Local Knowledge on Factors Leading to Agroforestry Diversification in Mid-hills of Nepal

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Abstract

This paper aims to understand the factors that affect decisions made by smallholder farmers in Mid-hills region of Nepal in diversifying tree and crop species on their agroforestry farmlands. Using an analytical hierarchical process implemented through focus group discussions in five sites in Kavre and Lamjung districts, the study documented 18 tree and crop species preferred by farmers and grown on their agroforestry farmlands. It was found that farmers select tree species based on 'output-based' strategy, primarily considering the products or the functions of the tree species. In contrast, they select crop species based on 'input-based' strategy, primarily considering enabling or constraining conditions for crop cultivation. The tree species having favourable characteristics such as fast growing, multipurpose, and low resource competitiveness in intercropping were the most preferred tree species. For crop species, availability of enabling and constraining factors to crop growth such as climate condition and land suitability, and availability of irrigation system were the predominant factors for species selection. Furthermore, preferences for tree species were considerably influenced by socio-economic conditions—household economy and ethnicity—whereas crop selection was not influenced by such conditions. We recommend that local context and knowledge, especially farmers' preferences in tree and crop selection and factors affecting their preferences, should be taken into account while formulating effective agroforestry programs and policy for Mid-hills of Nepal.

Keywords: Agroforestry, diversification, local knowledge, Mid-hills Nepal, selection factor

INTRODUCTION

Agroforestry is an integral part of rural subsistence in the Mid-hills of Nepal to maintain land productivity and products such as timber, fuel wood, fodder and leaf litters (Neupane *et al.* 2002; Pandit *et al.* 2012; Oli *et al.* 2015; Cedamon *et al.* 2017). Growing multiple tree and crop species along with livestock, poultry and/or fish, is a traditional practice for establishing food security and livelihoods. Amatya (1999) documented the characteristics of Nepalese agroforestry practices across 22 districts representing four physiographic zones i.e. Terai, Mid-hills, High-hills, and High Mountains. The systems fell into two categories: 1] farm-based systems such as home gardens, trees in agricultural fields, alley cropping, commercial crops under tree shade, intercropping with horticultural trees, intercropping with bamboo, trees around agricultural fields, woodlot and silvo-fishery, taungya system and shifting cultivation; and 2] forest-based agroforestry systems which include extraction and production of non-timber forest products and silvo-pastoral practices in forest lands.

The benefits of agroforestry has been widely reported by many authors, and more recently its contribution to climate change mitigation and adaptation has also been acknowledged (Campbell *et al.* 2014; Luedeling *et al.* 2014; Mbow *et al.*

2014b; Mbow *et al.* 2014a; Paudel *et al.* 2014a; Catacutan *et al.* 2017). Dhakal *et al.* (2012) observed that the design and level of integration of plant components in Nepalese's agroforestry reflected farmers' knowledge of the benefits of agroforestry, both economically and ecologically. Indeed, this knowledge or awareness can be quite high in community. For example, Regmi (2003) found that over 90 per cent of farmers in Dhading district were aware of the contribution of agroforestry practices in terms of providing environmental services, while over 85 per cent consented that the practices can also provide diverse benefits such as maintaining soil fertility and humidity, saving labour and time for fodder and fuelwood collection from nearby forests, improving family's income, as well as reducing economic risk through crop and product diversification.

Beside the consideration on the benefits, some studies also reported that farmers' decision in tree-crop selection for their agroforestry farmlands was also influenced by biophysical factors such as topography and soil fertility that determine land suitability and access to market, and socio-economic factors such as household economy and cultural traditions (Neupane 2000; Neupane and Thapa 2001; Neupane *et al.* 2002; Dhakal *et al.* 2012; Schwab *et al.* 2015; Oli *et al.* 2015; Dhakal *et al.* 2015; Cedamon *et al.* 2017). However, these studies have only linked the plant species selection to external factors, and does not explore the perspective of farmers as the main agent that formulate and implement the tree and crop selection strategy. There is thus a little understanding of the local knowledge, especially related to agroforestry farmlands in Mid-hills region. It is important to know these strategies since despite of being acknowledged as traditional practice, agroforestry in the region still adopts a primitive form generally dedicated for subsistence purpose. There is an ample opportunity and need to further enhance both economic and ecological benefits of the current systems. The strategy for improvement should combine both scientific and local knowledge, and through integrating and diversifying plant components that fit farmers' expectation on the outcomes and functions that can be derived from the systems.

Furthermore, farmers' perspective in tree and crop selection across diverse biophysical and socio-economic conditions is also important for promoting agroforestry practices in other areas within the region that recently experience an environmental, especially soil degradation. First, it has been reported e.g. by (Paudel *et al.* 2017a) that due to high population growth rate and limited lands for cultivation, intensive cropping systems have recently become more popular in the region. The authors also claimed that this trend makes some anti-productive measures such as application of organic fertilizers and fallow period have obtained much less attention. Second, a more frequent application of plowing and furrowing as part of soil preparation for the intensive cropping systems, has caused a severe soil degradation due to soil erosion and loss, that substantially reduces crop yields, especially maize as the main staple crop of poor farmers in the region. Due to these, the authors emphasized an urgency in introducing alternative farming techniques that can promote more sustainable agricultural systems, and that can reconcile productive and environmental functions.

This urgency is amplified since Mid-hills region is dominated by marginalized and smallholder farmers with high poverty rate, food insecurity and malnutrition.

This paper aims to present the results of a study carried out to understand the strategies that smallholder farmers in Mid-hills of Nepal use in tree and crop selection on their agroforestry farmlands. The study was conducted in the context of larger interdisciplinary research project, EnLiFT (see acknowledgements). This project focuses on two districts in the Mid-hills of Nepal. The Mid-hills constitutes 43% of the total land area of Nepal and is biophysically and socio-economically complex with a rugged terrain and different ethnic groups, and high poverty rate. Our study intended to capture local diverse perspectives and preferences in tree-crop selection for agroforestry, across different biophysical and socio-economic conditions that relate to the study sites, household's economy and ethnicity. It is expected that the results of this study will inform the development of appropriate agroforestry programs for further improving the outcomes of current smallholder's agroforestry systems as well as promoting agroforestry practices in the region, and contribute in the formulation of effective regulations and policy that support agroforestry development in the region as well as in the country.

MATERIALS AND METHODS

Study sites

The study was conducted in two Mid-hill districts of Kavre and Lamjung (Figure 1). Kavre district is located at 27°37'N 85°33'E to the east of Kathmandu and Lamjung is located at 28°14'N82°25'E to the west. These two districts are considered as representative of the 34 districts in Mid-hills region, particularly those in Provinces 3 and 4 and habitats of main socio-economic groups (Table 1).

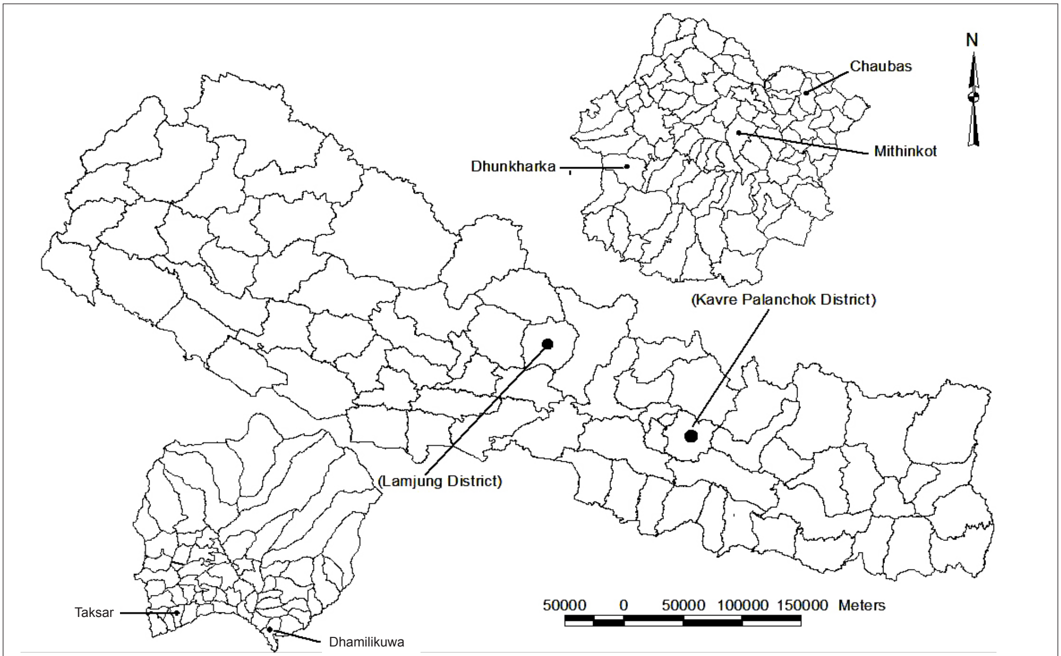

Figure 1. Location of the two study districts and the sampled villages

In Kavre, three village development committees (VDCs) namely Methinkot, Dhunkharka and Chaubas were selected for the purpose of this study. In Lamjung, the study sites involved Dhamilikuwa and Taksar. Table 1 describes key biophysical and socio-economic characteristics of each VDC. In general, the three VDCs in Kavre district have a higher elevation compared to the two in Lamjung, and they are in further distance to the main city namely Kathmandu, compared to the two villages to Besi Sahar as the main city of Lamjung. The greater distance will influence the access to information and market of smallholder farmers living in Kavre district, especially in Chaubas VDC.

Table 1. Key characteristics of study sites in Kavre and Lamjung District

District	Kavre			Lamjung	
Study site (VDC)	Methinkot	Dhunkharka	Chaubas	Taksar	Dhamilikuwa
Number of households	1,055	1,035	487	619	1,154
Population (people)	4,721	4,916	2,068	2,424	4,425
Male (% population)	45	46	46	44	43
Female (% population)	55	54	54	56	57
Elevation (masl.)	820-1,520	1,300-3,018	1,800-2,100	500-1,600	600-1,200
Main socio-economic groups	Brahmin/ Chhetri, Dalit	Brahmin/ Chhetri, Janajati	Tamang, Chhetri,	Brahmin/ Chhetri, Janajati, Dalit	Tamang, Brahmin/ Chhetri,
Land area (km^2)	21.4	27.8	13.2	8.8	16.1
Irrigation system	Very poor	Poor	Poor	Good	Moderate
Distance from Kathmandu/Besi Sahar (km)	55	52	72	38	40

Source: (CBS 2011; CBS 2015), and the EnLiFT project dataset

Household typology and characteristics

Cedamon *et al.* (2017) have described key socio-economic characteristics of six household types representing the main socio-economic groups in the study sites, based on household survey carried out in the five selected VDCs (Table 2). The households belonging to resource-poor *Brahmin/Chhetri, Janajati,* and *Dalit* groups, are represented by household type (HH type) 1, 2 and 6 respectively, and are mostly inhabitants of Methinkot, Dhunkharka and Dhamilikuwa. Those belonging to medium-resource *Brahmin/ Chhetri* and *Janajati* are represented by HH type 4 and 5 respectively, and are mostly residing in Taksar and Chaubas. The resource-rich mix-caste is represented by HH Type 3, and is mostly inhabitants of Chaubas.

While comparing different household types, resource rich households (HH type 3) have the highest average landholding area namely 4.1 ha per household, whereas resources-poor *Dalits* households (HH type 6) from Dhamilikuwa have the lowest namely 0.37 ha per household. The medium-resource household type (HH type 4 and 5) have higher active labour force per household and higher average household income as compared to other types.

The analytical hierarchical process was conducted through focus group discussions in five study sites with participants selected from these six household types, as described in detail below.

Table 2. Socio-economic characteristics of six household types in the study sites (Cedamon *et al*. 2016)

Household types	1	2	3	4	5	6
Socio-economic group	Resource-Poor Brahmin/ Chhetri	Resource-Poor Janajati	Resource-rich Mix caste	Medium-Resource Brah-min/ Chhetri	Medium-resource Janajati	Resource-poor Dalit
Study site	Methinkot	Dhunkharka	Chaubas	Taksar	Chaubas	Dhamilikuwa
Landholding area (ha)	0.79	0.66	4.10	0.83	0.78	0.37
Percentage of under-utilised land (%)	12.6	12.1	18.5	14.4	19.2	16.2
Average tree density in private land (trees per ha)	109	140	2,180	191	81	126
Average annual household income (USD*)	1,210	1,121	1,657	2,656	2,186	1,307
Livestock+ holding (animal unit)	2.9	2.4	12.3	2.5	2.4	2.4

Active labour force (person per household)	4.2	4.1	4.5	5.3	5.1	4.2
Average household size (persons)	5.6	5.8	5.9	6.9	6.6	5.8

*1 USD ≈ 103 NRs. +includes cattle, buffalo, goat, pig and poultry.

Analytical Hierarchical Process

The analytical hierarchical process (AHP) is widely used as a multiple criteria decision-making tool by researchers and policy makers in various disciplines, ranging from education (Yusof and Salleh 2013), natural resource management (Qureshi and Harrison 2003) and industry (Jayamani *et al.* 2017). It relies on the judgments of respondents to derive priority scales systematically through pairwise comparisons of criteria and alternative options (Saaty 1990; Saaty 2008) . The definition of criteria in making decision and prioritization are central in this method to assess the alternative options. Unlike the simple ranking analysis, AHP produces a quantitative measure that reflects the priority scale or a degree of importance among criteria and alternative options. Furthermore, when compared to other multi-criteria decision making approaches such as the WSM (weighted sum model), WPM (weighted product model), or TOPSIS (technique for order preference by similarity to ideal solution), AHP is the most widely used and can transform multiple attributes into hierarchies or categories, according to their entities and make a comparison among those categories (Song and Kang 2016). Due to this, it has an advantage of reducing cognitive errors and can confirm the respondent's consistency to the resulting degree of importance derived from the pairwise comparison process (Song and Kang 2016).

In this study, AHP method was used to gain understanding and rank the factors or criteria that farmers used in deciding tree and crop species on their agroforestry farmlands following the concept described by Dewi *et al.* (2013) and Amaruzaman *et al.* (2015). As described earlier, insight on criteria of tree and crop characteristics preferred by farmers is useful for improving the performance of current agroforestry systems, as well as to further promote agroforestry practices in the region. Similar to the AHP process recommended by Saaty (2008) the following steps were also carried out in the study:

Define the interest and determine the kind of knowledge sought

The interest was the decision in tree and crop species selection on farmers' agroforestry farmlands, either in *khet*, *bari*, or *kharbari* land. The main information sought was the criteria used by farmers in tree and crop selection, and tree and crop species preferably planted in their agroforestry farmlands. Information acquisition from farmers as respondents was carried out using focus group discussion (FGD).

Structure the hierarchy

In this step, two specific information were needed: (i) five main criteria or characteristics that farmers used to choose tree and crop species, as well as the criteria prioritization, and (ii) five tree and crop species preferably planted in their agroforestry systems. For these, during FGD, farmers were firstly asked to develop a list of 8-10 determining criteria in selecting tree and crop species on their agroforestry farmlands and eventually identified the five most important criteria. The list of these five criteria became the basis for pairwise comparison. The farmers were also asked to develop a list of 8-10 crop and tree species commonly planted in their agroforestry farmlands. Similarly, eventually they were asked to identify the five most preferable tree and crop species as the basis for pairwise comparison.

Construct sets of pairwise comparison matrices

There were twelve 5x5 pairwise comparison matrices needed to produce during the FGD to understand the prioritization of selection criteria. For example for tree species, one matrice was firstly produced to assess prioritization among criteria, and eventually five other matrices for assessing prioritization among five preferable tree species under each selection criterion. A similar procedure was applied for crop species, to constitute in total of twelve pairwise comparison matrices per FGD. The pairwise comparisons involved three levels of contrast. A species is assigned with a score of 5 when it is much more important than another under the selection criterion, 3 when it is moderately important than another, and 1 when both have an equal importance. For example, related to climate condition as one important criterion for cultivating crop species, Figure 2 describes how it is much more important related to paddy than maize. As a consequence, a score of 5 is given to paddy and 1 to maize, and the pairwise comparison between these two species will result in a score of 0.2 or 5 depending on the species order in the comparison. The respondents in the FGD only needed to make pairwise comparison for the upper half of the matrices, since the scores for the lower half (i.e. those in dark cells in table 3) can be derived from those in the upper half.

Table 3. Example of a 5x5 pairwise comparison matrix with five crop species assessed under a selection criterion.

	Maize	Paddy	Soybean	Wheat	Buck wheat
Maize	1	1/5	5/1	3/1	3/1
Paddy	5/1	1	5/1	3/1	3/1
Soybean	1/5	1/5	1	1/3	1/1
Wheat	1/3	1/3	3/1	1	3/1
Buck wheat	1/3	1/3	1/1	1/3	1

Calculate weights

Based on the scores provided in the pairwise comparison matrices, the Eigenvalues or the weights that represent farmers' prioritization on tree or crop selection criteria and their preference on tree or crop species for the associated criteria, can be calculated. In the presentation of the AHP results below, the weights that represent farmers' prioritization on the selection citeria are called 'determining levels', whereas those that represent farmers' preferences on tree and crop species are 'preference levels'. All AHP pairwise comparisons and weight calculations were carried out with Microsoft Excel™.

For this study, total six focused group discussions (FGDs) were conducted. Except Chaubas research site where two FGDs were carried out to represent two main ethnic groups, only one FGD per research site was conducted.

The FGD participants, comprising of male and female farmers, were randomly selected with the help of local resource persons and local leaders, from their respective socio-economic group (Table 2).The number of FGD participants were varied between 5-9 people, depending on the availability of farmers.

RESULTS

Preferred tree species and selection factors

In total, there were eighteen preferred tree species from all sites. Among the eighteen, ignoring the site effect, *Ficus neriifolia, Melia azadarach, Alnus nepalensis, Morus alba* and *Prunus serasoides* were the five most preferred tree species (Table 4). In contrast, *Choerospondias axillaris, Litsea polyantha, Garuga pinnate, Ficus glaberrima,* and *Brassiopsis hainla* were the least preferred species by farmers in the study sites. The five preferred tree species were also the most popular across the study sites, selected as preferable in three study sites, with an exception for *Prunus serasoides*, selected as preferable in two study sites only (Table 4). The five least preferred tree species were also those with the least popular across the study sites.

Table 4. Preferred tree species by household type and preference level

Tree species name*		Preference level+ by the six household types						Average preference level	Prevalence among household types**
Scientific	Vernacular	1	2	3	4	5	6		
Ficus neriifolia	Dhudhilao		0.16	0.24		0.12		0.089	3
Melia azedarach	Bakino	0.14			0.20		0.12	0.077	3
Alnus nepalensis	Utis		0.15	0.09		0.17		0.069	3
Morus alba	Kimbu	0.13		0.16		0.11		0.066	3

Prunus serasoides	Painyu			0.15		0.23		0.064	2
Ficus locor	Kavro				0.13		0.16	0.048	2
Leuceana leucocephala	Ipil-Ipil	0.15					0.10	0.042	2
Grewia optiza	Fasro	0.24						0.039	1
Ficus hipsida	Thotne				0.20			0.033	1
Saurauia napaulensis	Gogan		0.18					0.030	1
Pinus spp.	Sallo		0.11	0.07				0.030	2
Schima wallichii	Chilaune						0.17	0.029	1
Artocarpus lakoocha	Badahar						0.16	0.027	1
Brassiopsis hainla	Chuletro		0.11					0.018	1
Ficus glaberrima	Pakhauri				0.10			0.016	1
Garuga pinnate	Dabdabe				0.08			0.014	1
Litsea polyantha	Kutmiro					0.08		0.013	1
Choerospondias axillaris	Lapsi	0.06						0.010	1

*Ordered by average preference level. +Represented by Eigenvalues from AHP application. **Number of household types selecting the tree species as preferable.

In total, the farmers identified nine main factors that they consider while selecting tree species for agroforestry (Table 5). Among these, ignoring the site effect, a multipurpose characteristic was the most important factor, followed by the ability of the tree species to control soil erosion, provide nutritious yields for human or livestock, present low resource competitiveness in intercropping, and fast growing. Among these five important factors, multi-purpose was mentioned by all household types (Table 5). For the other four factors, the ability to provide nutritious yields for human/livestock was the second factor mentioned by almost all household types, but in terms of average determining level, it is less than the ability of tree species to control erosion. Regarding the least important criteria among the nine mentioned by farmers, the ability of tree species to produce timber and high fodder yield, with high product price, were the three with the lowest average determining levels and rarely mentioned across sites and socio-economic groups.

Table 5. Determining factors for tree selection in agroforestry farm

Determining factors*	Determining level⁺ for the six household types						Average determining level	Prevalence among household types **
	1	2	3	4	5	6		
Multipurpose	0.105	0.309	0.187	0.193	0.136	0.239	0.195	6
Control soil erosion	0.329			0.089	0.302	0.093	0.135	4
Nutritious for human/livestock	0.121		0.100	0.139	0.195	0.183	0.123	5
Less competing to crop	0.103		0.337	0.252			0.115	3
Fast growing		0.106	0.057	0.042	0.041	0.042	0.048	4
No legal restriction		0.117	0.034		0.041		0.032	3
Produce timber						0.158	0.026	1
Good product price	0.057	0.065					0.020	2
High fodder yield		0.117					0.020	1

*Ordered by average determining level. ⁺Represented by Eigenvalues from AHP application. **Number of household types selecting the factor as determining criterion.

Preferable crop species and selection factors

In total, nine agricultural crop species that are being grown in their agroforestry farmlands were listed by the farmers (Table 6). Among these nine, by ignoring the effect of study site, paddy (*Oryza sativa*), maize (*Zea mays*), wheat (*Triticum aestivum*), soybean (*Glycine max*), and millet (*Setaria italic*) were the most preferred crops whereas oat (*Avena sativa*), buck wheat (*Fagopyrum esculentum*), sesame (*Sesamum indicum*), and mustard (*Bassica campestis var. Toria*) were least preferred.

Among the five most preferred crop species, maize and wheat were considered by farmers in all study sites, although in terms of average preference level, they were less preferred as compared to paddy (Table 6). The latter was not among five preferred crop species for household type 5. Like paddy, soybean was also preferred in almost all study sites, but it was much lower compared to paddy in terms of average preference level.

Table 6. Preferred crop species by household type and preference level

Species name*	Preference level+ by the six household types 1	2	3	4	5	6	Average preference level	Prevalence among household types**
Paddy	0.241	0.258	0.190	0.362		0.358	0.235	5
Maize	0.167	0.138	0.257	0.100	0.311	0.153	0.187	6
Wheat	0.123	0.083	0.099	0.065	0.137	0.070	0.096	6
Soybean	0.109		0.099	0.124	0.049	0.074	0.076	5
Millet			0.069	0.063	0.121	0.059	0.052	4
Mustard		0.182					0.030	1
Sesame					0.097		0.016	1
Buck wheat	0.075						0.013	1
Oat		0.053					0.009	1

*Ordered by average preference level. +Represented by Eigenvalues from AHP application. **Number of household types selecting the crop species as preferable.

Similarly, nine major determining factors for crop selection were mentioned by the farmers of study sites (Table 7). Among these, by ignoring site effect, climate suitability was the most determining factor for crop selection. Apart from this, production capacity of the crop species, land suitability, water availability for irrigation, and market for the crop products were other key determining factors for crop selection for agroforestry farmlands. On the other hand, Factors such as product quality in taste or nutrition value, difficulty in cultivation practice and short-term profit that can be derived from cultivating the crop species, were the less determining factors. The five most important factors were also the ones mentioned in almost all sites, and the four less important factors were those rarely mentioned across study sites and socio-economic groups (Table 7).

Table 7. Determining factors for crop selection in agroforestry farmlands

Determining factors*	Determining level+ by the six household types 1	2	3	4	5	6	Average determining level	Prevalence among household types **
Climate suitability	0.323	0.331	0.291	0.309	0.329	0.271	0.309	6
Crop productivity	0.075	0.099	0.130	0.125	0.179	0.054	0.110	6
Land suitability	0.152			0.194	0.069	0.244	0.110	4
Irrigation availability	0.127	0.069	0.198	0.053		0.064	0.085	5
Access to market	0.037	0.181	0.057	0.033			0.051	4

Household demand				0.096		0.016	1
Immediate profit					0.081	0.013	1
Easy to cultivate		0.038		0.042		0.013	2
Taste/nutrition	0.034					0.006	1

*Ordered by average determining level. +Represented by Eigenvalues from AHP application.** Number of household types selecting the factor as determining criterion.

Relationship between tree species and selection factors

The relative strength of factors determining the selection of the tree species for agroforestry farmlands showed that the selection factors are strongly associated with the tree characteristics and function of trees perceived by the farmers (Figure 2). Among five most preferred tree species, Dhudhilao (*Ficus neriifolia*) was the most preferred species because of its quality of being multipurpose tree species and good fodder for livestock, and most importantly, not generating high resource competition with intercrops. Bakaino (*Melia azedarach*) was preferred because of multipurpose utility, it's, ability to grow fast and having potential economic benefit from its timber product. Farmers also preferred Utis (*Alnus nepalensis*) since it is a fast-growing tree species and has a good product price. Kimbu (*Morus alba*), which is also a fast-growing species, was favoured since it does not induce a high resource completion with intercrops. Moreover, fodder of Kimbu species is palatable and nutritious for livestocks. Likewise, Painyu (*Prunus serasoides*) was another preferred tree species for agroforestry farmlands because of its multipurpose characteristics, ability to control soil erosion, and no legal restriction to sell its products in Nepal.

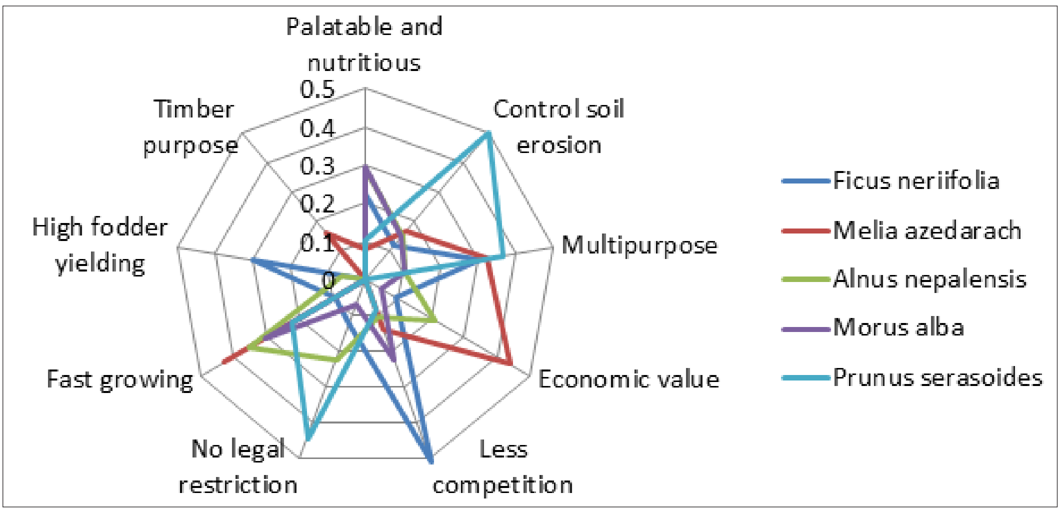

Figure 2. Determining factors for tree species selection by species type.

Relationship between crop species and selection factors

The relative strength of factors determining the selection of preferred crop species showed that unlike in trees, where the selection factors were associated with tree characteristics and functions, crop selection factors were mostly associated with the enabling condition to cultivate the crop species (Figure 3). Study showed that the decision of paddy cultivation was determined by factors such as climate and land suitability, production capacity of the paddy variety, product quality in taste and nutrition value, as well as irrigation facilities. For maize, some factors such as climate and land suitability, and production capacity of the variety were also important, but the strongest determining factor to cultivate this crop was the high household demand for feeding livestock. For wheat, climate condition is an environmental factor that needs to be considered, and farmers also considered this crop as easy to cultivate. Farmers also considered soybean as a crop that is easy to cultivate, but market demand is likely the strongest factor influencing its cultivation. Finally, for millet, while climate and land suitability are two important factors to consider, high demand for private consumption was the most important determinant for its cultivation.

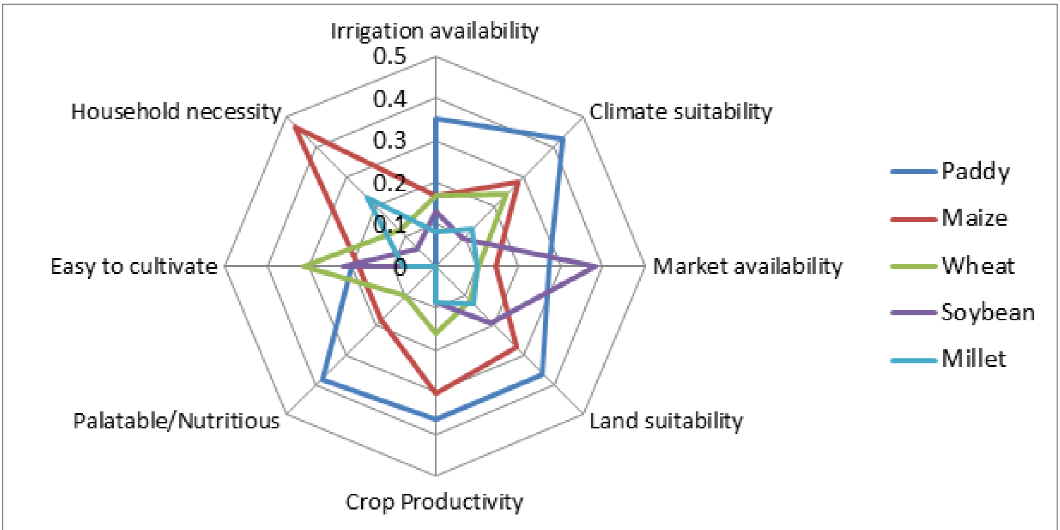

Figure 3. Determining factors for tree species selection by species type

Species selection by socio-economic groups

In case of tree species selection, Fasro (*Grewia optiza*) was the most preferred tree species by the farmers' of Methinkot VDC (Table 4). Likewise, farmers' of this socio-economic group were found to prefer such tree species which has the ability to control soil erosion and produce nutritious fodder for livestocks at the same time (Table 5).

Fasro, which is an indigenous fodder tree of Methinkot VDC, has a deep root system with the ability to control soil erosion and produce high yielding palatable fodder for livestock. Moreover, being a native indigenous species, this species can adapt and thrive well under the local climate condition, including under dry soil conditions.

Similarly, Gogan (*Saurauia napaulensis*) was the most preferred fodder tree species by the resource-poor Janajati farmers of Dhunkharka VDC (Table 3). Since this socio-economic group mostly relies on agriculture and livestock farming apart from seasonal daily wage as the sources of household economy, selling milk, milk products (primarily ghee) and animal meat is a prime source of household income. During lean period, usually between December and April, when there is scarcity of grasses, Gogan is the preferred option in terms of fulfilling the fodder requirement of the locals.

Dhudhilao (*Ficus neriifolia*) was the most preferred tree species by the resource-rich mix caste group farmers of Chaubas VDC whereas Painyu (*Prunus serasoides*) was the most preferred tree species by the medium-resource Janajati farmers of the same VDC. The former is less competitive with adjacent crops, while the latter has an ability to control soil erosion. The preferences by both socio-economic groups likely relate to the biophysical conditions of Chaubas VDC where farmers grow fodder tree species on terrace raisers.

Bakino (*Melia azedarach*) species was highly preferred by medium-resource Brahmin/Chhetri farmer group of Taskar VDC. This species is highly adaptable and tolerant to tropical and sub-tropical climate and Taskar VDC also have similar kind of climate. Moreover, Bakino (*Melia azedarach*) is a deciduous tree species, which during the winter season has less shading effects to the adjacent crops in the farmlands. Likewise, resource-poor *Dalit* group in Dhamilikuwa VDC preferred multipurpose species such as Badahar (*Artocarpus lakoocha).* This species is very popular for its fruit, timber and fodder products. The farmers usually use Badahar timbers to repair their houses and livestock sheds. The fresh fruits are mostly used for private consumption.

In contrast to tree species, the effect of socio-economic group on crop selection was not evident (Table 6). Paddy was the most important staple grain for daily consumption, regardless of the socio-economic status of the groups. Farmers generally have a higher priority for paddy when climate and land conditions are suitable for cultivation. Maize and wheat were other two prominent species in all sites, regardless of socio-economic group.

DISCUSSION

Existing studies have tried to link external biophysical and socio-economic factors to the plant component diversity in agroforestry systems (Regmi and Garforth 2010; Dhakal et al. 2015), yet none have reported results of direct interviews with farmers to understand their rationale behind tree-crop selection. It is important to combine scientific knowledge that investigates the influence of external factors, and local knowledge that understands farmer's perspective on drivers of tree/crop diversification in agroforestry, since farmers and their decision-making process are the two main agents that produce the diversification.

Using focus group discussion with the agroforestry practicing farmers, this study examined the drivers that shape famers' decision in selecting tree and crop to grow on their agroforestry farmlands. Finding of this study suggests that farmers select tree species considering the products or the functions of the tree species whereas selection of crop species is done by considering enabling or constraining conditions for crop cultivation. Analysis of result provides three prominent insights a. Output-based strategy in tree species selection; b. Input-based strategy in crop selection; and c. Influence of socio-economic condition to tree selection , which are discussed below.

Output-based strategy in tree species selection

According to the local knowledge, multi-purpose is one of the most important factors determining tree species selection for agroforestry. There are at least two main conditions driving this preference. First, the current forest policy in Nepal is more focused towards environmental protection (Dhakal *et al.* 2010; Paudel *et al.* 2016), and prohibits some basic practices such as open grazing of livestock in forest lands. This has impelled farmers to grow multipurpose tree species in their own private lands that can provide products such as fodder, fuelwood, and fruits. Moreover, due to the restriction on free grazing, stall feeding of livestock has become a norm (Dhakal *et al.* 2010). Second, limited household labour force, mostly because of male urbanisation/migration for non-farm jobs, has lowered the frequency at which household members can go into the forest to collect fodder.

Tree species with the ability to control soil erosion is preferred by the farmers because most of agricultural lands in the Mid-hills region are situated in terrain and steep slope which are very prone to soil erosion (Bajracharya 2001). Previous studies also suggested that farmers deliberately retained or incorporated multipurpose tree species on the steep slopes in order to mitigate erosion and thereby making cultivation of annual crops possible in such steep slopes (Fonzen and Oberholzer 1984).

Our study also informs that Nepalese farmers in Mid-hills region are concerned on tree-crop interaction and its impact on farm production. The farmers are conscious in selecting tree species which compete less to adjacent crops for above and belowground resources such as water, nutrient and light. This was also documented by IFAD (2010) in their case study conducted in the eastern hills of Nepal.

In another side, tree species selection is not strongly driven by the market factor. This indicates that most of the farmers were not planting trees in their farmlands merely for selling purpose. This likely relates to the current forest-related policy and regulation in the country. Farmers are reluctant to plant trees on their farmlands for the marketing purpose due to lengthy and complicated administrative procedures that need to follow starting from early stage of tree plantation to harvesting stage, and transportation for timber marketing. A similar situation was also reported by Amatya *et al.* (2016) in their case study conducted in three Mid-hill districts of Nepal. It was reported that lengthy administrative process of harvesting and transportation of timber to sawmill is the most hindering factors for timber flow particularly in Lamjung, Kavre and Sindu Palchowk district of mid-hills.

Moreover, inconsistency between the Forest Act promulgated in 1993 and Forest Regulation issued in 1995 have further de-motivated farmers to grow trees on their lands. Amatya and Lamsal (2017) argue that despite a clear provision in the Forest Act of 1993 that states either registered or unregistered farmers can manage their trees and tree products, as well as use or sell timber freely in the market; Forest Regulations 1995 (Rule 62), make a different arrangement for registered and unregistered farm trees. The authors stated that farmers have to follow a multi-stage process to harvest and sell tree products if their farm trees are not registered. These kinds of contradictory rules and regulations have discouraged farmers to plant trees in their farmlands for economic purpose.

Input-based strategy in crop selection

In Mid-hills of Nepal, most of agricultural lands are rain-fed, and planting as well as other agricultural activities are strongly dependent on climatic conditions (Saaty 1990). Furthermore, the region has been experiencing climate change since the last couple of decades (Banba and Shaw 2016). This change has made farmers more sensitive towards changing climatic condition and variability to conduct agricultural activity. Nepalese farmers were found to respond to climate variability, based on their own indigenous knowledge and experiences, through selecting more adaptive crop species to climatic and geographical condition and variability (Manandhar *et al.*, 2010).

The availability of irrigation system was also considered as one of the key factors that determines crop species selection. The official data indicates that more than 50 per cent of the arable lands of Mid-hills region do not have adequate and proper irrigation facilities (MoAD, 2014). Farmers must entirely depend on rainfall for irrigating their farms. However, about 70-90 per cent of the rain fall occurs during summer monsoon (June to September) and the rest of the months are usually dry (Wezel *et al.* 2014).

Currently, most of the farming practices in Mid-hill region are for subsistence rather than selling purpose. National-level data suggests that so far only 3 per cent of the Nepalese farmers practice commercial farming while the remaining farmers practice subsistence-based farming (GoN 2015a). The result of our study indicates farmers' interest in producing high market value crops for selling purpose, although it is less important compared to other factors such as enabling climate and land conditions for growing crops.

Influence of socio-economic condition to tree selection

In the study sites, farmers' preferences in tree species selection are considerably influenced by difference in biophysical as well as socio-economic condition particularly ethnicity. Furthermore, since the ethnic groups also have different characteristics related to household economic condition such as average annual income, land holding area, and livestock holding as described above in Table 2, it can be expected that these economic conditions also influence the farmers' preferences in the tree species selection. Cedamon *et al.* (2017) reported that the land size and livestock holding also determines tree species selection for agroforestry. Study by Webb and Dhakal (2011) also reported the same findings that the two factors, namely landholding area and livestock holding which are typical measures of rural household wealth, are key factors that influence farmer's decision in tree planting on private land, as well as its tree density. Related to influence of social factor, Das (2017) also found that in the eastern Nepal, the choice of tree species was also affected by ethnic background of the farmers.

CONCLUSION AND POLICY RECOMMENDATION

Knowledge on the factors that influence farmers' decision in tree-crop selection is important to understand the aspects of diversification of agroforestry farmlands. This study aimed at understanding local knowledge obtained through interviews with farmers,on the factors that affect their decisions in tree and crop species selection related to their efforts in diversifying plant resources in their agroforestry farmlands. The finding of the study suggests that strategy for tree species selection by smallholder farmers is more 'output-based' namely strongly influenced by the products and functions that the tree species can provide. In another hand, strategy for crop species selection is more 'input-based' namely depends on the prevailing climate and biophysical condition to cultivate the crop species. It was found that *Ficus neriifolia, Melia azedarach, Alnus nepalensis, Morus alba and Prunus serasoides* are the five most preferred tree species for agroforestry farmlands across study sites because of their favourable characteristics such as fast growing, multipurpose, and not generating high resource competition with adjacent crops. Similarly, paddy, maize, wheat, soybean, and millet are the most preferred crop species across all study sites. Study suggests that while cultivating these crop species, availability of enabling and constraining factors to crop growth such as climate condition and land suitability, and availability of irrigation system should be considered.

Furthermore, it is also found that farmers' preferences on tree species are considerably influenced by biophysical and household socio-economic condition whereas the effect is less related to preferences in crop selection. The results of our study indicate that any proposed agroforestry program or policy should consider local context and knowledge, especially farmers' preference in tree and crop selection, and factors that influence the selection. In the recent years, smallholder farmers' preferences have been gradually shifting towards tree-based diversified farming systems rather than conventional monoculture crop farming (Paudel *et al.* 2014b; Subedi and Shah 2015; Ojha *et al.* 2017). Therefore, while formulating any program it is important to consider farmers' point of view towards diversification, their preferences on tree/crop species and factors that contribute to their choices. Despite the trend towards tree-based diversified farming, currently agroforestry sector does not have its own separate policy and governing institutions in Nepal, and agroforestry programs and initiatives are guided by policies of agriculture, forestry and livestock sector.

As a positive initiative, in March 2015, the "Kathmandu Declaration on Agroforestry" was released to start the development of a national agroforestry policy for Nepal. The declaration is also expected to encourage the review of regulatory constraints and develop appropriate agroforestry models for different agro-ecological zones in Nepal. In formulating national agroforestry policy, policy makers should consider local context and knowledge of different agro-ecological zones of Nepal as much as possible and should involve different stakeholders in the policy making process. The local context and knowledge should relate both to the local preference on tree and crop species as the main components of agroforestry system, as well as factors that influence the tree/crop species selection. This 'bottom-up approach' will help to ensure acceptability, success, and sustainability of proposed policy and programs for Mid-hills region of Nepal.

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