Research Article:

EXPLORING AGROFORESTRY SYSTEMS AND THEIR PRACTITIONERS IN MID HILLS OF NEPAL

Lilu Kumari Magar and Gandhiv Kafle*
Faculty of Forestry, Agriculture and Forestry University, Hetauda, Makawanpur, Nepal

*Corresponding author: gandhivkafle@gmail.com
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ABSTRACT

Farmers of Nepal have a long history of integrating agriculture and forestry in the same piece of land as agroforestry (AF). Farmers of different socioeconomic characteristics have practiced different agro-ecological practices on their farmlands. This research was carried out in Raksirang Rural Municipality of Makawanpur District in the mid-hill region of Nepal, to explore major AF systems and determine the characteristics associated with farmers' adoption decisions. Data were collected using direct observation and different social survey techniques: household survey (n=80), focus group discussions (n=2) and key informant interviews (n=9). Two types of AF systems were found to be adopted at the study site, i.e., farm-based and forest-based. Agri-silviculture, agri-silvipasture and home gardening were commonly practiced systems. Landholding size, literacy rate, involvement in leasehold forest and provision of training are the major factors affecting the adoption of the AF system. There was no significant relation between the livestock unit and cast with the adoption of an agroforestry system. In-depth studies on the dynamism of agroforestry systems are recommended.

Key words: Agroforestry, farmers, characteristics, mid-hills, Nepal

INTRODUCTION

Agroforestry (AF) is an agro-ecological system that integrates two or more species of plants (or plants and animals), at least one of which is a woody perennial; has two or more outputs; and is more complex, ecologically (structurally and functionally) and economically, than a mono-cropping system (Young, 1994). AF is considered as a dynamic, ecologically based, natural resource management system that diversifies production and increases environmental and socioeconomic benefits by integrating trees in farms and range land (Leakey & Leakey, 2017). AF in the Nepalese context can be defined as "a land use system where trees and agricultural crops are grown together, incorporating livestock, medicinal and aromatic plants, in a given space and time, to raise the productivity of each component without compromising the yield of others" (Umrani & Jain, 2010).

AF is an age-old farming practice in Nepal. Nepal has traditionally practiced a system of integrated agriculture and forestry in various AF forms. The practice of AF followed in Nepal can be broadly categorized into farm-based and forest-based. The farm-based AF system includes home gardens, trees on or around agricultural fields, wood lots and commercial crops under shade trees, and inter cropping of agricultural crops and commercial trees. The forest-based practices involve specific agricultural practices associated with forests where farmers collect food, fruits and gums. AF contributes to farmers by fulfilling their subsistence needs in livelihood and food security (Gilmour et al., 2014). However, AF practices are gradually shifting towards the commercialization of products (Ulak et al., 2021).

Nepal's mid-hills, ranging from 800 to 2,400 meters in altitude, represent a unique agro-ecological zone characterized by rugged terrain, diverse microclimates, and a rich tradition of subsistence farming. Historically, communities in this region, such as those in Makawanpur District, have relied on integrated farming systems that blend agriculture, forestry, and livestock rearing to sustain livelihoods under resource-constrained conditions (Gilmour et al., 2014). Traditional agroforestry practices, such as home gardening and the cultivation of multipurpose trees like *Ficus semicordata* (Khanyu) and *Leucaena leucocephala* (Ipil Ipil) alongside crops, have been integral to these livelihoods, providing food, fodder, fuel wood, and timber. However, these practices are undergoing significant transformation due to population pressure, land fragmentation, and market influences, shifting from subsistence-oriented systems to more commercialized models (Ulak et al., 2021). Climate change, coupled with out migration and policy interventions like the promotion of leasehold forestry, further drives these changes, necessitating a deeper understanding of how traditional systems adapt to modern challenges (Paudel et al., 2019).

AF practice is becoming a considerable option for fulfilling basic needs and generating income in rural communities of Nepal (Paudel et al., 2019). The Forestry Sector Strategy (2016-2025) has provisioned on management of the private forest and promotion of tree species in agricultural sector and emphasized forest entrepreneurship and AF practices (MoFSC, 2016). The National Forest Policy, 2018 was formulated, which incorporates the policy level provisions as: development, expansion and promotion of AF (MoFE, 2020). Farmers have been knowingly or unknowingly adopting AF practice/s and fulfilling requirements for forest products and generating household income. Limited ownership of agricultural land by the families, dominance of middle and small farmers, lack of livelihood-oriented farming system, inadequacy of improved technology, and lack of technological knowledge etc. have hindered the development of the AF in Nepal (MoALD, 2019). Selection of better AF practices is crucial for optimizing benefits from the same piece of land used for AF. The decision to adopt an AF is influenced by various factors (Khadka, 2010). The structure of the AF systems has been studied well in Nepal; however, there is limited information about the household characteristics of different AF systems. In this context, this research was carried out to explore major AF systems and to determine the household characteristics associated with the practice of different AF systems in the mid-hills of Nepal. This study hypothesizes that the adoption of agroforestry systems in the mid-hills of Nepal, specifically in Raksirang Rural Municipality, is significantly influenced by household socioeconomic characteristics such as land holding size, literacy rate, and access to training, as well as institutional factors like involvement in leasehold forestry. It is further posited that farm-based and forest-based agroforestry systems serve distinct roles in meeting livelihood needs, with farm-based systems prioritizing food security and forest-based systems enhancing income diversification and resource access. These hypotheses are grounded in prior research suggesting that socioeconomic and institutional factors shape farmers' land use decisions in resource-limited settings (Neupane et al., 2002; Paudel et al., 2022).

MATERIALS AND METHODS

Study Area

The research was carried out in Raksirang Rural Municipality of Makawanpur District (27°21′ N to 27°40′ N latitude and 84°41′ e to 84°35′ E longitude) in the mid-hill region of Nepal, with an area of approximately 225.17 km² (Fig. 1). It is one of the remote areas of Makawanpur district. The study area lies in Northern Makawanpur, which is situated in the Churiya range. The focused study area consists of 497 Households (HHs) along with 3162 residents.

The climate of Raksirang Rural Municipality in Makawanpur District is subtropical to temperate, typical of Nepal's mid-hills, with an average annual temperature ranging from 15°C to 25°C and annual rainfall between 1,500 and 2,000 mm, concentrated during the monsoon season (June to September) (CBS, 2011). This climatic regime supports a variety of agricultural crops and tree species integral to local agroforestry systems. Major crops include paddy (*Oryza sativa*), maize (*Zea mays*), and pulses like black gram (*Vigna mungo*), which are cultivated on both irrigated (khet) and rainfed (bari) lands. Tree species such as *Dalbergia sissoo* (Sissoo), *Mangifera indica* (Aamp), and *Leucaena leucocephala* (Ipil Ipil) dominate agroforestry landscapes, valued for timber, fruit, and fodder, respectively (Khadka et al., 2021). The combination of seasonal rainfall and diverse topography influences the suitability of these species and cropping patterns, shaping the agro-ecological practices observed in the study area.

Makawanpur district encompasses 2418 sq. km., including hilly areas and plains (CBS, 2021). Subsistence agriculture farming, mainly traditional agriculture is the main source of occupation and livelihood of the majority of the population. Different ethnic groups are found in Makawanpur. Majorities are Tamang 47.65% (n=200,357) and followed by Brahman/Chhetri 25.28% (n=106,297), Newar 6.81% (n=28,634), Magar 4.54% (n=19,090), Chepang 3.94% (n=16,567), and others Kami, Rai, Thakuri, Gurung and others are 2.69% (n=11,311), 2.08% (n=8,746), 0.66% (n=2,775), 0.88% (n=3,700) and 5.47% (n=23,000) respectively (National Statistics Office, 2023).

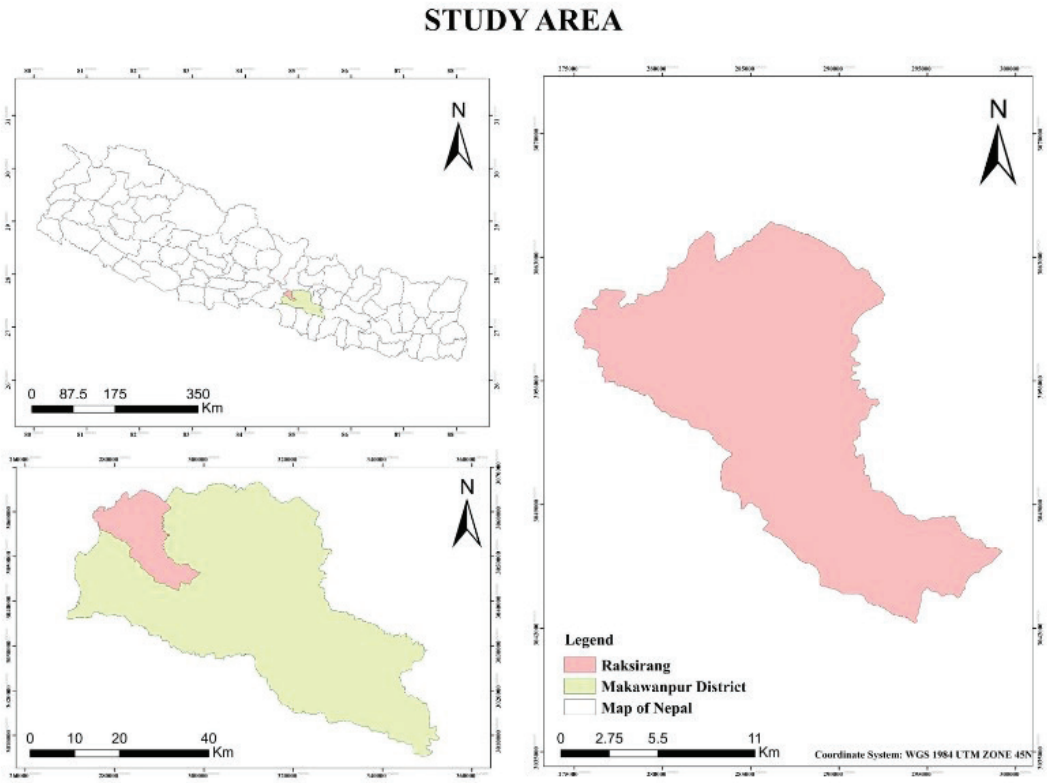

Fig. 1. Map of Raksirang Rural Municipality (study area)
Source: raksirangmun.gov.np/resource-maps

Sampling strategy

Households (HHs) for the study were selected at two stages. First, communities (toles) with AF intervention were selected with the help of key informants working there (officers of local level and forest office) for AF development. This was followed by the identification of farmers practicing farm-based AF system and farmers with the forest-based AF system in leasehold

forests through a reconnaissance field visit. Then, a sample of 80 HHs, 16% out of 497 HHs, was selected for the survey using simple random sampling.

Data collection

Primary data were collected through a reconnaissance survey, key informant interview, structured questionnaire survey, focus group discussion and direct observation through a transect walk. Key informants (n=9) were the leading farmers and persons in key positions of community-based organizations like community forest user groups, leasehold forest user groups, and cooperatives. Direct observation was carried out around the research sites for additional information and field verification for the existing AF systems.

The checklist used for key informant interviews (n=9) was designed to gather qualitative insights into the historical context, current practices, and institutional support for agroforestry in Raksirang Rural Municipality. It included open-ended questions on the types of agroforestry systems practiced, challenges faced by farmers, and the role of community-based organizations (e.g., leasehold forest user groups) in promoting adoption (Supplementary Information – S1). The structured questionnaire administered to 80 households comprised 35 questions divided into four sections: (1) demographic details (age, gender, education, family size), (2) land and livestock ownership, (3) agroforestry practices (types, species, outputs), and (4) socioeconomic factors (income sources, training access, food sufficiency) (Supplementary Information – S2). Data collected included both quantitative metrics (e.g., land holding size in kattha) and qualitative perceptions (e.g., benefits of agroforestry), enabling a comprehensive analysis of adoption drivers. Both tools were pre-tested with a small group of farmers to ensure clarity and relevance, following standard survey design protocols (Bryman, 2016).

Two focus group discussions (FGDs) were conducted to triangulate household survey data, each involving 12 participants and lasting approximately 90 minutes. The first group consisted of 7 men and 5 women, predominantly from the Chepang ethnic group (n=9), with Tamang (n=2) and Dalit (n=1) representation. The second group included 6 men and 6 women, with a similar ethnic composition (Chepang n=8, Tamang n=3, Dalit n=1). Participants were selected to reflect diverse gender and ethnic perspectives, as these factors influence resource access and decision-making in agroforestry (Paudel et al., 2019). Discussions, guided by a checklist (Supplementary Information – S1), explored community perceptions of agroforestry benefits, adoption barriers, and changing land use patterns. Sessions were held in local languages (Nepali and Chepang) to ensure accessibility, with notes and audio recordings taken for accuracy and later transcribed for analysis.

Data analysis

Data analysis was performed using a combination of descriptive statistics and inferential tests in MS Excel and SPSS (Version 25). Quantitative data from the household survey, such as land holding size, literacy rate, and livestock units, were summarized using means, percentages, and ranges. To assess factors influencing agroforestry adoption, a Pearson chi-square test was employed to examine the statistical significance of relationships between categorical variables (e.g., land holding size, caste, literacy rate) and the type of agroforestry system adopted (agrisilviculture, hortisilviculture, silvipasture). The chi-square test was chosen due to its suitability for analyzing contingency tables and non-parametric data, with a significance threshold of $p<0.05$ (Field, 2013). Qualitative data from key informant interviews and focus group discussions were coded thematically to identify recurring patterns (e.g., training impact, leasehold forest benefits) and triangulated with quantitative findings to enhance robustness, following standard mixed-methods approaches (Creswell & Plano Clark, 2017).

RESULTS AND DISCUSSION

Characteristics of the respondents

Among the 80 respondents of the household survey, 4% (n=3) were Dalit, 6% (n=5) were Tamang and 90% (n=72) were of Chepang. Among them, 19% (n=15) were female and 81% (n=65) were male. The average age of the respondents was 39.74 years, with a maximum age of 82 years and a minimum of 18 years. The average family size was found to be 5.57, ranging from 2 to 10. 21.3 % (n=17). Of the respondents 21.3%ere found to be illiterate (n=17), 36.3 % (n=29) were literate (those knowing only simple to read and write), 25% (n=20) had studied primary level and 15 % (n=12) had studied secondary level and 2.5 % (n=2) were those who had education level of higher secondary level.

Socio-economic context

The farmers had been living in the area for long generations for their livelihoods. They have converted forest patches, initially to shifting cultivation and later to other AF systems. The average land holding size in a household was reported to be 0.13 ha khet (irrigated land) and 0.213 ha bari (rainfed land) (Table 1), which is much less than the national average land holding size (0.68 ha per HH) Central Statistics Office, 2023). In forest land, agroforestry systems adopted an average of 0.25 ha land per HH. Among total land used for their livelihoods, 50.61% was used farm-land and 47.22% was leasehold forest land and remaining used as ghaderi (plot for house). Main occupation of the respondents was agriculture. Goat was the major domestic animal they reared. Average livestock unit (LSU) in the area is 2.33 per HH.
[Note: 1 LSU = 1 buffalo = 1.2 cow/ox = 4 goats (Thapa & Poudel, 2000)].

Table 1. Details of land holding size and land types

Variables	Khet	Bari	Residential plot/ Ghaderi	Shifting cultivation land
No of farmers	6	78	80	65
Minimum land (kattha)	2	0	0.15	1
Maximum land (kattha)	8	30	1	40
Total land (kattha)	24	499	22.4	488
Total land (ha)	0.81	16.64	0.75	16.38
Average land per HH (ha)	0.135	0.21		0.25

Note: 1ha=29.531 kattha

Only 20% HHs (n=16) of this area had sufficient food all around the year to sustain whole family. 2.5% HHs (n=2) had food sufficiency for 9-12 months, 20% (n=16) for 6-12 months, 55% (n=44) for 3-6 months and 2.5 % (n=2) with less than 3 months. Result shows that majority of the HHs had food sufficiency only for 3-6 months.

During the period of food deficiency, the farmers fulfilled their needs with money earned from other occupations, wild food collected from forests, and crop production from leasehold forests. They grow agricultural crops also inside leasehold forests, though it is prohibited. It was estimated that 73.8 % (n=59) of food grains, pulses, and other products were supplied from leasehold forests and 92 % (n=77) from wild foods to support food deficiency and as cultural values. Some farmers worked as labors on daily wage basis and some had gone to foreign countries for earnings.

Income diversity

Agriculture production from private farmland, leasehold land and livestock farming were the major sources of on-farm income. Likewise, employment, labor and remittance were the major sources of off-farm income.

Regarding on-farm income, among the total income of the respondents, 98.75 % (n=79) had earned from agriculture on farmland. 82.5 % (n=66) were from earning from livestock farming and khoriya farming (shifting cultivation) 62.5 % (n=50). Average Livestock Unit of the HHs was 2.33 per HH. As livestock farming and agriculture were major components of AF in the area, AF systems were contributing in livelihood of the study area in fulfilling food deficiency at hard time along with providing income and hence helping them to adopt with the climate change impacts with their limited land. The diversified products from AF systems were supporting for their livelihood. Fodder and grasses on farmland were supporting to livestock farming. Fruits and cereal crops were also contributing in income generation.

Due to the little land, there were other off-farm income sources of livelihood in the study area. 27 family members of respondents (33.75%) were in foreign countries to earn. 60 HHs (75 %) were fully or partially engaged on some sorts of employment. 50 % (40) of them worked as labor on wage basis. 41.25 % (33) were doing some business for the livelihood as off-farm income source.

Existing AF systems

Two types of AF systems were found to be practiced at the study site, i.e., farm-based and forest-based. 78.8% HHs (n=63) had practiced both AF systems. 18.8% HHs (n=15) had practiced farm-based AF system only and 2.5% (n=2) HHs practiced forest-based AF system only. Leasehold forest presently was the shifting cultivation land they have been using for many generations. Shifting cultivation was the primary practice in the area with rotation of 2-3 years.

With the involvement of the divisional forest office and non-government organizations, the shifting cultivation practices had been changed to AF practices regularly on the same piece of land throughout the year. Sloping Agriculture Land Technology (SALT) was found to be applied on leasehold forest with agri-silviculture, silvi-horticulture, horti-silvi-agriculture system in the area. As the farmers had little land as farmland, they used leasehold land for crop production too. Hedge row intercropping was the major AF practice. Under the farm-based AF system, agri-silviculture, agri-silvipasture and hortosilvo-pasture systems were adopted (Table 1,2,3). Home gardens, tress around the farmland, fodder and forest trees species along with agricultural crops were the major practices adopted on farm land.

Following were the major agro-forestry systems adopted:

Agrisilviculture

This system consisted of trees and/or shrubs along with agricultural crops. Trees were grown on and around farmland. This system was found on farmland only. Trees like Ipil Ipil (*Leucaena leucocephala*), Bakaino (*Melia azedarach*), Khanayo (*Ficus semicordata*), Tanki (*Bauhinia purpurea*), Khasreto (*Ficus hispida*), Tanki (*Bauhinia variegate*), Sissoo (*Dalbergia sissoo*), Kutmero (*Litsea monopetala*), Aamp (*Mangifera indica*) and Chiuri (*Diploknema butyracea*) were grown on farmland (Table 3). Crops like Paddy (*Oryza sativa*) and Maize (*Zea mays*) are grown on farmland (Table 2).

Silvi-horticulture

Trees like Ipil Ipil (*Leucaena leucocephala*), China berry locally known as Bakaino (*Melia azedarach*), Drooping Fig. locally known as Khanyu (*Ficus semicordata*) were inter cropped with fruit trees like banana (*Musa paradisiaca*), Bhuin Katahar (*Ananas comosus*) and lemon (*Citrus limon*) (Table 3,4).

Horti-silvi-agriculture

Trees and horticultural crops were grown in inter spaces. Agricultural crops were continued simultaneously in wider spacing. This system fulfilled the product requirements of fruits, wood crops, and fodder. It conserved more moisture and minimized erosion. This system was found mostly on leasehold forest land. Farmers were conserving forest trees of their previous khoriya land along with income generation from fruits and livestock with fodder and grasses grown on that land under this system. Agriculture crops that supplied their food were associated with this system.

Of three different AF systems practiced in the area, agri-silviculture was found to be the dominant system as in a study conducted by Khadka et al. (2021) in similar geographical region.

Table 2. Major Agricultural crops grown in AF systems

English name	Scientific name
Paddy	*Oryza sativa*
Maize	*Zea mays*
Black gram	*Vigna mungo*
Horse gram	*Macrotyloma uniflorum*

Table 3. Major trees and fodder species of AF systems

Local name	Scientific name
Kera	*Musa paradisiaca*
Bhuin Katahar	*Ananas comosus*
Ipil Ipil	*Leucaena leucocephala*
Bakaino	*Melia azedarach*
Khanayo	*Ficus semicordata*
Tanki	*Bauhinia purpurea*
Khasreto	*Ficus hispida*
Kagati	*Citrus limon*
Koiralo	*Bauhinia variegate*
Sissoo	*Dalbergia sissoo*
Kutmero	*Litsea monopetala*
Aamp	*Mangifera indica*
Chiuri	*Diploknema butyracea*

Table 4. Major Grass species of AF systems

Local name	Scientific name
Amriso	*Thysanolaena maxima*
Napier	*Pennisetum purpureum*
Stylo	*Stylosanthes guianensis*

Factors affecting adoption of agro-forestry systems

The research finding showed that land holding size is highly significant with AF systems adoption (Table 5). As land holding size increases, the system also differs. Farmers with little land adopted agri-silviculture that fulfill fodder and fuel wood needs along with crops. With the increase in land holding size, farmers adopted agri-silvipasture and hortosilvi-pasture systems. Landholding size had played a significant role in the practice of particular AF systems.

Table 5. Factors affecting adoption of AF systems

Variables	Category	AF systems practiced (%)			Pearson chi-square value
		Agrisilviculture	Hortisilviculture	Silvipasture	
Land holding size	0-10	70	0	30	0.001*
	10-20	20	14.3	65.7	
	>20	0	40	60	
Caste	Dalit	0	0	100	0.91
	Tamang	40	60	0	
	Chepang	34.7	18.1	47.2	
Literacy rate	Illiterate	42.1	31.6	26.3	0.01*
	Literate	32.8	8.2	59	
LSU	0-2	33.8	16.9	49.2	0.30
	2-4	16.7	16.7	67.7	
	>4	33.1	11.1	55.6	
Involvement in leasehold forest	Yes	16.9	18.5	64.6	0.001*
	No	93.3	6.7	0	
Provision of trainings	Yes	13.1	1.6	85.2	0.039*
	No	36.8	5.3	57.9	

Landholding size, literacy rate, involvement in leasehold forest, and provision of training were the major factors affecting the adoption of the AF system (Table 5). However, Khadka (2010) reported in the same study area that human capital characteristics such as farmer's age, education, and labor availability in the household played significant roles in the adoption of the AF system among Khoriya farming. HHs with illiterate HH heads were adopting agrisilviculture system and HHs with literate HH heads were found to be adopting agri-silvi-pastural system.

Farm size, availability of irrigation, education of household heads, extension service, household experience in AF, agricultural labor force, home-to-government forest distance, and expenditure on farm inputs were found to significantly influence farmers‘ decisions regarding the adoption of a farm-based AF system (Paudel et al., 2022).

A study carried out in Dhanusa district, Nepal by Dhakal (2013), found that farm size and education were among the factors influencing AF adoption decisions.

The study revealed that literacy rate had played a highly significant role in the adoption of AF systems in the study area. A study conducted to examine the socioeconomic factors that affect the adoption of AF technology in Nyando, Kenya, suggested that farmers with higher education were more likely to adopt AF systems (Magugu et al., 2018). The involvement of farmers in leasehold land also played a significant role in the adoption of AF systems. Farmers who were involved in leasehold forestry groups were adopting an agrisilvipasture system, and those who were not in leasehold forest land were adopting an agrisilviculture system limited within their little farmland.

The provision of training has played a significant role in agroforestry system adoption. However, farmers with and without training are adopting the same agroforestry system, agrisilvipastural system. There might be some other factors causing these farmers to adopt the same AF systems in spite of the difference in training provisions.

The research findings found no significant relation between the livestock unit and cast and the adoption of an agroforestry system. Farmers with more livestock seemed to adopt an agrisilvipasture system. Unlike other AF adoption studies of Nepal (Neupane et al., 2002), livestock had a positive sign but did not significantly affect the adoption of agroforestry.

With an increasing number of livestock units, farmers are more likely to adopt AF, as there will be a higher demand for fodder. The possession of livestock by HHs had a significant influence on the extent of AF adoption (Sood, 2006).

The result showed that farmers involved in leasehold forest (khoriya land) adopt Agrisilvipasture and horto-silvi culture rather than agrisiviculture whereas farmers not involved in leasehold forest practiced agrisilviculture system. Due to the limited land, the farmers were growing fodder and forest tree species with agriculture crops on farmland.

The decision to adopt AF practices was influenced by access and use of credit, location, and the implemented livestock system (Jara-Rojas et al., 2020). Livestock herd size, provision of extension service, home-to-forest distance, farmers' group membership, and awareness of farmers about the environmental benefits of AF positively influenced the adoption decision for AF, whereas area of farmland and irrigation were found to be the major constraint to AF adoption for smallholder farmers (Dhakal & Rai, 2020). Livestock units have influenced farmers are more likely to adopt AF, as there will be a higher demand for fodder. Possession of livestock by HHs had a significant influence on the extent of AF adoption.

CONCLUSION

Farmers have been practicing farm-based and forest-based agroforestry systems such as agri-silviculture, agri-horticulture, silvopasture, horti-silvi-pasture, Silvi, and agri-silvi-horticulture systems. Widespread integration of fodder and grasses with crops or trees was observed in AF systems adopted by the farmers. The prevalence of integrating fodder and grasses within these systems highlights a practical approach to resource management. Key determinants influencing the adoption of these diverse agroforestry practices include the literacy rate of the farmers, the size of their landholdings, and their participation in relevant training programs. Notably, the study found no significant correlation between livestock units or caste and the adoption of agroforestry. The practical implications of these findings are significant for agricultural extension services and policy formulation in the mid-hills of Nepal and similar regions. Recognizing the positive influence of literacy and training on agroforestry adoption suggests that investing in educational programs and providing targeted training on agroforestry techniques can be an effective strategy to promote wider adoption. Furthermore, considering the role of landholding size, interventions might need to be tailored to different farm sizes to ensure inclusivity. The observed integration of fodder and grasses points to the importance of promoting agroforestry systems that synergize crop production with livestock rearing. Given the dynamism inherent in agroforestry systems, the recommendation for in-depth studies on their temporal and spatial aspects underscores the need for continuous monitoring and adaptive management strategies to optimize their benefits and sustainability. Ultimately, this research provides valuable insights for enhancing the livelihoods of farmers in the mid-hills through the promotion and informed development of context-specific agroforestry practices.

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