Impacts of market-oriented agroforestry intervention on farm income and food security: A case study from Kavre and Lamjung districts of Nepal

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Abstract

Recently it has been realized that improving market access for smallholders will lead to improvement in income and food security. However, market failures often limit smallholders' ability to be linked to markets. To address these challenges, market oriented agroforestry action research program was implemented in six sites of Kavre and Lamjung district of Nepal in 2013.the main objective of this paper is to investigate the changing impacts of the market oriented agroforestry system on improving people's livelihood and meeting food security issues. The net-margin analysis of five priority products of agroforestry (AF) systems including (1) banana based fodder and livestock (2) ginger based fodder (3) tomato based fodder and buffalo (4) alnus- cardamom and fodder (5) round chili and fodder on private lands was conducted. Remaining other components (Tree and animal) constant, farmers benefitted most by banana based high yielding fodder (56%) followed by Alnus-cardamom system (48%), tomato fodder and buffalo (36%), chili fodder (26%) and ginger based (25%) systems due to facilitation of market oriented AF action research services. The impact of market oriented AF intervention revealed that household income was increased by 37 to 48%, which can provide up to additional six months of food to the poorest households. This innovation could be potential to make the majority of households (63%) out of poverty trap with no danger of food shortage during the year. Implications of the study are that farmers must be united for collective marketing of their production and develop marketing strategies to eliminate middle men for better return. Some key lessons learned for the success of this action research include farmers' own motivation, favorable environment and the inclusion of social activities and incentives for cultivating priority products species.

Keywords: Agroforestry systems, market oriented agroforestry, net-margin analysis, food security, poverty.

Introduction

Nepal is an agro based economy with agriculture being the largest contributor to GDP (29.37%) in 2016 (GoN, 2016). Over 60% of the population is engaged in agriculture, due to which it is the only sector that has the necessary multiplier effect to reduce poverty significantly (DANIDA 2013). The Nepal Trade Integration Strategy (2010) highlights the potential export commodities such as cardamom, honey, ginger, lentils and tea as export products. Because of economic liberalization, the expansion of marketing of these commodities is possible where farmers can participate and enter into regional and international export markets (FAO 2011; ADS 2015, Shrestha and Pandit 2017). Demography is another factor contributing to the changing farming landscape. While rural populations continue to grow, more people are migrating and settling in towns and cities (Paudel et al 2014; ADS 2015). This change has resulted in an increasing number of people in urban areas being fed by smaller numbers of farmers. As a result of which many ancient terraces become abandoned and labor scarcity has been prominent (Paudel 2014; Shrestha and Pandit 2017).

The FAO 2010 report indicated that 42 districts out of 75 are food deficit, which can be attributed to growing trees on private farmlands of Nepal instead of practicing agriculture or combination of agriculture and tree growing. Despite this, there have only been a few attempts to enhancing productivity of traditional agroforestry systems. There is a significant gap between current and potential agricultural production in Nepal. The low levels of productivity are the result of several factors including a high level of subsistence farming, low level of access to and adoption of suitable improved technologies (both on farm and post-harvest), poor availability of inputs (planting material, improved breeds, fertilizer, feed, plant and animal health protection, irrigation, electricity, finance), low labor availability due to youth migration (Cedamon et al 2017; Shrestha and Pandit 2017) and limited investment in the agricultural sector (MOAD 2015:104 page). A consequence of this limited investment is that farmers receive little direction and assistance in growing crops where they might capture a market advantage and improve their incomes.

Agroforestry is recognized as a key contributor to the livelihoods of farmers in the Nepalese mid-hills (Pandit et al, 2015). In this connection, there is a high scope to introduce high value priority agroforestry species, which have high market demand and contributes to food security. In the past, trees have been grown on farmlands for many purposes including aesthetic, cultural value and also financial values in many parts of this globe. Financial gain from Agroforestry (AF) system was not a high priority in the past in many rural communities (Duguma 2013). They were mainly grown for subsistence livelihood and considered low priority. The reason for low priority for the traditional system is that their yield was relatively low and some of the outputs such as fuelwood, fodder and some timber were locally available in nearby forests so farmers gave them low priority (Pandit and Thapa 2004; Duguma 2013). Valdivia et al (2012) pointed out that costs of establishing or managing trees, the time required to manage, and the lack of tree management experience are perceived as the most influential barriers limiting implementation of agroforestry on the farm. Duguma (2013) added that lack of understanding about the role of trees to contribute to income and labor shortage are the limiting factors for promotion of trees on farm. Farmers' fear from the shade of trees on crops (like maize in Nepal) (Strange 2013) which also created problem in AF promotion. Cedamon et al (2017) did a study on intersection of livelihood resources and agroforestry practice to identify the ways for adaptation to improve livelihood outcomes. They investigated that the AF is being challenged by social and economic change particularly in response to labour out-migration and remittance income.

The problem is not only one of low productivity in relatively low-value crops and poor input supply (Shrestha and Pandit 2017). Both the input and the output markets are poorly integrated. The smallholder farmers, who are mostly in rural areas, often do not have access to information regarding prices in urban areas; they mostly sell at farm-gate prices to local traders who on their part have access to price and market information prevailing in other markets. Most production systems in developing countries are done at small scale and, hence, farmers acting individually are not able to participate in new markets such as supermarkets where larger quantities and standardization of products are often required. Pandit et al (2009) suggest that because individual farmers have small quantities of produce for sale, they have little bargaining power with traders and most often accept almost any price offered (Gyau 2014). In contrast, large-scale farmers produce in large quantities with consistent quality and, hence, are able to attract buyers willing to buy their products at true market prices. Transaction cost economics stipulates that unevenness in market information is the main reason why markets perform poorly and why transaction costs are so high. Farmers, especially smallholders, not only lack access to quality inputs, the link to the markets for their products is also weak due to lack of infrastructure such as farm-to-market roads, collection centers and storage facilities, and poor access to information about markets and prices (Pandit et al 2009 and Gyau 2014).

The rural landscape that includes the agrarian economy, fragile ecology and complex and differentiated society is changing rapidly with creation of new opportunities and challenges (Choudhary et al. 2011, Pandit et al 2013). Despite this, the rural economy is still based on subsistence agriculture in rural villages of Nepal. In such a context, the cash income derived from agroforestry products (fruits, nursery, animal products and understory crops) have played a significant role in sustaining rural livelihoods (Gilmour 2011). The rural landscape that includes the agrarian economy, fragile ecology and complex and differentiated society is changing rapidly with creation of new opportunities and challenges (Choudhary et al. 2011, Pandit et al 2013). Despite this, the rural economy is still based on subsistence agriculture in rural villages of Nepal. In such a context, the cash income derived from agroforestry products (fruits, nursery, animal products and understory crops) have played a significant role in sustaining rural livelihoods (Gilmour 2011).

Considering these above roles, in many cases, farmers have introduced agro-forestry but without much consideration given to the marketing of the products apart from the increase in productivity. Subsequently, many producers of agroforestry and tree products are disconnected from the market and that can be attributed to problems such as high transaction costs, limited and asymmetric information, lack of coordination and lack of market power which continue to characterize smallholder agricultural production systems in the region where we work. These problems are compounded in the field of agroforestry due to weak policies and regulations (Amatya et al, 2017), poorer market information systems compared to staple crops and poor demand due to undervaluation of agroforestry products (Pandit et al 2014; Gyau et al 2014). The social status (caste/ethnicity), household status on foreign employment and landholding are strong predictors of household segmentation in rural Nepal (Cedamon et al 2017[b]), which has greater influence on producing AF crops and there by bringing them to the market for income (Shrestha and Pandit 2017). Nevertheless the market oriented AF intervention can assist smallholders to be more competitive, especially where the costs of accessing markets are high due to poor infrastructure, inadequate technology and information barriers (Gyau et al 2014). The problems of market access and farmers being able to achieve a fair return from their produce can be addressed using a market oriented approach to identify the most suitable crops for a specific situation and the leverage points for

increasing return to producers (Hoermann et al. 2010; Joshi et al. 2016; Shrestha and Pandit 2017).

In view of the above problems discussed, this paper aims to investigate the changing impacts of the market oriented agroforestry system intervention on improving people's livelihood and meeting food security issues. Specific research questions were:

1. What are the best Agroforestry options suitable for addressing local needs and priorities in the changing context? How can the AF system be improved?

2. What are the changes that have occurred in agroforestry practices due to market oriented intervention at the local level over the last 5 years

3. What are the contributions of AF to overall household economy and food security level of local community? Whether and how has the AF initiative made a difference in poverty level?

This paper reports an effort using action research principles to enhance farmer livelihoods by: first, identifying a best-bet high value crop that can be readily integrated into existing agroforestry systems; and then implementation of the best practices that addresses the issues and gaps reflected above. As it will be shown, some of the most suitable crops that could be integrated into agroforestry system for the study region were cardamom, ginger, tomato, round chili and banana.

The action research reported here was undertaken by the Nepal Agroforestry Foundation under a collaborative funding arrangement between the EnLiFT project and the ACIAR (see acknowledgements). The EnLiFT project's interest was to identify and analyze the most feasible agroforestry value chain option in six village development committee (VDC) areas in Lamjung and Kavre Districts during the year 2013. Of these six villages, two (Dhamilikuwa and Jita taxar of Lamjung) identified banana-based agroforestry as the value chain with the best potential and ginger based AF system in Mithinkot, Cardamom in between *Alnus* trees in Chaubas and Tomato in between fodder trees and buffalo in Dhungkharka of Kavre district. Similarly, round chili with fodder trees system implemented in Nalma of Lamjung. The paper describes the value chain selection process and comparison of five systems (Banana repeated in Dhamilikuwa and Jita Taxar) in terms of contribution to farm income and food security impacts. Finally, suggestions are made to improve the existing marketing systems for the future actions.

Research Methods

An action research methodology was chosen as it is designed to integrate economic, environmental, and social factors in the whole agroforestry system, while emphasizing strategic and political approaches to ensuring sustained improvements for disadvantaged groups (Riisgaard et al. 2010). Research methods involved mainly three distinct activities and steps that include:

1. Selection of action research communities
2. Action research approach and strategy
3. Baseline and end line household survey including key informant (KI) interviews and focus group discussions (FGDs)

Selection of action research sites

In the beginning of 2013, two districts (Kavre and Lamjung) were selected purposively for action research intervention (Figure 1). Three Village Development Committees (VDCs) each District were selected using standard criteria developed by the project in collaboration with 10 collaborating institutions (EnLIFT, 2013). There were a total of 4,788 households in these six VDCs. Of the total households, 3197 households fall within 24 Community Forest User Groups (CFUGs; 4 CFUGs/site) in six sites. From these 3,197 households, 1,200 households were targeted to work as cluster households for action research activities related to Community Forestry and at least 300 households were targeted for AF action research on market oriented AF intervention in 2013. In response to identified needs, the main objective of the AF theme of the project was to improve the capacity of household based agroforestry system s to enhance livelihoods and food security. In order to achieve this goal, the following five objectives were designed for implementation.

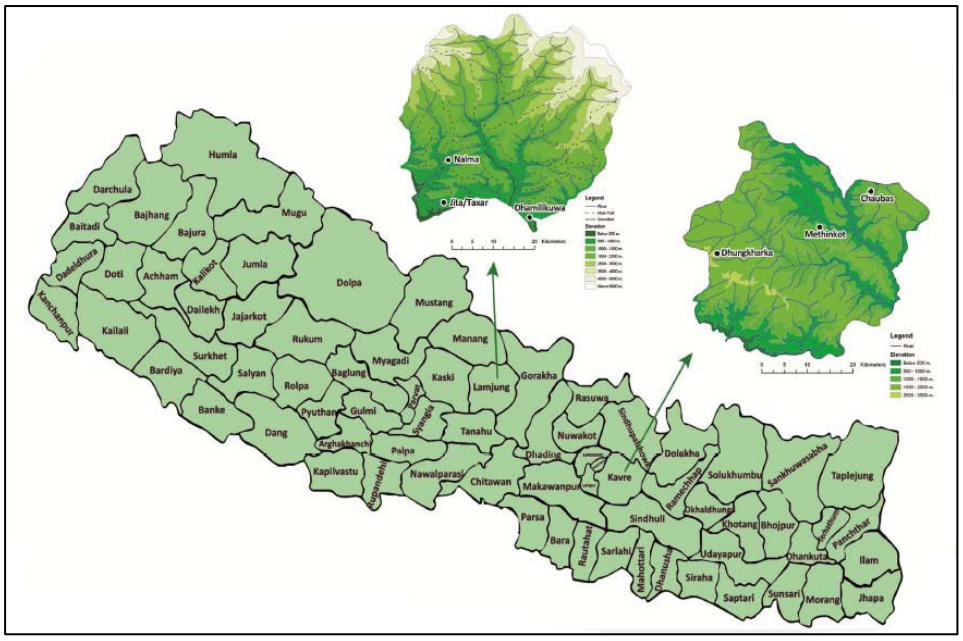

Fig 1 Research sites for the agroforestry value-chain analysis.

1. Identify baseline conditions and drivers of agroforestry practice and opportunities to improve productivity and increase income generation
2. Analyse the markets and value-chains for products from agroforestry systems
3. Analyse policy, institutional and governance issues associated with improving livelihoods from agroforestry systems
4. Develop functioning models to inform improved interactions between farm and forest systems
5. Plan, implement and evaluate participatory action research of innovative agroforestry systems and market opportunities at six sites

Action research approach and strategy

The project planned to implement a pilot innovative AF action research initiative in six field sites in 2013. This involved mainly six action research steps (Figure 2) including research need assessment to monitoring and refection through organizing local research groups (LRGs), training of Local Resource Persons (LRPs), planning for nurseries, action- business planting on farms, monitoring and reflections.

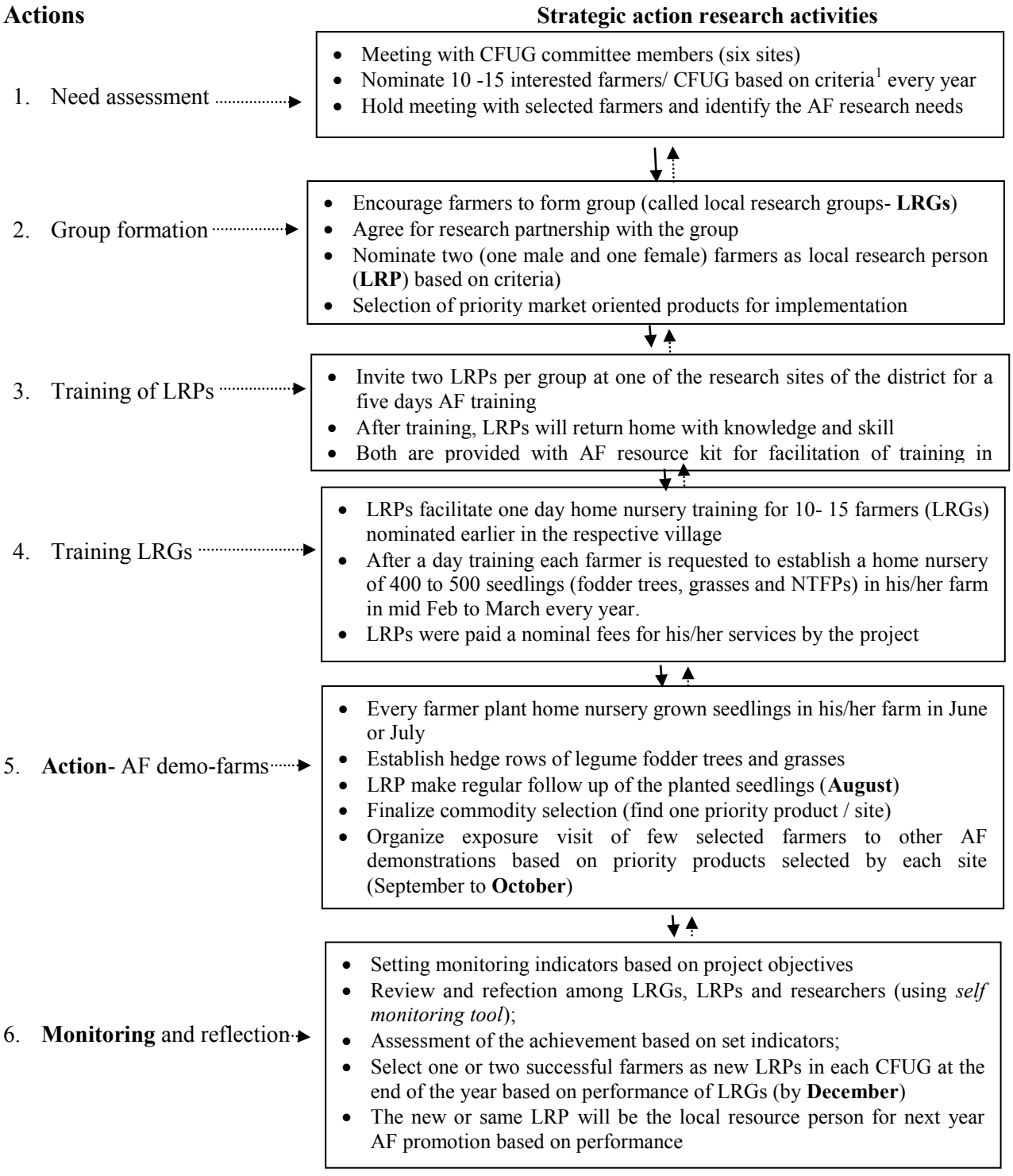

Figure 2: AF Action Research Planning

Market oriented intervention approach

Market oriented action research alone, however, is often not enough to get farm products from the farm to the consumer. This needs to be supplemented by a range of more 'tangible' activities that support marketing of farmers' produce. Farmers groups were formed and encouraged to act as research partners throughout the project period (2013 to 2017). The project supplied initial support for individual or collective management of AF inputs, improved cooperative behavior among farmers and collective action in the marketing of the existing and new priority commodities from AF system. Participating farmers and other stakeholders were trained in the new knowledge and skills of market oriented intervention. Key market oriented interventions followed by the project include:

- Facilitating the selection of range of priority product species for expansion on private land n between tree crops.

- Providing technical support aimed at resolving on-going farmers' problems (cardamom disease at Chaubas) and generating value by increasing the volume and quality of production.

- Facilitating support in strengthening producer associations and Local Resource Groups (LRGs) networks for improved collective marketing and business management.

- Training on business planning of priority products that involved economics, marketing and business management expertise (e.g. farm enterprise anaysis, marketing information and business planning).

- Training on nursery, cultivation practices, harvesting and post-production of priority products that aimed at creating value along the value chain through improved post-harvest handling, packaging, storage and distribution, while meeting food safety and quality requirements.

- Providing support in biochar based organic fertilization for improved productivity of priority products

- Facilitating institutional changes – forming producer organizations, clusters/networks and linkages with district and local level line agencies and supporting weekly market (Dhamilikuwa).

- Exposure visit to some of the best bet- AF intervention sites.

- Providing seeds and seedling subsidies, rewards for market oriented agroforestry products' promoters and creating LRG funds (Example: Mithinkot)

Baseline and End line surveys

This study has adopted a multipronged approach to collect relevant information. Both quantitative and qualitative information were collected. These information were integrated and sequenced to enhance understanding of the change in income, food security and poverty situation of the project beneficiaries. The quantitative information were mainly collected from household survey and qualitative information were collected through Focus Group Discussions (FGDs) and Key Informant (KI) survey as below.

Household survey: To collect necessary data, a simple socio-economic household survey questionnaire format was prepared to cover the information on socio-economic and demographic aspects of the participant farming families. A total of 289 households out of 1200 households within 24 CFUGs were interviewed in May 2016. Prior to household survey, the pre-testing of questionnaire was done in one of the sites. All sampled household heads were interviewed using this questionnaire. LRPs (at least 2 each site) were trained before recording data collection in each of the six sites during the second fortnight of May 2016. They helped data collection for both 'before and after' the project through recall method. The main focus was laid to record the data on the change of family income due to market oriented AF intervention.

Focus Group Discussion: The Focus Group Discussion (FGD) mainly complemented the data collected from household survey. This was mainly focused on the social and institutional aspects of the project intervention. The commodity selection was also done with each of the community groups. The FGD was mainly done to understand the existing best bet agroforestry options, social issues including gender differences of the action research communities and groups, food security situation, preliminary vegetable marketing and value chain system.

Key Informant Interview: The key Informant Interview mainly complemented the data collected from household survey and FGD. This was mainly focused on the socio-economic aspect of the AF farming and local communities' interest in promoting the best bet AF options. The KIS was mainly done to understand the existing AF system and its impact on food security and poverty.

Sampling of Households

Quantitative data were gathered through a household survey using a structured questionnaire. As explained earlier, a total of 289 (48 from Mithinkot, 50 from Dhungkharka and 54 from Chaubas of Kavre district and 53 from Dhamilikuwa, 58 from Jita-taxar and 34 from Nalma) from a population of 1200 cluster households (each cluster comprised of 200 households) were selected randomly as sample households for survey (Table 1). In order to assess the impact of the intervention of market oriented AF intervention, the 'before' and 'after' data was collected from these 289 participating households.

Table 1 Characteristics of value-chain research sites in Kavre and Lamjung Districts

District	Kavre			Lamjung			Total
Research site	Methinkot	Dhunkharka	Chaubas	Dhamilikuwa	Taksar	Nalma	
Household	1055	1035	487	1154	619	438	4788
Population	4721	4916	2068	4425	2424	1779	20333

Male	2125	2260	943	1909	1078	952	9267
Female	2,596	2656	1125	2516	1346	827	11066
Elevation Range	820 to1520masl	1300m to 3018m	1800-2100 m	600 to 1200 masl	500-1600 masl	950 to 2000 m	-
Major socio-economic group	Brahmin / Chettri and Dalit	Newar, Brahmin/ Chhetri, Tamang	Tamang and Chhetri	Tamang Bhahamin, Chettri	Brahmin/ chhetri, Janajati and Dalit	Gurung, Dalit	-
Land Area (km^2)	21.4	27.8	13.2	16.1	8.8	15.8	103.1
Total CFUG User HHs in 4 CFUGs	825	430	321	808	534	279	3197
Cluster HHs selected (50/CFUG)	200	200	200	200	200	200	1200
HHs sampled for AF work	48	50	54	53	58	34	289

Data analysis and measurement

The primary information obtained from household survey, FGDs and key informant surveys (KIS) were segregated into gender and well-being classes. Most primary data sets were analyzed by categorizing the households into groups (gender, food security level, income groups and poverty level) by sites. Descriptive statistics, particularly maximum- minimum range, relative frequencies, mean and percentages were computed as per the requirements. Information obtained from one source (such as FGD) were verified with other sources like key informant survey or field observation. Information on priority products or area covered per household, institutional system, net-margin analysis and contribution to household economy were mainly collected through HH survey, KIS and FGDs. SPSS and Excel data analysis tools were used.

Poverty measurement

According to the Nepal Living Standard Survey (NLSS), 2,200 calorie consumption by a person per day and access to essential non-food items are the index to measure poverty in Nepal. Based on current market prices, a person needs an income of at least Rs 19450 a year to manage food equivalent to 2,200 calorie per day and other essential non-food items (NLSS 2013). As per the report, an individual earning less than Rs 19450 per year is below the poverty line. The national average household size is 4.77 and therefore below poverty line income per household is NPR 92777 (4.77 HH size x 19450).

Food security measurement

To ascertain the role of AF innovations in meeting food requirement of a person, Nepal's per capita income was taken as a standard (i.e. 2200 calorie food can be purchased for NPR 19450). As explained earlier, the national average household size is 4.77. It means 4.77 persons need NPR 92777 for their food which is sufficient for 12 months. It means one person's food is enough for 2.5 months for a family of 4.77

size. For three months, NPR 23340 is needed. Three months food sufficient household is considered as poorest of the poor family. For six months feeding, the double (NPR 46680) of 23340 is required. Similarly, for nine months feeding NPR 70020 and for the whole year (12 months), NPR 93360 is required. Above this line is considered to be 'no' poverty (NLSS 2013).

Results and Discussion

This section discusses on answering the key research questions formulated in the beginning of the research.

What are the best Agroforestry options suitable for addressing local needs and priorities in the changing context?

Selection of best priority and market oriented AF products

There are many agroforestry-based products that are being sold in the markets from the six research sites. Many of them are marketed with low rates, some others have small margin, and very few of them are potentially highly profitable and socially acceptable by rural people. A total of 37 commodities were listed in the beginning from six sites (NAF, 2013). A commodity matrix ranking framework was used to identify the most promising option (ICRAF 2014; Shrestha and Pandit, 2017). This framework followed four procedural steps.

Step 1: Selection criteria: The value chains were evaluated in focus group discussions using seven criteria: market and market demand, economy of scale and outreach, high value, stakeholders' interest and commitment (women and poorest households), coordination, short turnover, and leverage.

Step 2: Weighing %: The first criteria 'market and market demand' was given 20% weightage, the second to fifth criteria were given 15% and rest two were given 10% weightage each.

Step 3: Assessing commodity fit against each criterion: Each criterion was given a score from 1 to 5, with 5 representing maximum compliance and 1 minimum compliance, 2 for compliance and 3 for good compliance. Overall ranking was determined using a weighted average of the seven criteria.

Step 4: Results of commodity scoring exercise: Based on the assessment of step 3 of phase 1, the result is presented in Table 2. A total of 16 commodities were selected in the first phase those who received at least the score of good compliance (agreement with set criteria) (Table 2). In the second phase, the high scoring (max compliance) commodities such as buffalo milk, goat meat, banana, tomato, cardamom, ginger and round chili were selected in the second phase whose score is more than four (4).

Table 2: Result of AF commodity selection process

Commodity name	Dhung kharka	Kavre Mithinkot	Chaubas	Dhamili kuwa	Lamjung Jita/ Taxar	Nalma
1. Buffalo milk	√√√√	√√√√	√√√	√√√√	√√√	√
2. Goat meat	√√√	√√√	√√√	√√√	√√√√	√√√

3. Timber	√√	√	√√√	√	√	√
4. Taxus baccata	√√√	x	√√	**x**	**x**	x
5. Brooms	√√	√	√√	√	√√√	√√√
6. Ginger	**x**	√√√√	**x**	√	√	x
7. Lapsi	√	√	√√	**x**	√	√√√
8. Cardamom	√√√	x	√√√√	**x**	**x**	√√
9. Banana	x	√	**x**	√√√√	√√√√	√√
10. Honey	√	√	√	√	√√√	√
11. Bamboo	x	√	x	√	√√√	x
12. Drum stick	x	x	x	√√√	√	x
13. Round chilli	x	√√√	x	x	√	√√√√
14. Tomato	√√√√	x	√√√	x	x	√√
15. Cinnamon	√√	√	√	√√√	√√√	√√
16. Asparagus	x	√√√	√	√	√	√
Number of products selected	5	5	5	5	6	4

Scale: x- no compliance (0 score); √ – little compliance (1-2 score);√√- compliance (2-3 score); √√√- good compliance (3-4 score); √√√√ – max compliance (4-5 score).

Best agroforestry systems identified in six sites

Taking into account of the dependency of animal component (either goat or buffalo) on fodder resources, tree component was considered to be an independent component in all AF systems defined in six sites and then crop and animal component thereafter. With this definition, the six AF systems (one each/site), which received the highest score among 16 selected in first phase (Table 2), have been identified to be applicable for promotion in all sites. Banana is repeated in two sites of Lamjung. They are presented in Table 3.

Table 3 Intervention species and system components

VDC name	AF system for intervention	AF components		
		Tree	Understory crop	animal
Lamjung	Banana based high yielding fodder system	Leucaena, Flemingia, Teprosia	Banana	buffalo
1. Dhamilikuwa				
2. Jitataxar	Banana based fodder and goat system	Mulberry and & Leucaena	Banana	goat
3. Nalma	High yielding fodder for goat keeping and chili system	Mulberry, Flemingia & Teprosia	Round chili	goat
Kavre	Cardamom based Alnus tree planting	Alnus nepalensis	Cardamom	goat & buffalo
4. Chaubas				
5. Dhungkharka	High yielding fodder with buffalo and tomato planting	Mulberry and Texus baccata	Tomato	buffalo
6. Mithinkot	Ginger based AF system with mulberry and legume fodder	Mulberry, Flemingia & Teprosia	Ginger	buffalo

Source: Compiled from Table 2

Priority products for marketing in six sites

The priority AF products (least one understory crop e.g. banana, ginger, cardamom) per site were identified in terms of scope of marketing. The priority products were selected based on local needs and priority. Site characteristics are discussed in Table 4 for each of the selected priority products.

Table 4: Priority species and site characteristics

VDC	Priority species	Site characteristics in terms of scope of marketing
Dhamilikuwa	Banana	Traditional part of the farming system, available land, good soils, cash culture already present, motivated women's group promoting banana value chain, close to 50% of families already growing banana on a very small scale. Proximity to banana market centers (Bhotewadar and Dumre). Some farmers also can sell to regional market (Narayangad)
Jitataxar	Banana	Available land, proximity to key market (Damauli), many organizations promoting activities (Agriculture service center, cooperatives), scope to grow banana as cash crops, banana traditional to region due to good soils and good climate (tropical).
Nalma	Round chili	Dry area, sandy soils, distant from markets, Round chili and lapsi only grown by a few farmers, active women's group raising goat for meat production. Only a few farmers grow banana, but climate is not suitable.
Chaubas	Cardamom	Hilly terrain with many competing crops especially cardamom grown with *Alnus* tree as shade trees mostly for cash generation and few farmers growing banana but priority given to other crops, poor transport, few promoters, not feasible for growing banana.
Dhungkharka	Tomato	Small land holdings, poor transport, distant from markets, few promoters, small sloppy terrace, rainfed, irrigation priority given to tomato not to banana.
Mithinkot	Ginger	Close to district headquarters and markets, many other competing crops, farmers' focus on ginger and buffalo milk as a livelihood strategy. Few farmers growing banana, but not for commercial purpose, very dry region, not suitable for banana growing.

2. What are the changes that have occurred in agroforestry practices due to market oriented intervention at the local level over the last 5 years?

Change in Agroforestry practices over time

Farmers in the region have been growing trees by themselves on various types of private lands in hills of Nepal (Neupane et al 2001; Pandit et al 2013; Pandit et al 2015; Amatya et al 2015). Previously farmers were growing traditional fodder species such as *Artocarpus, Ficus semicordata, Bauhinia purpurea/ variegata, Chuletro, gogan, Dhudhilo, Morus alba* in a few numbers, and they were not managed at low height and also not planted in a systematic

manner. There had been shade effect of trees on farm crops, and mostly trees were not leguminous, which would otherwise increase the yield of farm crops. This system was however important but not fulfilling the fodder and firewood requirement of local people and at the same time, the companion crops' yield was hampered. Farmers were therefore reluctant to plant trees on their farmlands. As a motivation strategy, the project introduced some of the new high yielding fodder trees (*Leucaena, Flemingia, Teprosia)* seedlings that can be managed at low heights and and nitrogen fixing were promoted. Similarly forage and grasses (NB-21, stylo, forage peanuts) slips were also planted on terrace edges and risers, and on fallow land. Fodder trees were planted in close spacing by maintaining 1–2 m tree height as hedgerows.

Table 5 shows that number of fodder trees on farm land terraces increased by five to six folds, while timber (*Bakaino, teak, khair, Masala, Paiyu, Utis, champ*) and non-timber tree species (*Lapsi, Tejpat* and *Loath Salla*) increased by almost triple folds now (2016) than before 2013. Farmers shifted to growing more understory crops such as tomato, ginger, cardamom, round chili and banana to augment their family income. Large animal number (cattle and buffalo) remain almost same while little increase of goat number was observed (Table 5). Consistent with the information of Table 3, the banana based AF system is dominant in Dhamilikuwa and Jita Taxar. Tomato high yielding fodder buffalo system at Dhungkharka, ginger and cardamom at Mithinkot and Chaubas, respectively.

Table 5: Change in Agroforestry system components over time (2013 to 2016)

AF components		Research sites (Before = 2013 and after = 2016)											
		Jita-taxar (n = 58)		Nalma (n = 34)		Dhamilikuwa (n= 53)		Mithinkot (n =48)		Dhungkharka (n= 50)		Chaubas (n = 54)	
		Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
1. Trees	Fodder	2	218	18	87	4	101	33	183	59	155	85	145
	Timber/Fuel	8	37	63	154	4	27	21	31	98	161	41	59
	NTFP trees	1	30	1	13	1	25	2	7	32	67	2	4
2. Under storey crops	forage/grasses	130	368	45	63	34	143	72	126	11	59	47	106
	Banana	8	30	13	17	12	45	2	2	0	0	0	0
	Tomato	8	41	7	18	5	26	13	42	30	90	0	11
	Cardamom	0	0	18	100	0	0	0	0	1	25	58	161
	Round chilli	0	0	1	17	0	0	47	60	6	14	0	0
	Ginger	91	108	27	37	0	0	325	383	0	0	0	0
3. Animal	Cattle/buffalo	2.1	2.1	2.0	1.5	1.7	1.8	2.1	3.0	2.0	3.2	1.6	0.7
	Goat	1.6	3.9	1.2	3.0	2.3	4.3	3.7	5.2	2.7	4.2	1.9	2.7

Note:
Fodder Species: Ipil, Bhatmase, Mendula, Raikhaniyo,Badahar, Tanki, Koiralo, Kimbu, Hattipaile, Gogan, Dhudhilo, Chuletro and Kutmiro
Timber/Fuelwood: Bakaino, Teak, Khair, Masala, Paiyoun, Uttis and Chap
NTFP species: Lapsi, Tejpat and Lothsalla
Forage/grasses: NB21, Molato, Seteria and Amriso

Key AF systems

Of the many AF systems being practiced in study sites, five systems were identified as best AF options by farmers in six sites. They are discussed below:

Cardamom Alnus system: This system is prevalent in hills of Nepal above 2000 masl. This system has been practiced mainly in Chaubas of the study sites, and a few farmers are also trying this at Nalma of Lamjung and Dhungkharka of Kavre district. Farmers appear to have taken the advantage of already established natural vegetation of *Alnus nepalensis* (Utis). However, in the last three to four years, *Alnus* trees have been promoted and now they reached to almost 20 to 25 ft. height. Farmers are planting cardamom under these trees. The practice of planting cardamom under *Alnus* is an old one. It has been more than 42 years farmers have practicing this system. Initially, this system was introduced in the subsistence level but now it is expending as one of the important income generating activities in these villages. *Alnus nepalensis* (Utis) is a pioneer species which grows in full light. It does not require high soil fertility but prefers moist soil. It fixes atmospheric nitrogen. It has been claimed that the production of Cardamom is more on the land having good moisture level. This system has been providing additional income to famers. The price of Cardmom is increasingly getting higher. It was 980 Rupees per kilogram (10 US $) in the year 2012 whereas it has gone up NRs 1800 at farm gate. More than 40 farmers in Chaubas are practicing this system with the earning of more than NRS 1,000,000 (10204.08 USD) per annum (Amatya et al 2013). Because of the high income and low input farmers are shifting towards this system from traditional tree-crop growing system.

Banana based high yielding fodder system: Banana is a high value agricultural product and used as a cash under story crop in many parts of Nepal. Banana based system is considered potential to contribute to the national economy and to generate income for farm families in tropical and sub-tropical regions. The contribution of banana system has been well recognized in many parts of the region in recent years. Banana with high yielding fodder trees and grasses (Tukan, 2005) and is being practiced as one of the important innovative systems in two sites of Lamjung. Banana matures in 18 months and can provide income at the end of second year in a good agronomic condition. Banana is currently grown in 68 of Nepal's 75 districts, and the total productive area of banana plantations in 2012/2013 was 11,864 ha, with a total production of about 182,005 tonnes. Despite its potential, there are very few banana plantations and its productivity is low, where the productivity ranging from 13.2 t to 20 t/ha (ICIMOD 2013). Nepal imported 27878 from India on the year 2011/12 for domestic demand (TEPC 2012). Farmers of these two sites were able to harvest almost double of banana with one tree fruiting maximum 300 banana. Fodder and grasses from the AF farm were fed to cattle and goats and obtained a good returns. Nitrogen fixing and high yielding fodder trees such as *Flemingia* was introduced along the terrace edges where banana was planted in between these fodder trees line.

*Ginger based fodder and livestock system***:** Growing ginger on agricultural land is a traditional practice in Nepal and elsewhere in other countries. However planting ginger with high yielding fodder trees was introduced in Mithinkot of Kavre district. Ginger was planted 30cm a part, and leguminous fodder trees (*Flemingia*, *Leucaena* and *Teprosia*) were planted at the edge of terrace and terrace risers as a hedgerows for nurturing the ginger plants. Ginger does not require high labor except in planting season and is harvested in 10 months. Almost all farmers practiced this system at Mithinkot and got good returns. However, because of market price fluctuations, farmers had to store ginger in the soil for another five to six months after harvesting season (April-May).

Tomato, fodder and buffalo system: Majority of farmers in Dhungkharka have been growing tomato as an important income generating crop in agricultural land. Besides tomato, buffalo raising for milk and thereby milk sweet (khuwa) making was also a common practice there. Farmers wanted to integrate tomato with this system. Farmers grow tomato in plastic tunnel and fodder trees and grasses along the terrace risers and edges in the same terraces where trees and grasses are grown in between, and trees are managed at low height keeping in view that they do not shade to tomato crops. This system was considered to be the best option for farmers for enhanced income. This system was also followed in other five sites, but in small area.

Round chili and high yielding fodder tree system: *Dalle Khursani* (round chili) is one of the hottest chilies found in the world. It is also commonly called *Akbare khursani*. *Dalle khursani* is almost round cherry size and bright red when fully ripen. It is grown and widely consumed in Nepal. It is also a high value crop and sold for around Rs. 500 per kg in cities, but in villages it fetches at least NPR 300 to 400. It can be grown almost everywhere, but better in sandy soils and in regions with temperate wet climate. Chili grows small to medium sized bush from half a meter to two meter tall. Chili grows in sub-tropical to temperate region. People at Nalma were growing round chili some years ago on terraces under traditional fodder trees and so this system was prioritized. Of the total 38 farmers, 16 farmers started growing chili in between fast growing leguminous fodder trees (Teprosia, Flemingia and Leucaena) on private farmland terraces. This however could not give the expected yield, but introduction of some vegetable crops such as cucumber, bean and green peas.

Net margin analysis of priority products

The cost benefit analysis revealed that banana system, which is practiced in Dhamilikuwa and Jita Taxar have been most profitable (56% margin) followed by cardamom- alnus (48%), tomato and fodder (36%), round-chili and fodder (26%) and ginger based fodder is 25% profit (Table 6). Since Alnus trees require at least 7 to 10 years for timber harvest, so this benefits could not capture in the research. If we consider timber value, the net margin would have been increased (MSFP, 2016). However, banana based system seems to be profitable in this case, the yield of fodder and grasses reduced to almost half compared to other five systems. Tomato based system is profitable, but farmers need to be always careful in trimming or coppicing their trees and shrubs (mulberry) which are planted along the terrace edges (NAF 2013).

Table 6: Cost benefit analysis of priority products

Details	Banana (Dhamilkuwa & Jita Taxar)		Cardamom (Chaubas)		Tomato (Dhungkharka)		Ginger (Mithinkot)		Round chili (Nalma)	
Liquid Investment	Amt	NPR	Amt	NPR	Amt	NPR	Amt	NPR	Amt	NPR
Seed/seedlings/no	1600	56,000	5000	75,000	22000	88,000	1500	150000	16666	66664
Manure/fertilizer/t	20	40,000	15	30,000	40	80,000	20	40000	25	50000
Chemical/lit	2	4,000	3	6,000	6	12,000	2	4000	5	10000
Charges for irrigation	4	8,000	2	4,000	24	48,000	4	8000	24	48000
Farm Labour/day	150	45,000	245	73,500	2272	681,600	589	176700	600	180000
Tractor or Oxen/day	10	10,000	10	10,000	20	20,000	20	20000	20	20000
Others (drying for cardamom, tunnel for tomato)	1	5,000	1	50,000	110	1,650,000	1	5000	1	20000
Subtotal		168,000		248,500		2,579,600		403,700		394664
Interest (12%)		20,160		29,820		309,552		48,444		47,360
Total Investment		188,160		278,320		2,889,152		452,144		442,024
Production t/ha/yr	20	426,667	0.966	531,300	150	4,500,000	15	600,000	6	600000
Profit/ha/yr		238,507		252,980		1,610,848		147,856		157,976
Profit (in percentage)		**56**		**48**		**36**		**25**		**26**

3. What are the contributions of AF to overall household economy and food security level of local community? Whether and how has the AF initiative made a difference in poverty level?

Change in household income

The change in family income between 2013 and 2016 is presented in Table 6. The change in average farm income is 11 (37 to 48) percent compared to negative change in off-farm income (-9%). The major change is due to understory crop in almost all sites followed by livestock and timber and nursery seedling sale promoted by the project (Table 7). Among farm income sources, the percent change in income is highest in Nalma (round chili and fodder system), but the income from the understory crop is the least. It is because the livestock and other vegetable including timber contributed to the highest percent of farm source income at Nalma. Timber in Nalma was used from previous stock. In terms of absolute income from under story crops, which is prime in AF system, banana based system contributed more than other systems where the income is highest (NPR 30725) at Dhamilikuwa. This is more than triple folds of Nalma village (NPR 9878). This is also justified from the facts of Jita taxar (banana system) followed by Alnus-cardamom in Chaubas (Table 6). Among all off-farm sources, income from remittance is highest. Nalma used to receive the highest remittance (41%) in 2013 and now it is dropped to 34 percent. Dhungkharka has the least remittance record (10% in 2013 and 07% in 2016) (Table 7).

Table 7: Sources of cash earning (NPR/year) per household (before -2013 and after- 2016)

Income sources	Period	Jita taxar		Nalma		Dhamilikuwa		Mithinkot		Dhungkharka		Chaubas		Total average	
		Mean	%	Mean	%	Mean	%	Mean	%	Mean	%	Mean	%	Mean	%
Agriculture	Before	11644	11	11702	10	13759	15	19566	14	27742	17	6118	6	15089	12
	After	12775	8	16685	13	18567	15	23082	14	37942	20	8183	7	19539	13
Livestock	Before	7858	7.259	10080	9	15670	17	29969	21	22271	13	11531	11	16230	13
	After	22748	14.79	24240	18	18792	15	40063	25	37492	20	18355	15	26948	18
Under story	Before	5390	4.979	5075	4	12623	14	11587	8	9404	6	16909	16	10165	9
	After	22256	14.47	9878	8	30735	25	12762	8	12450	7	21357	18	18240	13
Timber	Before	431	0.398	1400	1	3166	3	1562	1	9000	5	4445	4	3334	3
	After	1181	0.768	3520	3	7000	6	2713	2	12340	7	8618	7	5895	4
Farm total	**Before**	**25323**	**23.39**	**28257**	**24.9**	**45218**	**49.2**	**62684**	**44.484**	**68417**	**41.4**	**39003**	**38**	**44817**	**37**
	After	**58960**	**38.34**	**54323**	**41.4**	**75094**	**59.9**	**78620**	**48.42**	**100224**	**53.4**	**56513**	**46.6**	**70622**	**48**
Labor	Before	1345	1.242	15960	14	7672	8	14125	10	39900	24	23231	23	17039	13
	After	966	0.628	12700	10	6023	5	14271	9	35800	19	23513	19	15546	10
Business	Before	14276	13.19	13760	12	8642	9	2917	2	13540	8	4545	4	9613	8
	After	19758	12.85	10300	8	10604	8	4271	3	9680	5	5491	5	10017	7
Service/ pension	Before	29034	26.82	8800	8	18019	20	23167	16	26000	16	14909	15	19988	17
	After	34603	22.5	9400	7	21698	17	26458	16	28120	15	19303	16	23264	16
Remittance	Before	38276	35.36	46760	41	12358	13	38021	27	17300	10	20909	20	28937	25
	After	39482	25.68	44400	34	11943	10	38750	24	13900	7	16364	14	27473	19
OFF-farm total	**Before**	**82931**	**77**	**85280**	**75**	**46691**	**51**	**78230**	**56**	**96740**	**59**	**63594**	**62**	**75578**	**63**
	After	**94809**	**61.66**	**76800**	**58.6**	**50268**	**40.1**	**83750**	**51.58**	**87500**	**46.6**	**64671**	**53.4**	**76300**	**52**
Total	Before	108254	100	113537	100	91909	100	140914	100	165157	100	102597	100	120395	100
Total	After	153769	100	131123	100	125362	100	162370	100	187724	100	121184	100	146922	100

This study has opened up new opportunities for the hill farmers to pursue banana based and Alnus cardamom system. This is the additional income for the farmers. Between farm and off-farm sources of income, the combined income from all off-farm sources of income has been the largest contributing source, contributing 63 percent before the project and now it is more than half (52%). The out-migration of rural youth resulted in fallowing or abandonment of large tracks of fragile landscape in the study area. This land if utilized effectively through expansion of AF, which would contribute to both carbon sequestration and farm income in the hill slopes of Nepal, and it is expected to reduce the trend of migration (Subedi and Sah 2015; Cedamon et al 2017).

Change in Poverty level

Overall, the study found that the percentage of households below the poverty line dropped from 48 % in 2013 before project implementation to 34 % after the project in 2016. The highest level of poverty drop was observed in Dhamilikuwa, which is from 62 % to 28 % (Table 7). Chaubas have had the highest incidence of poverty, but changed positively over time (67% to 53%). The overall change in reduction in poverty level is significant between the project periods ($p<0.01$). The reduction in poverty is attributed mainly due to promotion of priority understory crops such as banana in Dhamilikuwa and Jita taxar, cardamom at Chaubas, ginger at Mithinkot and tomato at Dhungkharka. The difference in overall change in reduction of poverty is 14% (48% to 34%) (Table 8).

Table 8: Poverty level 'before' and 'after' project

Village	Poverty level (before 2013) (n = 279)**				Poverty level (after 2016) (n = 279)**				Total
	Below poverty		Above poverty		Below poverty		Above poverty		
	No	%	No	%	No	%	No	%	
1. Jita taxar	28	48	30	52	17	29	41	71	58
2. Nalma	14	56	11	44	11	44	14	56	25
3. Dhamilikuwa	33	62	20	38	15	28	38	72	53
4. Mithinkot	15	31	33	69	14	29	34	71	48
5. Dhungkharka	13	26	37	74	11	22	39	78	50
6. Chaubas	37	67	18	33	29	53	26	47	55
Total	140	48	149	52	97	34	192	66	289

*t is significantly different at the 0.05 level, **t is significantly different at the 0.01 level.

Change in food security level

Food security level 'before' and 'after' is presented in Table 8. Before project intervention, 146 households (52%) out of 279 were food sufficient, but now after the project was implemented, this increased to 192 households (69%) (Table 9). The change in food sufficiency level is highly significant ($p<0.001$). The change in food security level is attributed to expansion of priority products in AF.

Table 9: Food security 'before' and 'after' project

Village	Project period	Food security level				
		Up to 3 months	4-6 months	7-9 months	9-12 months	More than 12 months
Jita taxar (n = 58)	Before	3	9	6	10	30
	After	0	6	4	7	41
Nalma (n = 25)	Before	1	3	5	5	11
	After	1	0	4	6	14
Dhamilikuwa (n = 53)	Before	2	8	7	16	20
	After	1	4	6	4	38
Mithinkot (n = 48)	Before	3	3	5	7	30
	After	2	2	4	6	34
Dhungkharka (n = 50)	Before	4	4	3	2	37
	After	2	2	2	5	39
Chaubas (n = 55)	Before	4	17	7	9	18
	After	2	16	6	5	26
Total Before		17	44	33	49	146**
Total After		8	30	26	33	192**

Conclusions

The study was focused to assess the impact of the implementation of five market oriented Agroforestry systems on food security and livelihoods of the action research farmers of the project and draw lessons for future interventions of the agroforestry subsector. Using recalling ('before' and 'after') method, we tried to assess the level of poverty, food security and income change among the participants' households due to project intervention. The analysis suggests that the project helped increase income and reduce poverty among project participants, as well as improve the skills and knowledge of farmers in AF promotion in hills of Nepal.

Overall, it can be concluded that the project activities had no harmful environmental impacts and at the same time, the project had been successful in reducing poverty to a greater extent. This study provides important insights for people of this region, particularly policy-makers in relation to livelihood improvement and poverty reduction in rural mountain communities that depend on available natural resources for their livelihoods.

Lessons learned

- Farmers' skills and capacity needs enhancing to better cope with this changing economic and natural environment
- To retain viable livelihoods, small producers need to move from a focus on production for home consumption and occasional marketing of surpluses towards a more commercial and business orientation where they have the capacity and skills to respond to the ever increasing demands of the market. In order to run their farms as a modern business venture, farmers require the skills and competencies to adapt their farming systems, diversify production and respond to market change.
- Adjust farm-household systems according to the changing market conditions and opportunities. Farmers are working in a more competitive environment where in order to increase their income from farming they need to become more profitable and adaptable to change.

- Farmers should organize into producer groups or associations that can access larger markets and can also be sold locally through organized Saturday weekly market, which was initiated at Dhamilikuwa (Syaule Bazaar).
- The introduction of high yielding legume fodder trees such as *Laucaena, Flemingia* and *Teprosia* spp. with priority understory crops is an important approach for achieving the government's goal of increasing productivity and thereby increasing income of hill farmers.
- Opportunities should also be explored for targeting key institutions with processed AF products (such as banana chips, ginger essential oil, cardamom powder). NGOs and others can provide key linkages for farmers to access these markets, including relevant training on markets.
- Local research groups (LRGs) in all six sites have established savings mechanisms and are in the process of developing cooperatives. The finance available locally should be invested in the development of any of the innovative AF systems being profitable for the farmers.
- The combined 'farm'/ AF resources contributed at least 48 percent compared to baseline (37%) to household economy. This should be an important strategy of the government to sustain people livelihoods in the context of declining labor force and reducing farm productivity.
- Small incentive mechanism (NPR 2500/family) such as planting at least 50 to 100 legume fodder trees hedgerows along terrace risers or on the edge of terraces with understory crop can be rewarded for scaling up and scaling out AF project.

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