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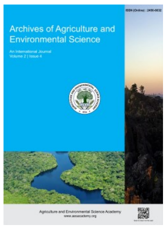

CASE STUDY

CrossMark

Existing agroforestry practices and their contribution to the socio-economic condition of the people of west Nawalparasi, Nepal: A case study

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ABSTRACT

The modern agroforestry systems have the potential to improve livelihood through the production of food, fodder, and firewood as well as mitigation of the impact of climate change. Therefore, it's high time to study local people's perception towards agroforestry adoption and suggest potential agroforestry practices and their benefits for the upliftment of their livelihood. This research was conducted in Susta rural municipality, Pratappur rural municipality, and Bardaghat municipality of Nawalaparasi (West) district to explore the existing agroforestry practices followed by the people, its contribution to the economy of households, to understand the people's perception/attitude towards its adoption and finally to propose the potential agroforestry practices. Primary data were collected using Participatory Rural Appraisal (PRA) tools and secondary information through journals and reports. The analysis begins with distinguishing agroforestry systems and practices, preference of trees, benefits through these practices, people's perception, and problems regarding these practices. A total of 39 tree species and 30 food crop species were planted by 282 household people surveyed. Mangifera indica (relative prevalence 25.92%) is the most predominant fruit species whereas Dalbergia sissoo (relative prevalence 21.28%) is the most predominant timber species. It was found that the boundary planting pattern of the agroforestry system is most (40%) used by farmers of Parasi. The result demonstrated that agroforestry aids in the improvement of livelihood. Nevertheless, respondents have experienced increment incidences of pests and diseases to the annual crops and trees. Hence, the provision of training to improve the skills and knowledge of households seem to be the major need to flourish the agroforestry practices.

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INTRODUCTION

Agroforestry (AF) involves the coexistence of the trees with agriculture, both in time and space, and has been practiced on an informal basis ever since humans began to till the soil and herd animals (Churchill, 1993). In Nepal, AF is a method of farming that allows trees and shrubs to grow along with crops and/or livestock, therefore blending agriculture and forestry in the same production system. AF in Nepal first started when Taungya AF practice was started in 1974/75 in Tamagadhi of Bara district; to prevent forest encroachment by the hill migrants (Amatya *et al*., 2018). There is a long-standing history of Nepali farmers propagating trees on their land (Neupane *et al*., 2002). In both tropical and temperate regions of the world, agroforestry can play a vital role in conserving and even boosting biodiversity from farms to the landscape level as part of a multifunctional working landscape (Jose, 2009). For millennia, farmers in Nepal's mid-hills have relied on agroforestry as a primary or secondary source of lumber, firewood, and feed from government forests (Cedamon *et al.*, 2018). Changes in crops and cropping patterns, such as switching from exclusively growing agriculture crops to cash crops, have altered the agricultural landscape and ecology of Nepal, culminating in an agricultural revolution (Deshar, 2013). In order to fully exploit the potential of agroforestry, there is a need to identify site-specific or region -specific agroforestry systems based on rigorous scientific trial and testing in Nepal (Atreya *et al.*, 2021).

The items harvested through agroforestry operations (food crops and tree resources) meet the multi-dimensional needs of rural populations (Rahman *et al.*, 2012). Furthermore, an agroforestry system composed of trees, agricultural crops, and animals has the ability to improve soil fertility, minimize erosion, improve water quality, promote biodiversity, improve aesthetics, and sequester carbon. (Garrett *et al.*, 2009; Garrity, 2004; Nair and Graetz, 2004; Williams-Guillen *et al.*, 2008). Along with environmental benefits, AF also provides socio-economic benefits to local people. Weyerhaeuser and Kahrl (2006) showed trees grown on farms in Southwest China contributed more to farmer livelihoods and ecosystem services conservation than trees grown in plantations Franzel *et al.* (2001) state that profitability is one of the determinants for the adoption potentials of agroforestry practices; hence, focus should be given to it in agroforestry research. A study by (Bugayong, 2003) in the Philippines showed that people's living standard had uplifted through AF practices. Another study in Indonesia showed, out of total income from agroforestry 15% is from timber i.e., 12% from teak (Tectona grandis) and 3% from other species (Roshetko *et al.*, 2013).

Income generation from agroforestry practices was of less priority among farmers in the past due to the sufficient availability of both wood and non-wood products. Additionally, the agriculture sector is hard hit with the unprecedented outmigration of the labor force in Nepal which left most farm work to women (Maharjan *et al.*, 2012; Upreti *et al.*, 2018). Neupane *et al.* (2001) has identified drivers for agroforestry adoption in Nepal as membership of a male household member in local NGOs; female educational level; livestock holding; and farmers' positive perception towards agroforestry. Many studies also revealed that individual feelings and aspirations also influence the adoption of AF technologies (Garforth *et al.*, 1999; Thapa and Paudel, 2000). Even if the degradation of the natural forest resources resulted in poor availability of wood and non-wood products, the market value of the outputs of the agroforestry practices is increasing. Hence, poor availability of forest products is assumed to have motivated people to grow trees on their farmland (Garforth *et al.*, 1999).

The financial analysis of farmer-managed land uses has got little attention in Nepal. So, it is vital to conduct the livelihood analysis of the agroforestry practices to show farmers the relatively realistic estimates of what the land uses can produce and whether they are/will be profitable from exercising such practices. In the 1990s, effective economic evaluation of agroforestry methods was a low priority study subject, but now there is a need for an accurate assessment of the economic, social, and environmental costs and benefits (Nair, 1998). Even though social aspects of agroforestry have been studied by, e.g., Neupane and Thapa, 2001; Regmi and Garforth, 2010, there are few studies that have addressed the financial as well as the perception of local people regarding Agroforestry practices. To contribute to the above-mentioned gaps, research was conducted in Parasi i.e., West Nawalparasi of Nepal, with the following major objectives: (1) to document the composition, diversity, and uses of AF practices of Parasi (2) to show how agroforestry contributes to the livelihood of people (3) to evaluate potential problems and future choice of agroforestry practices of local people. Research like this helps farmers and planners to design and implement the appropriate agroforestry practices. It also encourages farmers to practice agroforestry system those who were practicing monocropping. The study was performed in small part which may not be applicable for other geographical regions as well as whole terai belt.

MATERIALS AND METHODS

Study area

The study was carried out in Parasi (west Nawalparasi) which lies in province number five (Figure 1. It lies between 27.32° N and 83.40° E. Parasi district has 3 municipalities and 4 rural municipalities. One municipality i.e., Bardghat municipality, and two RM i.e., Susta RM and Pratappur RM were chosen as study areas. Two wards from each municipality were chosen i.e., 2 and 13 from Bardaghat municipality, 3 and 5 from Susta, and 5 and 8 from Pratappur RM which is shown in Figure 1. The climate of the district varies from lower tropical to subtropical with an average maximum temperature of 29.4°C and an average minimum temperature of 16°C. GPS was used to take coordinates of the AF field and the map of the study area was made by GIS. Agriculture is the main source of income in the district, as it is in other regions of Nepal, where the majority of the people are engaged in rice, maize, wheat, and sugarcane farming (Dhakal and Rai, 2020). Among the study areas, Bardaghat municipality is the one which is among the highest forest cover, Pratapur being the least forest cover area and the Susta around the mean forest coverage which is shown in Table 1. This was the reason behind the selection of these three areas for the study.

Sampling procedure

Primary data from all three sites were collected through a questionnaire survey. Key informant interviews, household surveys, formal and informal discussions, focus group discussions, and direct observation was carried out for data collection. The number of HH was obtained from the Cochran formula and the selection of HH was done randomly. Structured and semi-structured questionnaires were prepared to acquire information about AF practices in the study site and to understand

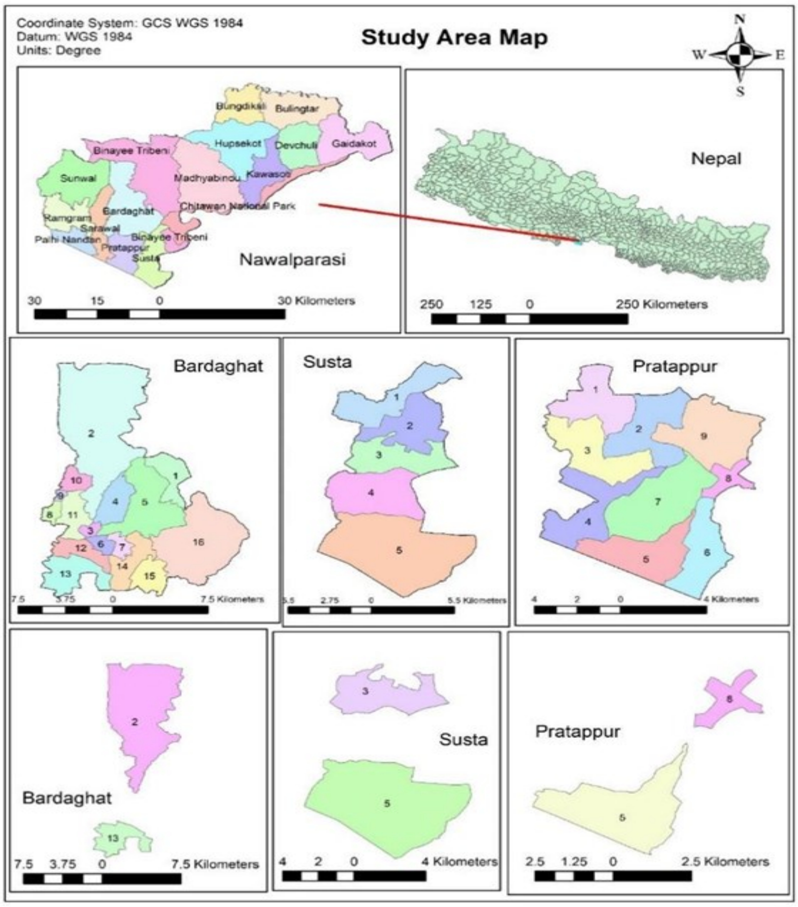

Figure 1. *Map of the study area.*

Table 1. Forest cover percentage.

S.N.	Municipality	Total area (sq.km.)	Total forest (sq.km.)	Forest (%)
1	Bardaghat	178.18	97.22	54.56
2	Palhinandan	44.59	0.09	0.2
3	Pratappur	71.01	0.07	0.1
4	Susta	91.07	10.5	11.53
5	Sunawal	173.2	102.77	59.34
6	Sarwal	73.07	7.46	10.21
7	Ramgram	93.71	0.48	0.51
	Total	724.83	218.59	

(Source: Annual report, DFO, Nawalparasi)

the contribution to the economic condition and the problems faced due to AF practices of the respondents.

Cochran formula

$n = Nz^2p(1-P)Nd2+z^2p(1-P)$

Where,

n = sample size

N = total number of households

Z = confidence level

p = estimated population proportion

Data collection and analysis

Data was collected on the biophysical, demographic, and socio-economic conditions of the households selected using a semi-structured questionnaire. The collected material was also supplemented with time-to-time focus group discussions and Key Informant (KI) Surveys of the AF practitioners. Plant species (trees, shrubs, grass, and food crops) in each sampled cropland agroforestry were identified and recorded. Each recorded plant species was classified by family types (trees, shrubs, and grass) according to morphology, and common uses. Information on types of Agroforestry, problems, future plans of crops were also collected. Statistical analysis (multiple response and descriptive statistics) was performed using MS Excel and R-Studio. Furthermore, density, relative density, and relative prevalence (Rp) of different tree species were determined by the following equation (Chowdhury 1997):

Density= Total number of individuals of a species /Total number of croplands surveyed

Relative density (RD) = Total number of individuals of a species / Total number of individuals of all species × 100

Rp= (N/C) × Cropland with specimen species (%)

Where Rp is the relative prevalence; N is the number of trees; C is the area of croplands.

RESULTS AND DISCUSSION

Demographic and socioeconomic status of respondents

Among 282 respondents, about 75% were male and 25% were female with a mean of 141. Based on the education level, the largest proportion (59%) of respondents had studied below secondary level, 22% had secondary level education whereas the remaining 19% were illiterate. The family size of the respondents ranged from 1 to 22, with a mean family size of 6.6, which is slightly more than the national average household size i.e., 4.6 people per family (CBS, 2016, p. 13). Regarding occupation, the majority (83%) of respondents had agriculture as an occupation, followed by 6% of government service, 4% had the business, 3% were labor, and the remaining 4% practiced other occupations. In case of income, 35% of respondents had annual income of 10,000-30,000 while 32% had less than 10,000, 22% had about 30,000-50,0000 and remaining 12% had more than 50,000 annual incomes. The cropland was categorized as marginal (less than 6 Kattha), small (6-15 Kattha), medium (16-30 Kattha), and large (more than 30 Kattha). Respondents with small landholdings are the majority in number. The majority of the respondents have their own cropland whereas some of the respondents who have very small landholding rented in from those having medium and large landholding. Very few respondents have also rented out their landholdings due to lack of time as well as labor.

Species composition of AF practices

All together 35 tree species, 3 shrub species, and 1 grass species from 22 families which is shown in Table 3. Among these, the majority were fruit species (36%) followed by fodder species (28%), timber Species (26%), ornamental (8%), and medicinal species (3%) which is similar to study carried out by Hasanuzzaman and Hossain, (2014). Mango (*Mangifera indica*) and *Eucalyptus camaldulensis* are the highest prevalent fruit and timber species respectively (Hanif *et al.* 2018). In our study, we also found that *M. indica* (Rp 25.92%) is the most prevalent fruit tree species followed by *Litchi chinensis* (RP5.28%), and *Artocarpus heterophyllus* (Rp 3.84%). Among the timber species *Dalbergia sissoo* (RP 21.28%) was the most prevalent timber species followed by *Tectona grandis* (Rp 18.72%), Bombax ceiba (Rp 7.04%), *Bambusa* spp. (Rp 5.12%), and *Anthocephalus chinensis* (Rp 3.04%). *Melia azedarach* (Rp 5.76%) is the most prevalent fodder species followed by *Artocarpus lakoocha* (Rp 2.24%) and *Leucaena* spp. (Rp 1.12%). The relative density showed that *T. grandis* comprises 60.51% of the species followed by *D. sissoo*, *M. indica*, *Bombax ceiba*, and *M. azedarach* which occupied 18.17%, 6.43%, 4.79%, and 2.32%, respectively. 30 species of food crops from 10 families were recorded which is shown in Table 4. In Susta and Pratappur RM most of the respondents cultivated sugarcane in their field which grows throughout the year and other crops were grown according to the season. Wheat is the most cultivated crop in winter whereas rice is mostly cultivated in the summer season. Besides wheat, major agriculture crops cultivated by farmers are bananas, mustard, and lentil. Apart from this, farmers also cultivated cereal crops like maize, millet, oilseed like sunflower, peanut, legumes like pigeon pea, broad bean, pea, spices like turmeric, coriander, onion, ginger, garlic, and vegetables like cabbage, cauliflower, carrot, tomato, potato, etc. A study by Endale *et al.*, (2017) showed that maize and teff were cultivated abundantly and other food crops were common bean, wheat cabbage, haricot bean, pea, barley, cowpea, potato, pigeon pea, and lablab bean.

Table 2. Demographic and socio-economic status.

Characteristics	Categories	Respondents		Mean	SD	Chi-square test
		Number	Percentage			
Gender	Male	212	75%	141	100.409	X^2 = 71.504, df = 1, p-value < 0.05
	Female	70	25%			
Educational qualification	Illiterate	54	19%	94	61.6523	X^2 = 80.872, df = 2, p-value < 2.2e-16
	Under SLC	165	59%			
	Above SLC	63	22%			
Family Size	Small	63	22%	94	68.0221	X^2 = 98.447, df = 2, p-value < 2.2e-16
	Medium	172	61%			
	Large	47	17%			
Occupation	Agriculture	235	83%	56.4	99.9115	X^2 = 707.96, df = 4, p-value < 2.2e-16
	Business	10	4%			
	Government Service	18	6%			
	Labor	8	3%			
	Others	11	4%			
Income	Less than 10,000	89	32%	70.5	29.7265	X-squared = 37.603, df = 3, p-value = 3.43e-08
	10,000-30,000	99	35%			
	30,000-50,000	61	22%			
	More than 50,000	33	12			

Table 3. Trees species along with relative prevalence, density, relative density in the study area.

English Name	Scientific Name	Family	Types	Relative prevalence	Density	Relative density (%)	Uses
Mango	*Magnifera indica*	Anacardiaceae	Tree	25.92	1.813	6.43	Fruits
Sissoo	*Dalbergia sissoo*	Fabaceae	Tree	21.28	5.12	18.71	Timber, furniture, and fuelwood
Teak	*Tectona grandis*	Lamiaceae	Tree	18.72	17.052	60.51	Timber and fuelwood
Cotton tree	*Bombax ceiba*	Malvaceae	Tree	7.04	1.351	4.79	Timber, furniture, and fuelwood
Persian lilae	*Melia azedarach*	Meliaceae	Tree	5.76	0.653	2.32	Fodder and fuelwood
Litchi	*Litchi chinensis*	Sapindaceae	Tree	5.28	0.263	0.93	Fruits
Bamboo	*Bambusa spp.*	Poaceae	Grass	5.12	-	-	Construction
Jackfruit	*Artocarpus heterophyllus*	Moraceae	Tree	3.84	0.124	0.44	Fruits
Kadam	*Anthocephalus chinensis*	Rubiaceae	Tree	3.04	0.606	2.15	Timber and fuelwood
Monkey's jackfruit	*Artocarpus lakoo-cha*	Moraceae	Tree	2.24	0.199	0.71	Fodder and fuelwood
Lemon	*Citrus lemon*	Rutaceae	Tree	2.08	0.068	0.24	Fruits
Gauva	*Psidium guajava*	Myrtaceae	Shrub	1.44	0.044	0.16	Fruits
Lime	*Citrus aurantifolia*	Rutaceae	Shrub	1.28	0.032	0.11	Fruits
Neem	*Azadirachta indica*	Meliaceae	Tree	1.28	0.032	0.11	Medicine
Ipil ipil	*Leucaena leucocephala*	Fabaceae	Tree	1.12	0.116	0.41	Fodder and fuelwood
Jamun	*Syzgium cumini*	Myrtaceae	Tree	0.96	0.56	0.20	Timber and fuelwood
Garuga	*Garuga pinnata*	Burseraceae	Tree	0.96	0.076	0.27	Fodder and fuelwood
Pomegranate	*Punica granatum*	Lythaceae	Shrub	0.8	0.02	0.07	Fruits
Drooping fig	*Ficus semicordata*	Moraceae	Tree	0.64	0.04	0.14	Fodder and fuelwood
Indian goosberry	*Phyllanthus emblica*	Phyllanthaceae	Tree	0.64	0.016	0.06	Fruits
Indian plum	*Ziziphus mauritiana*	Rhamnaceae	Shrub	0.64	0.016	0.06	Fruits
Wood-apple	*Limonia acidissima*	Rutaceae	Tree	o.64	0.016	0.06	Fruits
Orange	*Citrus sinensis*	Rutaceae	Tree	0.48	0.076	0.27	Fruits
Eucalyptus	*Eucalyptus spp.*	Myrtaceae	Tree	0.48	0.028	0.10	Timber and fuelwood
Poplar tree	*Populus deltoids*	Salicaceae	Tree	0.48	0.1	0.35	Timber and fuelwood
Litsea	*Litsea polyanthus*	Lauraceae	Tree	0.32	0.028	0.10	Fodder and fuelwood
Cocconut	*Cocos nucifera*	Arecaceae	Tree	0.32	0.012	0.04	Fruits
Siris	*Albizia lebbeck*	Fabaceae	Tree	0.32	0.02	0.07	Timber and fuelwood
Papaya	*Carica papaya*	Caricaceae	Tree	0.32	0.012	0.04	Fruits
Cutch tree	*Acacia catechu*	Fabaceae	Tree	0.16	0.12	0.42	Timber and fuelwood
Saj Corcodile bark tree	*Terminalia tomentosa*	Combretaceae	Tree	0.16	0.012	0.04	Timber and fuelwood
Pears	*Prunus persica*	Rosaceae	Tree	0.16	0.004	0.01	Fruits
Bedda nut tree	*Terminalia bellerica*	Combretaceae	Tree	0.16	0.004	0.01	Fodder and fuelwood
Orchid tree	*Bauhinia purpurea*	Fabaceae	Tree	0.16	0.004	0.01	Fodder and fuelwood
Java fig	*Ficus lacor*	Moraceae	Tree	0.16	0.004	0.01	Fodder and fuelwood
Mulbery	*Morus alba*	Moraceae	Tree	0.16	0.004	0.01	Fodder and fuelwood
Ashoka	*Saraca asoca*	Fabaceae	Tree	0.16	0.032	0.11	Ornamental trees
Nut palm	*Areca catechu*	Arecaceae	Tree	0.16	0.008	0.003	Ornamental trees
Rudrakshya	*Elaeocarpus ganitrus*	Elaeocarpaceae	Tree	0.16	0.004	0.01	Ornamental trees

Table 4. Agricultural crops found in the study area.

S.N.	Local name	Scientific name	Family	Crop type
1	Ukhu	*Saccharum officinarum*	Poaceae	Cash crop
2	Kera	*Musa sapientum*	Musaceae	Horticulture crop
3	Gahun	*Triticum aestivum*	Poaceae	Cereal crop
4	Makai	*Zea mays*	Poaceae	Cereal crop
5	Kodo	*Pennisetum glaucum*	Poaceae	Cereal crop
6	Tori	*Brassica campestris*	Brassicaceae	Oil seed
7	Suryamukhi	*Helianthus annuus*	Asteraceae	Oil seed
8	Ground nut	*Arachis hypogeea*	Fabaceae	Oil seed
9	Musuro	*Lens culinaris*	Fabaceae	Legumes
10	Adhar	*Cajanus cajan*	Fabaceae	Legumes
11	Latari	*Lathyrus sativus*	Fabaceae	Legumes
12	Bakulla	*Vicia faba*	Fabaceae	Legumes
13	Kerau	*Pisum sativum*	Fabaceae	Legumes
14	Dhaniya	*Coriandrum sativum*	Apiaceae	Spice
15	Besar	*Curcuma longa*	Zingiberaceae	Spice
16	Aduwa	*Zingiber officinale*	Zingiberaceae	Spice
17	Pyaj	*Allium cepa*	Amaryllidaceae	Spice
18	Lasun	*Alium sativum*	Amaryllidaceae	Spice
19	Cauli	*Brassica oleraceae*	Brassicaceae	Vegetable
20	Banda	*Brassica oleracea var. capitata*	Brassicaceae	Vegetable
21	Tamatar	*Lycopercicum esculentum*	Solanaceae	Vegetable
22	Khursani	*Capsicum annum*	Solanaceae	Vegetable
23	Rayo	*Brassica juncea*	Brassicaceae	Vegetable
24	Mula	*Raphanus sativus*	Brassicaceae	Vegetable
25	Kakro	*Cucumis sativus*	Cucurbitaceae	Vegetable
26	Vanta	*Solanum melongena*	Solanaceae	Vegetable
27	Alu	*Solanum tuberosum*	Solanaceae	Vegetable
28	Brocauli	*Brassica oleracea* var. *italica*	Brassicaceae	Vegetable
29	Gajar	*Daucus carota*	Apiaceae	Vegetable
30	Chamsur	*Lepidium sativum*	Brassicaceae	Vegetable

Table 5. Preferred timber species.

Criteria	Tree Species				
	Eucalyptus	Kadam	Lahare peepal	Sissoo	Teak
Fast growth	4.33	4.05	3.87	4.15	3.36
Marketability	3.72	3.39	3.84	4.08	4.7
Disease Resistance	2.42	2.61	1.71	2.08	2.25
Grow well in Marginal land	3.19	3.83	3.95	3.85	4.54
Durability	4	3.82	3.26	4.1	4.75
Total	17.66	17.7	16.63	18.26	19.61
Rank	IV	III	V	II	I

Agroforestry system and associated practices

Agroforestry has been practiced by the majority (88%) of the respondents in the study area. Farmers planted in three different ways i.e., boundary planting, scattered planting, and block planting. The most frequent strategy was the boundary planting (40%) followed by the scattered and block planting system respectively. A study in India showed that farmers are planting poplars in blocks and boundaries in an agroforestry system to fulfill their demands of wood and fuelwood (Jain and Singh, 2000; Verma *et al.*, 2017).

Economic status and income from agroforestry product

During the survey when were respondents asked about whether AF had an impact on their economic status, many of them (43%) have told that there is no change in their status, some told it's only manageable (30%) and the rest (27%) of them were agreed that their economic status has increased from their farm income. Their responses were significantly different (X-squared = 11.128, df = 2, p-value = 0.003834). Likewise, our study concluded that moderate respondents had an increment in their economic status after the adoption of AF practices. Agroforestry highly encourages the farmers to plant trees on their cropland which consequently increases the abundance of tree species. Agroforestry also ensures tree cover in agricultural landscapes from which poor farmers can earn their livelihood (Rahman *et al.*, 2012). AF practices have given direct benefits by selling products like timber, fuelwood, fodder, fruits, crops, and vegetables. In susta RM, sugarcane yields maximum income (41%) and NTFP does minimum (0.10%). Additionally, in Partappur RM, by selling fruits, responded generate maximum

Table 6. Preferred fodder species.

Criteria	Tree Species				
	Monkey's jackfruit	Persian lilae	Garuga	Java fig	Litsea
Palatability	3.87	2.11	2.63	4.57	4.35
Milk production	4.16	2.36	2.14	4.52	4.13
Dry season fodder	2.9	3.8	3.85	4.7	3.78
Biomass production	1.47	1.72	1.78	4.61	1.48
Easy to propagate	3.39	3.68	2.66	1	2.41
Fast growth	4.2	2.79	3.42	3	2.91
Multiple use	1.77	1.74	1.21	2.74	2.07
Total	21.76	18.2	17.69	25.14	21.13
Rank	II	IV	V	I	III

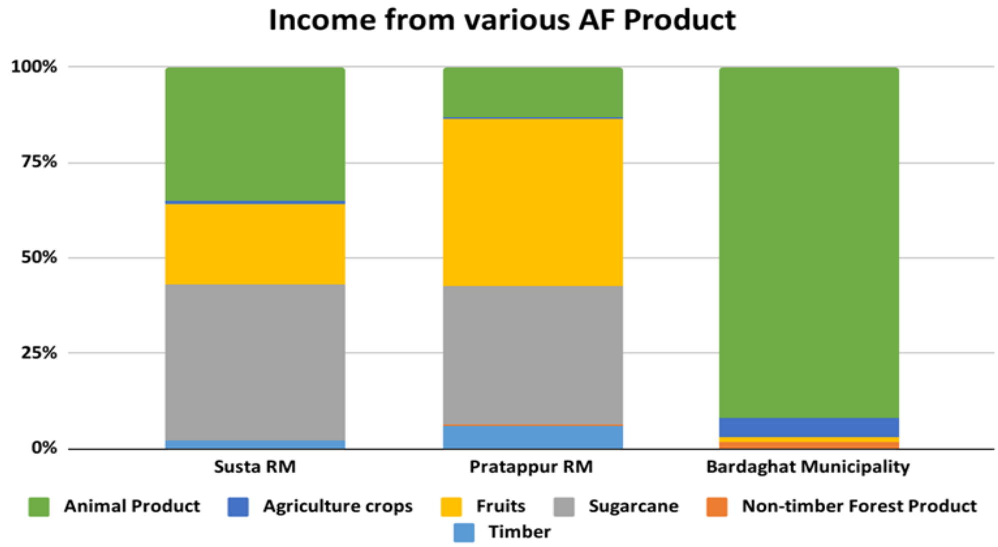

Figure 2. *Income from AF products.*

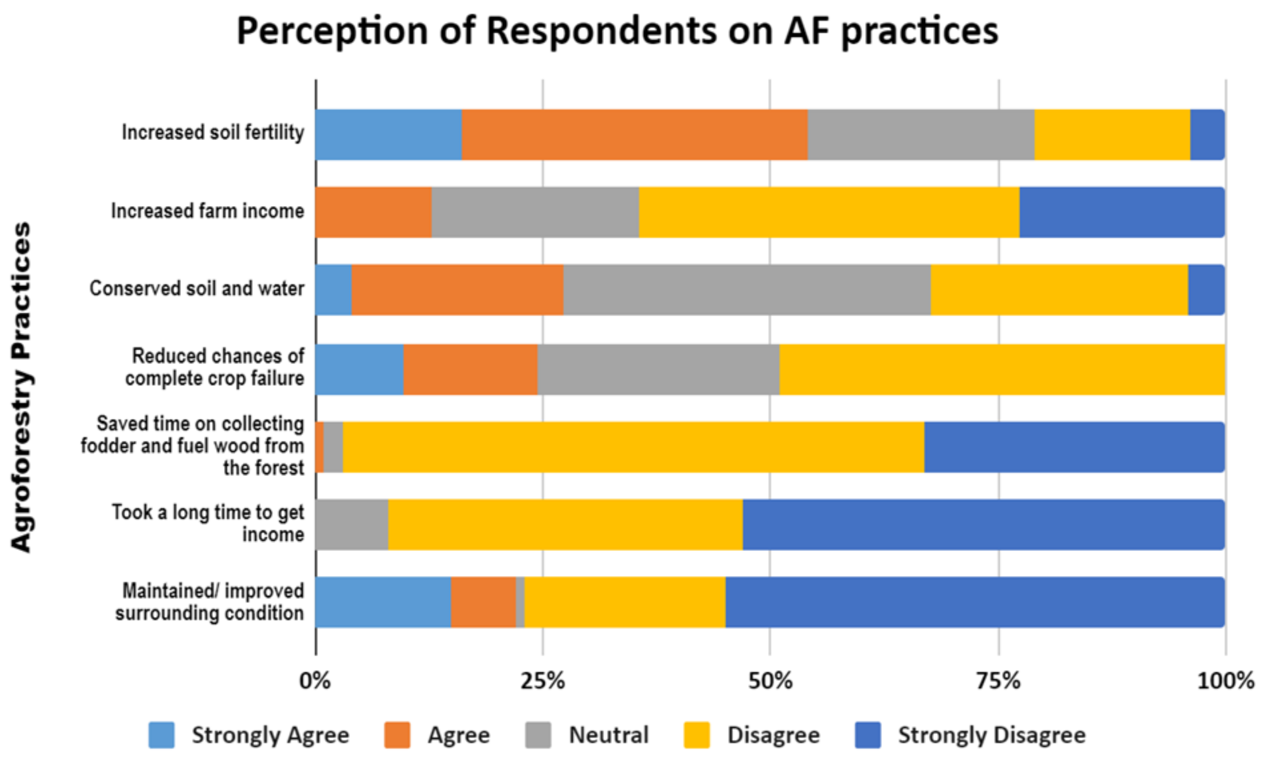

Figure 3. *People's perception.*

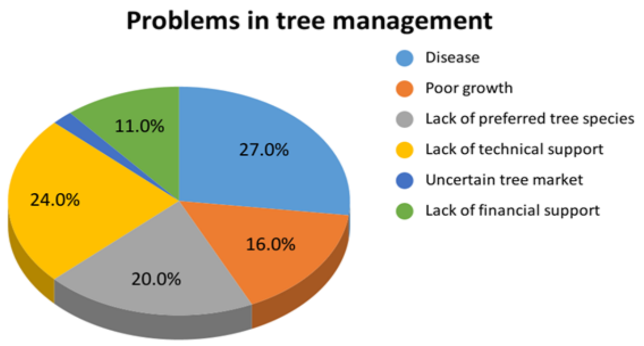

Figure 4. *Problems in tree management.*

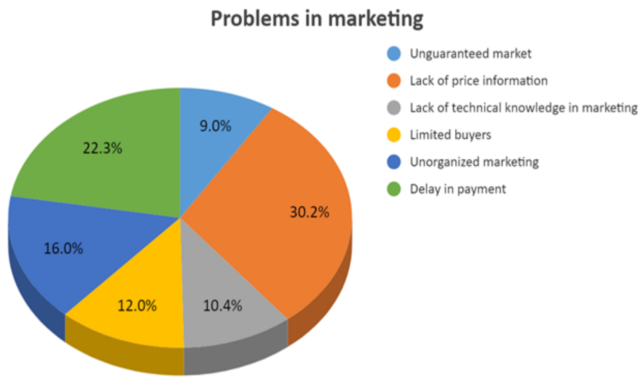

Figure 5. *Problems in marketing.*

(44%) income whereas from NTFP they generate minimum (0.20%). However, in Badraghat Municipality, respondents earn a maximum (92.24%) income from animal products and a minimum (0.03%) from timber which is shown in Figure 2. In our study, income from livestock is higher in Susta RM and Bardaghat Municipality whereas in Pratappur RM income from fruit is more however a study in Dhading district showed that income from vegetable/fruit is highest followed by livestock and crop (Regmi, 2003). A similar study in the Kavrepalanchowk district by Pandit *et al.* (2014) showed that income from livestock is higher followed by vegetables and fruits.

Attitude/Perception of respondents on AF

AF practice was beneficial to the respondents in one way or the other. When respondents were asked about the beneficiaries of AF practices in multiple factors, they responded in the following ways as shown in Figure 3. People's attitude towards direct benefits of the agroforestry system such as benefits from products were highly positive but the people were not interested in the indirect benefits of agroforestry (Islam *et al.*, 2015).

Future of respondents on AF crop selection

During the survey when the respondents were asked about their future crop selection, the majority (41.1%) of the respondents are planning to grow multipurpose trees, some (35.5%) are planning to grow fast-growing tree species, some (12.8%) are planning to grow food crops only and rest (10.6%) are planning to grow fruit trees. Agroforestry surely ensures maximum production, increasing farmers' incomes and hence improving their socio-economic condition. Long-term economic gain can be achieved through planting trees in the cropland which could trigger socioeconomic development (Chakraborty *et al.*, 2015). As farmers want to have increased profit over a short period of time, they prefer species with a fast growth rate over slow and long rotation age in our research which was similar to the study done by (Dagar and Tewari, 2018; Rahman *et al.*,2008).

Respondents preferred timber and fodder species

According to the given criteria, i.e., fast growth, marketability, disease resistance, grow well in marginal land, and durability *T. grandis* (19.61) was ranked first while *D. sissoo* (18.26), *A. chinensis* (17.7), *E. camaldulensis* (17.66), and *Populus deltoids* (16.63) were ranked second, third, fourth and fifth respectively which is shown in Table 5. According to the given criteria, i.e., palatability, milk production, dry season fodder, biomass production, easy to propagate, fast growth, and multiple-use *Ficus lacor* (25.14) was ranked first while *Artocarpus lakoocha* (21.76), *Litsea polyantha* (21.13), *M. azedarach* (18.2), and *Garuga pinnata* (17.69) were ranked second, third, fourth and fifth respectively which is shown in Table 6. A similar study in the Dhanusha district by Dhakal *et al.* (2012) found that Eucalyptus (*E. camaldulensis*) and Ipil (*Leucaena leucocephala*) are the most preferred timber and fodder species respectively.

Challenges in current/future AF practices

Respondents stated different problems they were facing in practicing agroforestry. When they were asked about the problems in tree management, they mentioned diseases (27%) as the major problem followed by lack of technical support (24%), lack of preferred tree species (20%), poor growth (16%), lack of financial support (11%) and uncertain tree market (2%) as shown in Figure 4. The responses were significantly different i.e., x^2= 140.2, df = 5, p-value < 0.05. Several challenges such as shortage of land, seedling, labor, and drought are faced for practicing agroforestry in farmland (Legesse and Negash, 2021). Sugarcane is the major crop of most of the respondents in the study area and people are facing several challenges during the marketing of sugarcane. They mentioned lack of price information (30.2%) as the major problem followed by delay in payment (22.3%), unorganized marketing (16%), limited buyers (12%), lack of technical knowledge in marketing (10.4%), and unguaranteed market (9%) as shown in Figure 5. Sugarcane producers, mill owners, and government offices have inefficient and unproductive information sharing and connections. People are facing several problems such as low cane prices, uncertainty, and delay in payments and fixing the price of sugarcane (Neupane *et al.*, 2017). This is not the case in our country only similar challenges are also faced by the farmers of our neighboring country India also (Mehta, 2015; Sharma, 2015).

Conclusion

The present study has confirmed that good agroforestry practices and their sustainable development in farm-based communities help to diversify rural livelihood. Immediate results from the research indicated that fruit species Mangifera indica is the most prevalent fruit species whereas Tectona grandis is the most abundant timber species. Wheat, rice, and sugarcane are the major food crops grown in association with trees. The majority of the people have practiced agroforestry in their farmland and most of the people have planted trees on the boundary. Though many people have practiced the agroforestry system on their farms the income from animal products is maximum rather than timber. People's attitudes towards direct benefits were highly positive rather than indirect benefits. People want to have multiple benefits in a short time thus many people prefer to grow multipurpose trees such as "kavro", "badhar" and fast-growing trees such as "eucalyptus", lahare peepal" in their farmland. Several challenges in tree management such as disease, lack of technical support, lack of preferred species, and in marketing such as lack of price information, delay in payments, are faced by farmers. Moreover, clear policy assistance for agroforestry promotion, proper market, assistance with land and water management strategies, and up-mounting of the good practice might be the keystone in building improved communities in the face of climate change through improving the capacity of communities and robust ecosystems.

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Conflicts of interest

The authors have no conflicts of interest to declare relevant to this article's content.

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