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Original Research Article

Traditional Agroforestry System in Eastern Himalaya: A Case Study of Fringe Villages of Doimukh Forest Range, Arunachal Pradesh, India

Govinda Pangging* and Sagolsem Lenin Singh

Environment and Natural Resource Management Lab., Department of Forestry, North Eastern Regional Institute of Science and Technology, Nirjuli-791109, Arunachal Pradesh

**Corresponding author.*

Abstract

Three categories of farmers have been identified that practises agroforestry viz., small farmer, medium farmer and large farmer. Of this, small farmer is the dominated category of farmer (40.86%). Four types of agroforestry system have been traditional practise by the farmers' *viz.*, agri-silvicultural system, agri-horticultural system, agro-silvi-horticultural system and aqua forestry. Based on the types of agroforestry system practise by farmers, small farmers adopted three types, followed by medium farmer (2) and large farmer (1). The biomass requirement of three categories of farmers have been quantified i.e. fuel wood, fodder, bamboo, etc.

Keywords

Agri-silvicultural system

Agroforestry

Agri-horticultural system

Aqua-forestry

Introduction

Agroforestry is a land use system that consists of trees, food crops, and livestock which is scientifically sound, ecologically desirable, practically feasible, and socially acceptable to the farmers (Nair, 1979). It is also considered as sustainable landuse system that increases overall production, combines food crops, tree crops and forest plants and/or animals simultaneously or alternately in same piece of land and applies management practices that are compatible with the cultural patterns of local population (Bene et al., 1977). It is an old art and new science that has been practiced by indigenous community since time immemorial in various part of the world.

In Arunachal Pradesh, jhum cultivation, a traditional agroforestry has been practised since time immemorial. Shifting cultivation is engrained in their culture and have played significant role in the socio-economic condition of the indigenous community (Deori, 1992). The traditional agroforestry system is sustainable when the jhum cycle is20 to 30 years, but the jhum cycle is reduced to 3-5 years due to increase in population (Shukla, 1992). The present practice of jhum may become threat to the rich in biodiversity of the state, since the region is well renowned as 12th Mega Biodiversity hot spot of the world i.e., Eastern Himalaya". Moreover, it falls in Biotic Province 2D `East Himalayas' of Zone 2-The Himalayas (Rodgers and Pawar, 1988).

The present study will investigate the traditional agroforestry systems, which are practised by the indigenous community in the fringe villages of Doimukh forest range other than shifting cultivation. This study

will document the socio-economic condition of the indigenous community; estimate the biomass requirement of the communities; and also identify the traditional agroforestry system. Through this study, a better management system of agroforestry will be evolved by identification and meeting the technological gaps.

Materials and methods

Geographical location of the area

The study was carried out in the selected fringe villages of Doimukh forest range, Banderdewa forest division, Papumpare district, Arunachal Pradesh. The area received average annual rainfall of more than 2700 mm. Doimukh, Pampum pare district lies between 27° 5' 3.09768" North and 93° 4748.50268" East.

Sample collection

The study was conducted during December 2011 to April 2012 by semi-structured questionnaire survey. Ransom sampling was adopted and it covers 25% of household from each village and total 115 household were surveyed. The selected six fringe villages of Doimukh forest range viz., Rono, Midpu II, Nonpu, Emchi, Midpu I and Amba villages.

The farmers have been categorised based on the sizes of their operational land holdings:

(i) Marginal farmer : Less than 1ha
(ii) Small farmer : 1 to 3ha
(iii) Medium farmer : 3 to 4ha.
(iv) Large farmer : Above 4ha.

Identification of agroforestry systems in the study site: The agroforestry prevails in the study area have been categorised based on Nair (1985). The system types and the system units of agroforestry system identified according to Zou and Sanford (1990).

Results

1. Socio economic status of the peoples

(a) Demographic structure of the villages: In the studied villages, Amba village have the highest number of household i.e., 114, followed by Rono (107), Midpu-II (81), Midpu-I (75), etc. Moreover, the highest population among the fringe villages is Amba village, which is651, followed by Rono (107), Midpu-Il (466), etc. The average family size of family isfound highest in large family i.e., 15, followed by medium farmer (8) and small farmer (5). (Table 1).

Table 1. Database on number of house per village, population and family size.

Name of the villages	Total no. of house	Total population	Average family size (Nos.)		
			Small	Medium	Large
Rono	107	633	5	7-9	14
Midpu II	81	466	6	6-8	15
Nonpu	35	173	4	7	20
Emchi	24	133	5	8	13
Midpu I	75	457	6	9	15
Amba	114	651	4	6-8	15
Source: Surveyed					

(b) Categories of farmers: In the study site, three types of farmers is found i.e., small farmers, medium farmer and large farmer. Of this, small farmer is the dominant farmer category i.e., 40.86%, followed by medium farmer (33.91 %) and large farmer (28.69%) (Table 2).

Table 2. Distribution of category of farmers in the study site.

Name of the Village	Category of Farmer		
	Small	Medium	Large
Rono	6	7	17
Midpu II	12	5	3
Nonpu	3	5	1
Emchi	4	7	2
Midpu I	3	8	10
Amba	19	7	0
Total (N=115)	47	39	33
Total (%)	**40.86%**	**33.91%**	**28.69%**

Literacy rate were recorded highest in the medium farmer (72.56%), followed by large farmer and small family sizes. The man female ratio is highest at large family size (1:0.94) which is followed by medium and small (Table 3).

(c) Live stock population: The highest ACU is found in large farmer, which is 20.85 ACU, followed by medium farmers and Small farmers (Table 4).

(d) Land use pattern per house hold: The highest average land holding is found in large farmers, which is8.13 ha, followed by medium farmer and small farmers. The land and man ratio is found highest in medium farmer (0.58), followed by large farmer (0.53) and small farmer (0.50). The land and ACU ratio is found highest in large farmer (0.39), followed by small farmer (0.35) and medium farmer (0.29) (Table 5).

Table 3. Demographic pattern and education status of the farmers.

Category of the farmers	Literacy rates	Male and Female ratio	Av. family size (No. of individuals)
Small	60.36%	1: 0.83	5
Medium	72.56%	1: 0.88	8
Large	70.19%	1: 0.94	15

Table 4. Live stock population in different category of farmers.

Category of the farmers	Livestock				Total ACU	Poultry	Pig
	Cow	Mithun	Young stock	Goat			
Small	2	1	4	5	6.75	14	6
Medium	6	3	7	10	15.75	36	13
Large	9	3	9	14	20.85	66	19
ACU- Animal Cattle Units							

Table 5. Landuse pattern per household, Land man ratio and land ACU ratio of different category of farmers.

Category of the farmers	Agricultural land (ha)	Private forest (ha)	Average land holding (ha)	Land : Man ratio	Land : ACU ratio
Small	2.02	0.5	2.52	0.50	0.37
Medium	3.44	1.0	4.44	0.55	0.28
Large	5.63	2.5	8.13	0.54	0.39

2. Biomass requirement

(a) Fodder requirement: The free grazing is the mode of grazing in all the categories of farmers, which are generally done in agricultural land during fallow period, reserve forest, community forest and private forest. The highest requirement of fodder is found in large farmer i.e., 19, 265.4 kg, followed by medium farmers and small farmer and the details are given in Table 6.

Table 6. Live stock population in different category of farmer.

Category of farmers	ACU	Fodder requirement Kg/ACU/HH	Total consumption (Kg)	Mode of grazing	Source of fodder	Fodder species
Small	6.75	189kg	8,883kg	Free grazing	AL+ CF+ RF+ PF	Straw of rice, residue of maize, natural grass
Medium	15.75	441 kg	17,199 kg	Free grazing	AL+ CF+ RF+ PF	Straw of rice, residue of maize, natural grass
Large	20.85	583.8 kg	19,265.4 kg	Free grazing	AL+ CF+ RF+ PF	Straw of rice, residue of maize, natural grass
Total	**43.35**	**1,223.8 kg**	**4,5347.4 kg**			

AL: Agricultural land, CF: Community Forest, RF: Reserve Forest and PF: Private forest;
* Fodder requirement is based on the adult cattle unit (ACU) per day requirement = 28 kg/ACU (1/3 of dry+2/3 grass).
* Adult cattle unit (ACU) equivalent given by Yang (1971). Cow/Bullock/Mithun = 1ACU; Buffalo = 1.3 ACU; Sheep and Goat = 0.15 ACU.

Table 7. Total biomass requirement per household at different category of farmers.

Category of the farmer	Fuelwood per day per HH	Bamboo required per year per HH
Small	2.53 kg	24
Medium	4.12 kg	34
Large	8.6 kg	50
Total	**15.25 kg**	**108**

3. Identification of traditional agroforestry system

The four types of traditional agroforestry systems have been identified viz., agrisilvicultural system, agro-horticultural system, agri-silvi-horticultural system, and aqua forestry.

(a) Small farmer: In small farmer category, three types of agroforestry systems have been identified *viz*., agrisilvicultural system, agri-horticultural system, agri-silvi-horticultural system. In agrisilvicultural system, agricultural component consists of *Zea mays, Solanum melongena, Cajanus cajan, Phaseolus sp.* and silvicultural component consists of *Mesua ferrea, Bambusa tulda, Gmelina arborea* and *Lagestroemia* spp. In agri-horticultural system, agricultural component consists *Zea mays, Solanum melongena, Cajanus cajan* and horticultural component consists of *Citrus* spp., *Areca catechu, Mangifera indica, Psidium guajava, Artocarpus heterophyllus* and *Musa* spp. In agri-silvi-horticultural system, agricultural component consists of *Cajanus cajan*, silvicultural component consists of *Mesua ferrea* and *Bambusa* spp. and horticultural component consists of *Areca catechu, Mangifera indica, Psidium guajava, Artocarpus heterophyllus* and *Musa* spp. (Table 8).

Table 8. Agroforestry system in small farmer category.

System type	System units	Stratification
AS	**Agricultural crops:** *Zea mays, Solanum melongena, Cajanus cajan, Phaseolus sp.* **Silvicultural crops:** *Mesua ferrea, Bambusa tulda, Gmelina arborea, Lagestroemia* spp.	**Double layered**
AH	**Agricultural crops:** *Zea mays, Solanum melongena, Cajanus cajan.* **Horticultural crops:** *Citrus* spp., *Areca catechu, Mangifera indica, Psidium guajava, Artocarpus heterophyllus, Musa* spp.	**Double layered**
ASH	**Agricultural crops:** *Cajanus cajan.* **Silvicultural crops:** *Mesua ferrea, Bambusa* spp. **Horticultural crops:** *Areca catechu, Mangifera indica, Psidium guajava, Artocarpus heterophyllus, Musa* spp.	**Three layered**
AS-Agri-silvicultural system; AH- Agri-horticultural system; AS- Agri-silviculture.		

(b) Medium farmer: In medium farmer category, two types of agroforestry system have been identified viz., agri-silvicultural system and aqua forestry system. In agri-silvicultural system, agricultural component consists of *Zea mays* and *Oryza sativa;* and silvicultural component consists of *Melia azedarach*. In aqua forestry system, fish component consists of *Labeo rohita, Catla catla, Ctenopharyngodon idellus;* silviculture component consists of *Bambusa* spp., *Melia azedarach;* horticultural component consists of *Areca catechu, Musa* spp., *Artocarpus heterophyllus* (Table 9).

Table 9. Agroforestry system in medium farmer category.

System type	System units	Stratification
AS	**Agricultural crops:** *Zea mays, Oryza sativa* **Silvicultural crops:** *Melia azedarach.*	**Double layered**
AF	**Aqua crops:** *Labeo rohita, Catla catla, Ctenopharyngodon idellus.* **Silvicultural crops:** *Bambusa* spp., *Melia azedarach.* **Horticultural crops:** *Areca catechu, Musa* spp., *Artocarpus heterophyllus.*	**Three layered**
AF-Aqua forestry, AS-Agri-silvicultural system.		

(c) Large farmer: In large farmer category, only one type of agroforestry system has been identified i.e., aqua forestry system (Table no. 9). In aqua forestry system, fish component consists of *Labeo rohita, Catla catla* and *Ctenopharyngodon idellus;* silviculture component consists of *Bambusa* spp. and *Melia azedarach;* and horticulture component consists of *Areca catechu, Musa* spp. (Table 10).

Table 10. Agroforestry system in large farmer category.

System type	System units	Stratification
AF	**Aqua crops:** *Labeo rohita, Catla catla, Ctenopharyngodon idellus.* **Silvicultural crops:** *Bambusa* spp., *Melia azedarach.* **Horticultural crops:** *Areca catechu, Musa* spp.	**Three layered**
AF-Aqua forestry.		

Discussion

In Lakhimpur district of Assam, agroforestry study was conducted wherein three types of farmer categories were documented viz., small farmer, medium farmer and large farmer (Sood et al., 2000). The literacy rate was found higher in medium farmer (73%) than small farmer and large farmer. The male: female ratio was found highest in large farmer (1:1.3), followed by medium farmer and small farmer. The average sizes of the family in small, medium and large farmer were 6, 11 and 26, respectively (Sood et al., 2000). The total ACU was found highest in large farmer (37.65), followed by medium farmer (15.7) and small (6.9). The average land holding was found highest in large farmer (23.34 ha), followed by medium (5 ha) and small farmer (1.7ha). The highest land:man ratio was found in large farmer (0.89), followed by medium farmer (0.46) and small farmer (0.28). The land: ACU ratio was found highest in large farmer (0.62) followed by medium farmer (0.32) and small farmer (0.28) (Sood et al., 2000).

In small farmer, three types of agroforestry system were documented viz., agrisilviculture, silvihorticulture and pastoral silvicultural system. In medium farmer, three types of agroforestry system were documented viz., agri-silvi-horticultural, pastoral silvicultural and silvihorticultural system. In large farmer, three types of agroforestry system were documented *viz.*, agri-silvi-horticultural, pastoral silvicultural and silvihorticultural system (Sood et al., 2000).

Conclusions

Four types of agroforestry system (AF) were found in the studied villages viz., agri-sivicultural system, agri-silvi-horticultural system, agri-horticultural system and aquaforesty. In small farmer, the common AF systems found are agri-silvicultural system, agri-horticultural system and agri-silvi-horticultural system. In medium farmer, the common AF systems found are aqua forestry and agri-silvicultural system. In large farmer, one AF system is found i.e. aqua forestry. In aqua forestry, the common fish species used are *Labeo rohita, Catla catla* and *Ctenopharyngodon idellus*. The important agricultural crops raised in existing AF system are *Zea mays, Solanum melongena, Cajanus cajan, Phaseolus sp*., etc. and the common horticultural crops raised are *Citrus sp., Areca catechu, Mangifera indica, Psidium guajava, Artocarpus heterophyllus, Musa sp.* The common silvicultural crops are *Lagerstroemia spp., Melia azedarach, Gmelina arborea*, etc.

Small farmer is the dominated category of farmer that consists of 40.86% of the farmer's category. The average family sizes of the small, medium and large farmer are 5, 7.67 and 15.33, respectively. The land and man ratio is found highest in Medium farmer i.e., 0.58, followed by large farmer (0.53) and small farmer (0.50). The lowest land:man ratio is found in small farmer. They may need additional supplement income source. The land:cattle ratio is found highest in large farmer i.e., 0.39, followed by small farmer (0.37) and medium farmer (0.28). The man:cattle ratio is lowest in medium farmers, which mean possible chances of under nourishment of the cattle. The highest fodder requirement is found in large farmer (19,265.4 kg), followed by medium farmer (17,199 kg) and small farmer (8,883 kg). It may also exert high pressure on the existing forest area to meet their fodder requirement due to unavailability of fodder from farmland and private forest. The literacy rate is lowest in small farmer which is about 60.36%, which may have technological constrains in adopting recent farming technology.

The domestic animals found in the village are cows, mithun, goats, poultry and pigs. The traditional poultry and piggery farming meets only the subsistence need however it can be improved to commercial level by adopting the best breed with proper capacity building on

commercial production that will help in providing supplementary income to the small and medium farmers.

Most of the traditional agroforestry systems adopted by small and medium farmer are subsistence AF system, which need to be improved to either intermediate or commercial level. The application of fertilizer like urea is done in the farming system. However biggest lacuna in the farming system is the absence of the soil testing. It is generally done to determine the nutrient status of soil and also cation exchange capacity (CEC) of the soil for optimum application of fertilizer. In various agroforestry system, the choice of silvicultural component have the big lacuna is terms of absence of the nitrogen fixing trees in traditional agroforestry viz., *Leucaena leucocephala, Acacia auriculiformis, Gliricidia sepium, Sesbania grandiflora, Casuarina equisetifolia, Acacia nilotica, Alnus nepalensis*, etc. that helps in replenishing the nitrogen loss from the soil. In aqua forestry, duck farming could be another integral component that could generate additional income. Thus, the traditional agroforestry system can be improved from subsistence agroforestry system either to intermediate agroforestry system or commercial agroforestry system by adopting best practices.

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