Pomelo	<i>Citrus grandis</i>	1.087	3.199	1.327	1.910	17
Lemon	<i>Citrus aurantifolia</i>	13.363	21.248	5.733	13.086	6
Litchi	<i>Litchi chinensis</i>	17.580	36.809	6.123	20.311	2
Papaya	<i>Carica Papaya</i>	15.260	26.645	2.863	14.924	5
Elephant apple	<i>Dillenia indica</i>	1.222	0.887	1.057	1.215	25
Star fruit	<i>Averrhoa carambola</i>	1.774	0.942	0.119	0.803	28

Olive	<i>Elaeocarpus robustus</i>	1.805	0.922	0.119	0.805	27
Bullocks heart	<i>Annona reticulate</i>	1.428	0.922	0.132	0.716	30
Wood apple	<i>Feronia limonia</i>	1.350	0.914	0.132	0.693	32
Jujubee	<i>Zizyphus jujum</i>	7.340	6.292	5.041	6.194	11
Pome granate	<i>Punica granatum</i>	2.308	1.375	1.026	1.599	21
Banana	<i>Musa paradisiaca</i>	9.515	11.707	5.267	8.827	9
Hog plum	<i>Spondias mombin</i>	3.148	1.043	3.037	2.421	16
Sapota	<i>Manilkara zapota</i>	2.143	1.076	10.581	4.400	12
Tamarind	<i>Tamarindus indica</i>	1.515	1.435	2.190	1.702	18
Palmyra palm	<i>Borassus flabellifer</i>	0.782	0.912	0.826	0.881	29
Cucumber Tree	<i>Averrhoa bilimbi</i>	1.075	1.554	1.085	1.238	24
Drumstick tree	<i>Moringa oleifera</i>	3.675	1.472	4.254	3.363	15
Orange	<i>Citrus chinensis</i>	10.445	2.168	0.079	3.184	13
Dragon	<i>Hylocereus undatus</i>	0.885	1.110	0.079	0.610	35
Coconut	<i>Cocos nucifera</i>	6.971	3.223	9.981	6.654	10
Monkey jack	<i>Artocarpus lakoocha</i>	0.989	0.971	1.020	1.018	26
Sweet orange	<i>Citrus sinensis</i>	1.539	2.628	0.064	1.102	22
Date-pump	<i>Phoenix sylvestris</i>	2.174	1.360	7.363	3.491	14
Indian almond	<i>Terminalia catappa</i>	0.817	0.904	2.087	1.628	23
Stone apple	<i>Aegle marmelos</i>	0.824	0.913	0.174	0.580	41
Star gooseberry	<i>Phyllanthus acidus</i>	0.824	0.929	0.174	0.584	39
Wax jambu	<i>Syzygium samarangense</i>	1.073	1.988	1.771	1.922	20
Cowa	<i>Garcinia cowa</i>	0.676	0.669	0.684	0.676	36
Custard apple	<i>Annona squamosa</i>	0.647	0.640	0.625	0.637	40
Fig	<i>Ficus carica</i>	0.753	0.754	0.745	0.748	33
Velvety apple	<i>Diospyros discolor</i>	0.661	0.654	0.654	0.657	38
Rose apple	<i>Syzygium jambos</i>	0.676	0.669	0.684	0.676	37
Bengal currant	<i>Carissa carandas</i>	0.818	0.810	0.810	0.812	31
River ebony	<i>Diospyros peregrine</i>	1.138	0.924	0.174	0.669	34
Timber species						
Mahogany	<i>Swietenia macrophylla</i>	59.418	38.281	15.790	37.830	1
Auri	<i>Acacia auriculiformis</i>	11.954	29.354	6.265	15.688	5
Crow bean tree	<i>Samanea saman</i>	10.654	19.827	9.445	13.329	2
Eucalyptus	<i>Eucalyptus camaldulensis</i>	5.224	8.115	3.583	5.716	4
Indian lilac	<i>Melia azedarach</i>	6.637	12.444	1.513	6.070	8
Sissoo	<i>Dalbergia sissoo</i>	2.697	3.425	2.569	3.101	12
Lebbek tree	<i>Albizia lebbek</i>	3.113	3.161	2.815	3.131	6
Mangium	<i>Acacia mangium</i>	5.388	7.592	1.615	4.505	10
African Mahogany	<i>Khya senegalensis</i>	3.824	6.414	3.037	4.482	7
Beechwood	<i>Gmelina arborea</i>	0.949	6.194	0.888	2.508	16
White sirs	<i>Albizia procera</i>	6.471	2.814	3.962	4.373	11
Chapalish	<i>Artocarpus chapalasha</i>	0.893	1.490	1.472	1.279	9
Golden rain tree	<i>Cassia fistula</i>	1.000	1.218	0.843	1.016	14
Pride of India	<i>Lagerstroemia speciosa</i>	1.000	1.245	1.036	1.445	3
Hatiamiuki	<i>Albizia richardiana</i>	1.018	3.209	6.736	3.654	13
Kadam	<i>Anchocephalus cadambu</i>	1.000	1.000	0.338	0.740	15
Kassod tree	<i>Cassia siamea</i>	1.000	1.000	1.427	1.142	17
Coast sheoak	<i>Casuarina equisetifolia</i>	0.002	1.090	1.000	0.489	18
Medicinal and Spices plants						
Crown flower	<i>Calotropis gigantean</i>	1.235	0.870	9.290	3.629	5
Indian gooseberry	<i>Phyllanthus emblica</i>	3.345	1.513	5.390	3.410	6

Ashoka	<i>Sara assoca</i>	1.000	1.100	1.163	1.087	12
Beleric myrobalam	<i>Terminalia bellirica</i>	1.317	1.045	2.254	1.526	10
Basak	<i>Adhatoda vasica</i>	1.000	13.927	2.245	5.724	2
Arjuna	<i>Terminalia arjuna</i>	0.902	2.053	2.863	1.897	8
Black myrobalam	<i>Terminalia chebula</i>	1.612	2.490	7.990	4.024	4
Neem	<i>Azardirachita indica</i>	4.109	9.918	8.636	7.554	1
Basil	<i>Ocimum basilicum</i>	1.063	11.409	3.236	5.236	3
Angel's trumpet	<i>Datura innoxia</i>	1.036	1.018	1.018	1.024	14
Black nightshade	<i>Solanum nigrum</i>	1.000	0.963	1.000	0.987	15
Devil tree	<i>Alstonia scholaris</i>	1.847	3.855	0.287	1.779	9
Bay leaf	<i>Cinnamum tamala</i>	1.198	2.189	3.281	2.219	7
Cinnamon	<i>Cinnamomum zeylanicum</i>	1.162	1.249	1.327	1.246	11
Tooth brush tree	<i>Streblus asper</i>	1.036	1.027	1.027	1.030	13
Fuel and ornamental Plants						
Wdier	<i>Lannea coromandelica</i>	15.172	11.133	12.790	13.014	2
Baniyan tree	<i>Ficus bengalensis</i>	0.882	1.726	0.349	0.926	12
Royal poinciana	<i>Delonix regia</i>	1.327	3.254	1.309	1.011	11
Night-flowering Jasmine	<i>Nyctanthes arbortristis</i>	3.727	2.154	2.318	2.733	8
Coral tree	<i>Erythrina variegata</i>	0.963	16.763	8.218	8.602	3
China rose	<i>Hibiscus rosa-sinensis</i>	6.309	8.245	6.318	6.957	4
Bamboo	<i>Bambusa vulgaris</i>	15.095	19.356	16.281	16.934	1
Ipil-ipil	<i>Leucaena leucocephala</i>	2.478	8.372	3.427	4.662	5
Cape jasmine	<i>Gardenia jasminoides</i>	4.172	6.754	2.963	4.630	6
Medlar	<i>Mimusops elengi</i>	3.390	4.245	1.990	3.209	7
Wavy-leaved fig	<i>Ficus infectoria</i>	0.069	1.000	0.053	0.265	17
Silk cotton	<i>Gossypium herbaceum</i>	2.312	1.923	1.372	1.884	10
False ashoka	<i>Polyalthia longifolia</i>	0.704	0.877	0.010	0.391	16
Henna	<i>Lawsonia inermis</i>	1.644	1.247	0.010	0.704	14
Chinese box	<i>Murraya exotica</i>	3.145	1.436	1.854	2.145	9
Parrot tree	<i>Butea monosperma</i>	0.145	1.190	1.000	0.680	15
Camel's foot tree	<i>Bauhinia variegata</i>	0.620	1.775	0.384	0.842	13
Domestic birds						
Chicken	<i>Gallus gallusdomesticus</i>	11.018	8.081	6.763	8.621	1
Duck	<i>Antidae anseriformes</i>	7.500	5.063	7.009	6.524	2
Pegion	<i>Colomba livia</i>	1.728	1.543	4.198	2.405	4
Japanese quail	<i>Coturnix japonica</i>	3.393	4.123	5.251	4.240	3
Guinea fowl	<i>Numida meleagris</i>	0.919	0.714	0.877	0.834	6
Goose	<i>Anser cygnoides</i>	0.575	0.568	0.561	0.568	7
Turkey	<i>Meleagris gallopavo</i>	0.876	0.893	0.876	0.882	5
Domestic animals						
Buffalo	<i>Bubalus bubalis</i>	1.084	1.036	1.399	1.178	5
Cow	<i>Bos Taurus</i>	4.954	7.163	5.409	5.842	1
Hare	<i>Lepus spp</i>	2.286	2.125	3.264	2.579	4
Horse	<i>Equus feruscaballus</i>	0.317	0.336	0.250	0.300	7
Goat	<i>Capra aegagrushircus</i>	5.296	6.227	5.176	5.564	2
Sheep	<i>Ovie saries</i>	2.475	2.447	5.774	3.477	3
Swine	<i>Sus scrofa</i>	0.156	3.990	0.135	0.877	6

Fruits: In the hill forest area, Mango (50.853), betel nut (19.216), guava (17.588), litchi (17.580) and papaya (15.260) were five most prevalent fruit species followed by jackfruit

(13.571), lemon (13.363), orange (10.445), banana (9.515) and pineapple (8.457). The prevalence of mango (40.755), jackfruit (37.454), litchi (36.809), papaya (26.645), guava (21.745), lemon (21.248), pineapple (19.456), banana (11.707), lotkon/Burmese grape (7.446) and betel nut (6.620) was higher in Sal forest area; while mango (13.790), sapota (10.581), coconut (9.981), guava (9.972), date plum (7.363), litchi (6.123), lemon (5.733) banana (5.267), jujube (5.041) and drumstick (4.254) had a higher prevalence in the mangrove forest area. All forest Mango, litchi, jackfruit, guava, papaya were the five most prevalent fruit species in the study areas (Table-3).

Timber: Regarding the timber species, the most prevalent species in hill forest area was mahogany (59.418) followed by akashmoni (11.954), rain tree (10.654), goraneem (6.637); white siris (6.471), mangium (5.388), eucalyptus (5.224) and lombu (3.824). Mahogany (38.281) was the most prevalent species and ranked 1st in Sal forest homestead areas and other species were akashmoni (29.354), rain tree (19.827), goraneem (12.444); eucalyptus (8.115); mangium (7.592), lombu (6.414) Beachwood (6.194); Sal (5.816) and pitraj (4.980). Mahogany ranked 1st in the Mangrove forest . Among other species, rain tree, rajkori, akashmoni, sheel koroi, eucalyptus, lombu, lebbek tree, sissoo, and mangium were more prevalent in mangrove forest homestead areas. According to the mean dominance rank of all forest, prevalence of, mahogany, raintree, jarul, eucalyptus, akashmoni were relatively higher in the study area (Table-3).

Medicinal and spices: Regarding the medicinal and species were recorded at three study areas, neem was the most prevalent species followed by basak, basil, black myrobalam, crown flower, Indian gooseberry and bay leaf (Table-3).

Fuel and ornamental: Based on mean dominance bamboo occupied the 1st position followed by wider/jiga, coral tree/maunder, china rose, ipil-ipil, cape jasmine, medlar, night flowering jasmine were relatively higher in the study area (Table-3).

Domestic birds and animals: the chicken was the most prevalent followed by duck, cow, goat, koel, sheep, rabbit, and buffalo at each of the three study areas. The RP value for swine, turkey, titir, goose, and the horse was very low in all the study areas indicating a low prevalence of these species (Table-3).

Interspecies diversity in the rural homesteads

The species diversity index was computed the following Simpson’s Species Diversity Index (D). Results presented in Table 4.1 and Table 4.2 showed that species diversity varied with different farm categories and also among the study areas. The species diversity index values 0.787585657, 0.738947499, and 0.649296817, respectively for marginal, small, and medium farms indicate that plant biodiversity was higher in all categories of the farm (Table 4.1).

Table 4. Species Diversity Indices of Different Categories of Species in Different Forest Zones of the Studied Areas of Bangladesh

Farm Category	Plant and animal group	Relative abundance (Pi ²)	Diversity index (D)
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Farm Category	Plant and animal group	Relative abundance (P_i^2)	Diversity index (D)
Marginal (>0.20 ha area)	Fruit	0.045968778	0.954031222
	Timber	0.076556284	0.923443716
	Medicinal and spices	0.095249903	0.904750097
	Fuel and ornamental	0.109147867	0.890852133
	Homestead birds	0.21332129	0.78667871
	Homestead animals	0.201735182	0.798264818
	All	0.212414343	0.787585657
Small (0.21-1.00 ha area)	Fruit	0.07722794	0.92277206
	Timber	0.153340369	0.846659631
	Medicinal and spices	0.116433071	0.883566929
	Fuel and ornamental	0.100583696	0.899416304
	Homestead birds	0.233159894	0.766840106
	Homestead animals	0.184446979	0.815553021
	All	0.261052501	0.738947499
Medium (1.1-3 ha area)	Fruit	0.084997001	0.915002999
	Timber	0.119639121	0.880360879
	Medicinal and spices	0.108710185	0.891289815
	Fuel and ornamental	0.13555251	0.86444749
	Homestead birds	0.258947061	0.741052939
	Homestead animals	0.193844206	0.806155794
	All	0.350703183	0.649296817

Forest area-wise analysis of species diversity presented in Table 4.2 showed that the diversity of plant species was higher in each of the forest areas. The diversity index (D) values against each of the plant groups and the overall plant biodiversity index (0.7216361) indicates that plant biodiversity was higher in the areas, while the evenness index (E) value of 0.598736641 indicates that the abundance of different plant species was somewhat dissimilar i.e. proportion of all the species were not similar over the area.

Considering all the three study areas together, diversity was the highest with fruits (0.93166513) followed in descending order by medicinal and spices (0.9085095), fuel, and ornamental plants (0.887265707) timber (0.885586674), homestead animals (0.8091042) and homestead birds (0.77344853). The total evenness values against the three study areas (0.756123336, 0.638992843 and 0.57443528 in Mangrove forest, Hill forest, and Sal forest respectively) indicate that the abundance of different species was very dissimilar.

Table 5. Species Diversity of Different Plant Groups and Animals in Rural Homesteads

Study areas	Plant and animal group	Relative abundance (P_i^2)	Diversity index (D)	Evenness (E)	t-value
Hill forest	Fruit	0.079375323	0.9206246	0.299961284	M-H =.754 M-S =.430 H-S=-.373
	Timber	0.1929974	0.8070026	0.172713898	
	Medicinal and spices	0.083891884	0.9161081	0.745006517	
	Fuel and ornamental	0.138271685	0.8617283	0.361606934	
	Homestead birds	0.25890737	0.7410926	0.55176932	

	Homestead animals	0.202794432	0.7972055	0.704443122
	Total	0.260827126	0.739172874	0.638992843
Sal forest	Fruit	0.084948314	0.915051686	0.280282478
	Timber	0.099335294	0.900664706	0.387189052
	Medicinal and spices	0.146506465	0.853493535	0.426602334
	Fuel and ornamental	0.108545863	0.891454137	0.438699793
	Homestead birds	0.23266248	0.76733752	0.61401022
	Homestead animals	0.194005555	0.805994445	0.73635594
	Total	0.290140026	0.709859974	0.57443528
Mangrove forest	Fruit	0.052259515	0.947740485	0.466713933
	Timber	0.082159737	0.917840263	0.468131228
	Medicinal and spices	0.106258425	0.893741575	0.553589322
	Fuel and ornamental	0.119719879	0.880280121	0.334113267
	Homestead birds	0.20947398	0.79052602	0.68198036
	Homestead animals	0.206008216	0.793991784	0.693453618
	Total	0.220422593	0.779577407	0.756123336
Overall	Fruit	0.06833487	0.93166513	0.34032133
	Timber	0.114413326	0.885586674	0.213176601
	Medicinal and spices	0.0914905	0.9085095	0.0050828
	Fuel and ornamental	0.112734293	0.887265707	0.30587639
	Homestead birds	0.22655147	0.77344853	0.63057256
	Homestead animals	0.1908958	0.8091042	0.74835141
	Total	0.2783639	0.7216361	0.598736641

Total plant biodiversity was higher in Mangrove forest areas with an index value of 0.779577407 which gradually decreased in Hill forest and Sal forest as shown in Table 4.2. The diversity index value against each plant and animal group in the Mangrove forest was higher than in the other two areas. The t-test indicated that there was a significant difference among Mangrove, Hill, and Sal forest with respect to the diversity of different plant and animal groups (M-H $t=0.754$), (M-S $t=-.430$) and (H-S $t=-.373$). However, considering the frequency of occurrence, the relative prevalence of different species, and the diversity index (D), it can be said that plant biodiversity is increasing significantly with increase NGOs activities as well as through massive plantations.

4. Conclusion:

The identification of the most prevalent and dominant fruit, timber, medicinal and other species is an important finding of the study. In this study, it is observed that the homestead plant composition, diversity, and species richness were medium level in the study areas. Therefore, there was a lack of scientific knowledge of the farmers, an absence of proper

planning, and no specific goals. A comprehensive agroforestry planning, proper scientific management of plants using agroforestry cultivars are needed to promote plant and animal diversity. Government and NGOs should initiative a program for the conservation of forests at local levels.

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