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Phyto-sociological study of woody components in traditional agro-forestry systems of Boudh district, Odisha, India

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ABSTRACT

Phyto-sociological study of woody components in traditional agro-forestry systems of Boudh district of Odisha was undertaken. Eight different types of agro-forestry systems viz alley cropping, horti-silviculture, home gardens, canal bank plantation, agricultural field bund plantation, boundary plantation, scattered tree planting and block plantation of tree species were observed. Plantation of multipurpose tree species in agricultural field bund (50.4%) was the major agro-forestry system practiced in rainfed areas while as alley cropping was practiced by 72.6 per cent people in irrigated agro-forestry. Out of the 91 tree species observed in tropical dry deciduous forests of Boudh 52 species were observed in different agro-forestry systems. *Acacia nilotica, Tectona grandis, Madhuca latifolia, Borassus flabellifer* and *Phoenix alba* were common tree species observed in both irrigated and rainfed agro-ecosystems. Relative important value index of tree species suggests that *Acacia nilotica* was the most desirable tree species of farmers (IVI-69.4). The diversity of tree species in rainfed agro-forestry was high (30.3/ha) but the density was more in irrigated agro-forestry (81.9/ha). People harvested an array of products from tree species but mostly fuel wood, fodder and medicines were mostly collected. These agro-forestry systems are sites of conservation of a large number of diversity of plants both wild and domesticated because of their utility to rural people. Further scientific and socio-economic evaluation of these complex productive systems is essential for wider adoption in the district and in other similar agro-climatic zones of the country for sustained food and livelihood security.

Keywords: Agro-forestry; alley cropping; bund plantation; rainfed; irrigated

INTRODUCTION

Cultivation of tree species in association with agricultural crops is an age old practice but use of term agro-forestry to it is quite recent (Tewari 1995). It is a collective name for land use systems and technologies where woody perennials are deliberately used on the same management units as agricultural crops and/or animals in some form of spatial arrangement or temporal sequence (Lundgren and Raintree 1982). Now a days this system of farming has gained the attention of researchers and planners because of its potential in discharging multiple ecosystem services

apart from giving livelihood security to the rural poor. The presence of trees though creates some hindrance in routine agricultural operations and on the productivity of associated crops yet the diversified benefits harnessed encourage farmers to grow trees at suitable places (Bijalwan 2012). The products and services provided by agro-forestry are many. This dynamic and ecologically based natural system management aims at diversifying social, economic and environmental benefits on a sustainable basis (Leakey et al 1996). Apart from financial benefits to farmers it provides many ecosystem services and environmental benefits like carbon sequestration, biodiversity conservation, soil enrichment and improves air and water quality (Jose 2009).

Boudh is one of the centrally locked land under developed district Odisha. The tropical dry deciduous forests of this land mass are very rich and diverse in floristic composition because of its unique position in the Eastern Ghats. Agriculture is the main occupation of people and more than 70 per cent of people depend on it. Farmers have been planting tree species along with other annual crop plants since time immemorial and it is culturally associated with people. About 23.19 per cent of annual income of 48 per cent farmers living in plain areas and 11.02 per cent of annual income of 78 per cent of farmers in hilly areas is contributed by different non-timber products (Behera and Nath 2012). Often flowers, fruits and leaves are worshiped in many social functions. However perusal of literature suggests that no work has been conducted so far to analyze the traditional agro-forestry systems practiced, their structure, composition and species richness which will be very helpful in conservation and restoration of biological diversity. Hence seeing the importance of agro-forestry in this arid part of Odisha an attempt has been made to identify, analyze and document these practices which may assist the researchers and planners for further scientific and socio-economic evaluation and replication of best systems in similar agro-climatic zones.

MATERIAL AND METHODS

The study was conducted in Boudh district of Eastern Ghats region, which lies in the central part of Odisha between 20^0 22' to 20^0 50' N latitude and 83^0 34' to 84^0 49' E longitude.

The survey was conducted in 18 randomly selected villages covering all three blocks in the district. Preliminary group discussion with the villagers was conducted to gather information on geographical area, land tenacity, sources of irrigation, farming systems, cropping pattern, asset holdings, institutional linkages and socio-economic aspects of households. A structured questionnaire survey was conducted to collect information on status of farming situations, agro-forestry practices operating,

composition, diversity and density of tree species in agro-forestry systems, geometry of usufructs harvested from trees, management of trees for smooth agronomic practices and diagnosis of problems faced by farmers in adopting agro-forestry practices. To conduct survey villages were grouped as rainfed and irrigated agro-ecosystem areas based on their available sources of irrigation. Survey was conducted in six villages of each block across the cross section representing both rainfed (3 villages) and irrigated (3 villages) situation. Fifteen farmers from each village were interviewed irrespective of their land holdings. Thus 90 farmers were interviewed in each block of which 45 farmers represented rainfed situation and 45 represented irrigated situation from each block. The survey was conducted during Kharif (June-September) and Rabi (October-March) during 2010-11. The data collected for various aspects related to agro-forestry were analysed (through mean average, percentile) and expressed in terms of per cent response from the respondents. The species relative importance value index (IVI) was calculated using relative density and relative frequency of occurrence (Brower and Zar 1984). The specimens thus collected were identified by using the plant description given by Saxena and Braham (1994). The secondary data were collected from the published or unpublished documents of district administration and other line departments.

RESULTS

Structure and composition of agro-forestry in Boudh

In the present investigations it was observed that plantation of different kinds of tree species along field bunds, irrigation canal bunds, in home gardens etc was a common practice throughout the district and people derived an array of products from it. The agro-ecological situation of the district can broadly be divided into two categories viz the rainfed farming and irrigated farming (on the basis of availability of irrigation water). The cultivation of tree species in association with agricultural crops can be grouped into eight different types viz alley cropping, horti-silviculture, home gardens, canal bank plantation, agricultural field bund plantation, boundary plantation, scattered tree planting and block plantation. In rainfed agro-ecological situations plantation of tree species along agricultural field bunds was the major agro-forestry practice (50.4%). Following to this scattered tree plantation (48.2%) and home gardens (47.4%) were also practiced by majority of farmers. In irrigated farming situations home garden was the dominant agro-forestry system with 72.6 per cent of people practicing it. Agriculture field bund planting (55.6%) and scattered tree planting and boundary plantation (51.9%) were also observed. Agro-forestry systems like alley cropping, horti-silviculture, block plantation and canal bank plantation were practiced

by limited number of farmers in both rainfed and irrigated agro-forestry (response <50%, Table 1).

Acacia nilotica, Tectona grandis, Madhuca latifolia, Borassus flabellifer and *Phoenix alba* were common tree species observed in both irrigated and rainfed agro-ecosystems. In rainfed farming *Madhuca latifolia, Bambusa nutans* and *Azadiratch indica* were either planted or naturally established along agricultural crop field bunds, boundary of orchards, home gardens etc. *Mangifera indica, Psidium guajava*, *Butea monosperma, Albizia lebbek* and *Syzygium cuminii* were commonly found in irrigated farming situations. These woody perennials formed the upper canopy layer. In the middle layer citrus, banana, papaya, custard apple etc were frequently observed in both irrigated and rainfed conditions. In the ground layer cereals, pulses, vegetables, oil seed crops etc were commonly grown. Paddy was the main cereal crop grown in both situations. Cereals like red gram, green gram, black gram, horse gram, oil seed crop sesamum, small millet Ragi were primarily grown in Kharif in rainfed uplands. During Rabi season green gram was grown depending upon the availability of residual soil moisture. Places where irrigation facility was available oilseed crops like sunflower, spices like onion, garlic, chili etc; vegetables like

Table 1. Agro-forestry systems found in rural areas of Boudh district

Practice	Percentage of respondents following the practice (n=90)							
	Boudh		Harbhanga		Kantamal		Average	
	R	I	R	I	R	I	R	I
Alley cropping	22.2	40.0	35.6	28.2	33.3	24.5	30.4	30.9
Horti-silviculture	15.6	42.2	15.5	22.2	17.8	37.8	16.3	34.1
Bund planting	51.1	46.7	46.7	46.7	53.4	73.3	50.4	55.6
Boundary plantation	22.2	53.4	40.0	60.0	42.2	42.2	34.8	51.9
Scattered plantation	48.9	48.9	42.2	57.8	53.4	55.5	48.2	54.1
Block plantation	37.8	37.8	31.1	33.3	37.8	40.0	35.6	37.0
Canal bank plantation	0.0	44.5	0.0	28.9	0.0	24.4	0.0	32.6
Home gardens	71.1	75.6	35.6	73.3	35.6	68.9	47.4	72.6
Other	22.2	15.6	2.2	15.6	13.3	11.1	12.6	14.1

R: Rainfed farming I: Irrigated farming

tomato, brinjal, cabbage, cauliflower, gourds etc and cash crop water melon were grown.

Benefits harvested from trees

Agrarians of Boudh harvested a wide range of products from trees for smooth management of farm and meeting the domestic requirement of food, fodder, fuel wood, medicine etc. It can be observed from Table 2 that leaf was the major product (35.3%) harvested followed by stem (29.9%) and fruit (15.0%) for domestic consumption as well as for other

Table 2. Plant parts used by farmers for various purposes

Plant part	Domestic use	Fuel wood	Fodder	Green manuring	Medicine	Cottage industries	Soil conservation	% use
Leaf	21	7	20	5	4	2	-	35.3
Flower	4	-	1	-	-	1	-	3.6
Fruit	17	-	1	-	7	-	-	15.0
Seeds	3	-	-	2	3	5	-	7.8
Stem	-	42	-	-	-	3	5	29.9
Bark	-	-	-	-	6	-	-	3.6
Root	-	-	-	-	-	-	8	4.8
Total	45	49	22	7	20	11	13	100

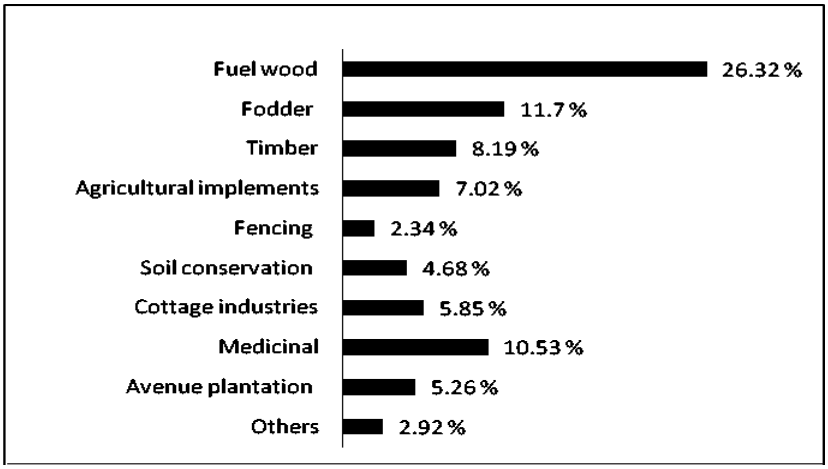

Fig 1. Utility matrix of tree species (Total tree species observed= 52)

uses like fuel wood, fodder, manuring etc. About 52 number of tree species were being planted in different ways in various agro-forestry practices under both rainfed and irrigated agro-ecosystems. Of these 26.3 per cent of species (45) were used for fuel wood, 15.2 per cent for food, 11.7 per cent for fodder and 10.5 per cent for medicinal purposes. Though only 8.2 per cent of species were used for timber purpose their availability was very crucial for farmers (Fig 1).

Preference of tree species

Preference of tree species for different agro-forestry systems depends on the requirement of the farmer, argo-ecological situation of the farm, compatibility of the tree species with agricultural crops, availability of quality planting material etc. The present investigations revealed that in rainfed agro-forestry timber yielding tree species (56.8%) were more preferred followed by fruit plants (50.1%) and short duration tree species (49.9%). In irrigated farming situations fruit plants were more preferred (82.2%) followed by short rotation species (48.6%) and timber species (45.4%). Similar trend in preference of tree species was observed in all the three blocks studied (Table 3). The diversity of tree species was higher in rainfed agro-forestry (30.3) than irrigated agro ecosystem (14.7). The density of tree species ranged between 5.3-81.9 numbers/ha in rainfed agro-ecosystem to 24.1-46.4/ha in irrigated agro-forestry. Both the diversity and density of tree species was comparatively higher in Harbhanga block (except for irrigated agro-forestry with density 12) than both Boudh and Kantamal blocks (Table 4). However some external and self radiant constraints compelled the farmers to limit the incorporation of tree component in their agro-forestry (Fig 2).The study of relative importance value index for frequently occurred plants reveals that *Acacia nilotica* was the most desirous plant with IVI 69.4 per cent. Following to this *Madhuca latifolia, Bambusa nutans, Bambusa vulgaris* and *moringa oleifera* were highly desired by people having IVI more than 60 per cent (Table 5).

DISCUSSION

Boudh is one of the centrally locked land under developed district of Odisha. Agriculture is the main occupation of people and more than 70 per cent of people depend on it. Paddy, red gram, green gram, sesamum, ground nut, maize and Ragi are major crops grown in Kharif. During Rabi season green gram, Bengal gram and horse gram are grown in the rainfed medium and low lands depending upon the availability of residual soil moisture. Where irrigation facilities are available crops like banana, water melon, onion and garlic are grown on commercial basis. Vegetables like brinjal, chili, tomato, cabbage, cauliflower and gourd are grown either for sustenance or commercial purpose. Fruit orchards of mango and citrus have also come up with

Table 3. Trees species preferred by farmers of Boudh

Type of tree	Percentage liking in three blocks (n=90)							
	Boudh		Harbhanga		Kantamal		Average	
	R	I	R	I	R	I	R	I
Timber species	55.6	46.7	57.1	49.6	57.8	40.0	56.8	45.4
Fuel wood trees	37.0	32.6	31.9	20.0	38.5	32.6	35.8	28.4
Fruit plants	46.7	82.9	51.1	83.0	52.6	80.7	50.1	82.2
Ornamental species	16.3	12.6	12.6	5.9	11.8	5.2	13.6	7.9
Fodder species	34.8	23.0	47.4	31.1	34.8	22.2	39.0	25.4
Short rotation species	50.4	48.9	49.6	51.9	49.6	45.2	49.9	48.6
Other species	32.6	30.4	37.1	37.8	31.1	25.9	33.6	31.4

R: Rainfed farming I: Irrigated farming

Table 4. Diversity and density of tree components observed in three blocks of Boudh district

Block	Tree diversity		Tree density (No/ha)			
	Rainfed agro-ecosystem	Irrigated agro-ecosystem	Rainfed agro-ecosystem		Irrigated agro-ecosystem	
			Range	Maximum	Range	Maximum
Boudh	24	18	18.2	32.6	2.7	65.3
Harbhanga	36	12	29.4	57.1	4.9	97.0
Kantamal	31	14	24.8	49.6	8.2	83.5
Average	30.3	14.7	24.1	46.4	5.3	81.9

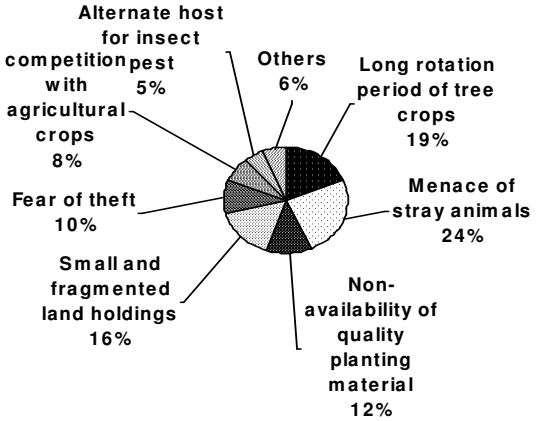

Fig 2. Constraints in admixting woody component

few farmers during recent few years. Commercial plantation of teak (*Tectona grandis*), bamboo (*Bambusa vulgaris*) and eucalyptus (*Eucalyptus teriticornis*) were observed on degraded uplands.

The practice of growing trees in association with agricultural crops is an age old practice but use of the term agro-forestry to this is quite recent (Tewari 1995). These types of farming activities are also being practiced by the farming community of Boudh since time immemorial. But grouping and naming to this kind of farming has been done for the first time. Sahu et al (2007) reported presence of 91 number of tree species in the dry deciduous forests of Boudh of which 51 species were cultivated in different agro-forestry systems (Annexure-I). The IVI index suggests that *Acacia nilotica* was the most favorable species along with ten other trees which were very commonly observed in the crop fields, orchards and home gardens of people (Table 5).

The diversity of tree species in the rainfed agro-forestry system was much more as compared to irrigated farming situation. This might be due to the occurrence of natural tree species in the farm lands which were either encroached or converted forest lands. The occurrence of old large trees of *Madhuca longifolia, Tamarindus indica, Buchanania lanzan* etc authenticates this fact. However the density of tree species in irrigated farming situation was more (81.9%). This might be because of plantation of different tree species on commercial basis (Table 4). This type of trend in tree density was also reported by Devaranavadgi et al (2010).

In rainfed farming situations plantation of forest tree species like *Acacia nilotica, Phoneix alba, Borassus flabaliform, Tectona grandis* etc in the agricultural field bunds was the predominant agro-forestry system practiced by farmers. Popularization of this practice might be because of its easy understandability and simplicity in execution in field condition. This agro-forestry practice seemed to be practiced in rainfed uplands of other districts of Odisha (Mohapatra et al 2007). It is often seen that people lopped and feed *Acacia nilotica, Albizia lebbek* and other fodder tree species in situ during the lean season of the year. Prevalence of this type of agro-forestry systems in tropical and sub-tropical arid agro climatic zones of India is also reported by (Toky and Bisht 1992).

In irrigated farming situations home garden was the widely accepted agro forestry system with 72.6% of people practicing it. Though the system is complex in its structure it has multiple functions (Fernandes and Nair 1986). The greater adoption of home gardens in this ecosystem might be because of better socio-economic status of farmers inhabiting in this zone. Similar reason for extensive adoption of

Table 5. Tree components inventoried under agro-forestry practices in Boudh district

Species	Family	Common Name	Local name	Use	RIV(%)
Acacia auriculiformis A Cunn ex Benth	Mimosaceae	Australian wattle	Sunajhari	Small timber, fuel wood, soil conservation	27.7
A leucopholia Willd	Mimosaceae	White bark Acacia	Gohira	Fodder, fuel wood, composting, medicinal	18.5
A nilotica L	Mimosaceae	Babul	Babul	Agricultural implements and fodder, fuel wood, soil conservation, composting	69.4
Aegle marmelos Corr ex Roxb	Rutceae	Bel	Bela	Medicinal, fuel wood, fencing	25.7
Albizia lebbek L Benth	Mimosaceae	Kokko	Sirisa	Timber, fodder, fuel wood, soil ornamental, conservation	31.6
A procera (Roxb) Benth	Mimosaceae	White siris	Dhalasirisa	Timber, fodder, fuel wood, ornamental, soil conservation	29.7
Annona squamosa L	Annonaceae	Custard apple	Bhadiala	Medicinal, fruit, fuel wood	44.6
Anogeissus latifolia (Roxb) Wall ex Bedd	Combretaceae	Axle wood	Dhaura	Timber, fuel wood, fodder, medicinal	6.5
Artocarpus heterophyllus Lamk	Moraceae	Jackfruit	Panasa	Timber, fuel wood, fruit, fodder	8.3
Azadirachta indica A Juss	Meliaceae	Neem	Nimba	Control of stored grain pest, crop protection, foods, medicinal	41.8
Bambusa nutans Wall ex Munro	Gramineae	Bamboo	Kanta baunsa	Fodder, foods, construction of house, fencing, decorative items etc.	65.3
Bambusa vulgaris Schrad ex Wendl	Gramineae Orchid tree	Golden Bamboo baunsa	Sundakani	Fodder, foods, baskets, mats, brooms , fencing etc	65.2

Bauhinia variegate (L) Benth	Leguminosae	Mountain-ebony	Kanchana	Foods, fodder	32.4
Bombax ceiba L	Bombaceae	Silk cotton	Simuli	Making pillows & cousins, medicinal	9.1
Borassus flabellifer L	Palmae	Palmyra palm	Tala	Fiber extraction, thatching roof	43.5
Bridelia retusa (L) Spreng	Euphorbiaceae	Kasi	Kasi	Timber, fuel wood	16.9
Buchanania lanzan Spreng	Anacardiaceae	Almondette tree	Chara	Small timber, fuel wood, fruit, cash	37.2
Butea monosperma (Lamk) Taub	Fabaceae	Flame of the forest	Palasa/Sargi	Mulching, medicinal, religious, firewood	52.3
Carica papaya L	Caricaceae	Papaya	Amuta bhanda	Fruit, vegetable, medicinal	32.5
Cassia Siamea Lamk	Leguminosae	Kassod tree	Sana Chakunda	Timer, avenue plantation, fodder	7.4
Citrus limon (L) Burm	Rutaceae	Lemon	Lembu	Fruit, cash, medicinal	49.3
C reticulate Blanco	Rutaceae	Orange	Kamala	Fruit, cash, medicinal	42.2
Cocos nucifera L	Arecaceae	Coconut	Nadia	Fruit, timber, medicinal, roof thatching, rope & broom making	5.3
Delonix regia (Boj) Raf	Leguminosae	Gold mohur	Krushna chura	Timer, avenue plantation, fuel wood	4.7
Dendrocalamus strictus (Roxb) Nees	Gramineae	Solid Bamboo	Salia baunsa	Fodder, foods, construction of house, brooms, fencing	59.3
Dillenia Indica L	Dilleniaceae	Elephant apple	Kaintha	Fruit, medicinal, fuel wood	6.8
Diospyros melanoxylon Roxb	Ebenaceae	East Indian Ebony	Kendu/ Tiril daru	Bidi making, foods	47.2
Eucalyptus hybrid	Myrtaceae	Eucalyptus	Nilagiri	Timber, poles	47.1
Ficus bengalensis L	Moraceae	Banyan tree	Bara	Religious, fodder	4.2

F hispida L	Moraceae	Kakdumur	Dimiri	Fodder, fuel wood	8.3
F religiosa L	Moraceae	Pipal tree	Usta	Religious, fodder	9.4
Gmelina arborea Roxb	Verbenaceae	Gamari	Gambhari	Timber, fodder	32.7
Jatropha curcus L	Euphorbiaceae	Barbados nut	Rama jada	Medicinal, fencing	11.2
Lagerstroemia speciosa (L) Pers	Lythraceae	Queen carpemyrtle	Patali	Timber, fodder, agricultural implements	14.4
Madhuca latifolia (J Konig) JF Macbr	Sapotaceae	Mahua	Mahula	Liquor making, food, cooking oil, cake in pisciculture	66.4
Mangifera indica L	Anacardiaceae	Mango	Amba	Fruit, timber, religious, cash, medicinal	57.3
Melia azedarach L	Meliaceae	Persian lilac	Badanimba	Timber, fodder, fuel wood	16.2
Moringa oleifera Lam	Moringaceae	Drumstick	Sajana	Fruit ,vegetable, medicinal	64.9
Phoenix sylvestris Roxb	Palmae	Indian wine palm	Khajuri	Foods, making mats, liquor, Fencing	44.7
Phylanthus emblica L	Euphorbiaceae	Indian gooseberry	Aonla	Medicinal	30.9
Pongamia piñata L	Fabaceae	Indian beech	Karanga	Control of stored grain pest, tooth brush, medicinal	12.7
Psidium guajava L	Myrtaceae	Guava	Piguli	Fruit, cash, medicinal, fuel wood	52.8
Schleichera oleosa (Lour) Oken	Sapindaceae	Ceylon oak	Kusuma	Cooking oil	13.6
Syzygium cuminii (L) Skeels	Myrtaceae	Java plum	Jama koli	Timber, fodder, medicinal, fuel wood	41.6
Tamarindus indica L	Caesalpiniaceae	Indian date	Tentuli	Foods, making pickles, fodder	33.8
Tectona grandis L	Verbenaceae	Teak	Shaguan	Timber, fuel wood	53.5

Terminalia arjuna (Roxb) Wight and Arn	Combretaceae	Arjun	Arjun	Tassar cultivation, medicinal, timber, fencing, fuel wood	39.1
T belerica (Gaertn) Roxb	Combretaceae	Beleric myrobolan	Bahada	Medicinal	15.4
Terminalia chebula Retz	Combretaceae	Chebulic myrobolan	Harida	Medicinal, timber, fuel wood	11.2
Vitex nigundo L	Verbenaceae	Chaste tree	Begunia	Control of stored grain pest, medicinal, tooth brush, Fencing	34.2
Ziziphus mauritiana Lamk	Rhamnaceae	Indian jujube	Bara koli	Fodder, fruit & making pickles, fuel wood	49.4

home gardens was also reported in Assam by Das and Das (2005). Other agro-forestry systems like field bund plantation and boundary plantation were also widely adopted in both rainfed and irrigated agro-ecosystems. This might be for the intensive use of resource input and assured higher economic benefit from these systems which is a major criterion for adoption of an agro-forestry system (Sharma and McGregor 1991).

A substantive diversity in tree species is observed in different traditional agro-forestry systems practiced in the district. Understandability of structure, composition and species richness would be very helpful in conservation and restoration of biological diversity in the area and reducing pressure from natural forests which are diminishing at an alarming rate. Scientific and socio-economic analysis of these systems is essential for wider adoption of productive agro-forestry systems in the district and replication to similar agro-climatic zones of the country.

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