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# Factors Influencing the Adoption of Large Cardamom-based Agro-forestry System in the Eastern Hills of Nepal

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## Abstract

*The cardamom-based agroforestry is a traditional production system in the hills and mountains of eastern Nepal. Such system is believed to be ecologically sustainable, socially acceptable and economically viable. Using the agricultural census data of 2011/12, this paper aims to identify the factors influencing the adoption of cardamom-based agroforestry system in the eastern hills of Nepal. Being the censored type sample population, Tobit model has been used. On an average, the households experienced no food shortage for about 9 months, the cultivated land per household was 0.88 hectare and around 77 percent of the total land was under upland category. The results showed that the proportion of the area under upland, age and education level of the household head, the male headed household and distance to road heads and markets were significant variables affecting the adoption of this type of agroforestry system. Farmers might have utilized the upland area for this agroforestry system probably perceiving the economic, social and environmental benefits. For further increasing its adoption so as to get optimal benefits, there is a need to create awareness among the households through trainings, extension and other educational programs. Similarly, the households should be supported in both pre-production and post-harvest related activities. In addition, the constraints on adoption of female headed households should be identified and special programs need to be implemented for increasing the level of adoption. In order to improve the access, the investment should be increased for developing physical infrastructures such as roads and markets.*

**Keywords:** Cardamom-based, Agroforestry, Adoption, Hills, Nepal.

## Introduction

An Agroforestry system is an age old practice of land use and management which started from time immemorial. Although the practice of agroforestry is old, its application as a scientific discipline is relatively new. With the scientific innovation, this discipline has contributed to create diverse, productive, profitable, ecologically sound and sustainable land use systems. This system integrates crops and/or livestock with trees and shrubs to meet the diverse needs of the farm households. The benefit that the people get through diversification of income sources, increased biological production, enhanced water quality, and improved habitat for both humans and wildlife. The direct benefit from these systems include food, fuel wood, fodder, timber and medicines while indirect benefit include supplementing soil organic matter and nutrients, helping to control soil erosion and conserving water. The Himalayan alder (*Alnus nepalensis*) based agroforestry is an accepted form of land management system in the hills and mountains. In addition to provide economic benefit, it also supplies nutrients such as nitrogen and phosphorus also to the plantations or croplands located downstream[1].

Agroforestry is a dynamic, ecologically-based natural resources management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels[2]. It is also evident from various research and studies that agroforestry provides cost-effective alternatives that increase farm profits and protects the environment within rural settings[3-5]. In such a scenario, agroforestry practices that integrate trees, crops and animal components are emerging as part of an intensive land management approach focused on sustainable resource use and production within given economic, social and environmental settings[6,7].

Agroforestry is a collective name for land use systems in which woody perennials are grown in association with herbaceous plants and/or livestock in a spatial arrangement or temporal sequence. In agroforestry systems there are both ecological and economical interactions between the various components of system[8].

In the recent days, agroforestry research and development has also come to view agroforestry as a landscape level system which can play significant roles in provision of environmental services and livelihoods for communities. While an ‘ecosystems approach’ to forests, as part of wider social landscapes and land use patterns, has recently become better appreciated[9], and an accepted part of Convention on Biological Diversity, yet, at the same time, detailed research has shown that traditional societies have long managed and transformed their wider landscapes as integrated wholes. In sum, agroforestry is viewed both as an approach to land use and as a set of integrated land use practices[10].

Nepal has three main ecological regions – mountains, mid-hills and Terai -the low lying plains. The mid-hills shares 44.2 percent of Nepal's population, 66 percent of whom derive their livelihood largely from a combination of agriculture and forestry. The hill farming system in Nepal demonstrates a complementary relationship among crops, trees and livestock components of agroforestry. Assorted species of trees and shrubs grown on farms are an integral component of local economies[11]. In addition to supplying human needs, crops and trees supply feed, fodder, and bedding materials (litter) to livestock. Animals provide manure which supplements the nutrients required for crops and trees.

Agroforestry systems practiced in Nepal can be divided into two main categories: farm–based and forest-based practices. The farm-based practices are home gardens, planting trees on and around agriculture fields, tree wood lots and cash crops under shade trees or crops and commodities inter-cropped with commercial trees. The forest-based practices involve specific agricultural practices associated with forests, The agroforestry systems practiced varies with the ecological zones and within the ecological zones these systems vary locally by elevations, communities and societal values and norms. The subsistence farmers in the hills of Nepal have adopted many types of agroforestry practices as per their needs and ecological settings. Hill farming system are, in fact, based on strategies to manage forest, pasture, and arable lands simultaneously, and in an integrated fashion, to obtain essential items of food, shelter, and clothing[12].

**Importance of Agroforestry:** The role and importance of agroforestry to people, and their livelihood and ecosystem are immense as revealed from the past studies. Agroforestry plays a vital role in achieving sustainability in the hills farming system[13,14]. It can also contribute to increasing agricultural productivity through recycling nutrient, reducing soil erosion, and improving soil fertility[15]. The research has shown that agroforestry can offer huge benefits both economically and environmentally, produces more output and proved to be more sustainable than forestry or agricultural production alone. Furthermore, agroforestry also has promising potentials for reducing deforestation while increasing food, fodder, and fuel wood production[16,17].

Soil and land degradation are considered among the major challenges towards global efforts of achieving sustainable development. This has threatened the livelihood of millions of poor and marginalized population who occupy such resources. For over the last four decades, this issue has been addressed by considering the multi-functionality of the agroforestry systems. Over the years, research and development in agroforestry has emphasized and focused on their functioning, diversification from local, landscape to regional level, development of local knowledge systems, and valuation of economic and environmental services they provide[18].

Agroforestry can support the livelihood of farmers by offering multiple alternatives and opportunities for increasing farm productivity and incomes. This also provides productive and protective functions to the ecosystems while protecting the natural environment. Its scope is further elaborated in the form of sustainability enhancing practice that combines the best characteristic properties of forestry and agriculture. In recent years, this practice has been fully recognized as an applied science and has been instrumental in ensuring food security, reducing poverty and enhancing ecosystem resilience. Therefore, strengthening linkages between knowledge systems using "community" participatory management approaches is now seen as critical for sustainable forestry and agroforestry systems[19,20].

The traditional agroforestry systems existed in the mountains were very close to natural ecosystems in terms of providing various forms of ecosystem goods and services. Those were considered as the sources of biodiversity and, providers of different services. They offer provisioning services (food, fibre, water, regulating services (climate regulation, water purification, and carbon sequestration) supporting services (nutrient cycling, soil formation) and cultural services (recreation, educational and ecotourism) for the well being of the people and society. Moreover, the integration of large cardamom like cash crop in the system offered higher economic return there by contributing to poverty alleviation, and promoting human wellbeing. Such agroforestry systems are unique examples of the ecological sustenance and economic viability for the mountain people while providing goods and services for the downstream users[21].

Large cardamom-based agroforestry is a common practice in the hills of eastern Nepal. Cardamom is a shade loving plant and generally cultivated under shade trees; *Alnus* is used for shade in most new plantations. There is no rotation length as such for large cardamom plants in the traditional practice, and many old plantations are the least productive[22]. Himalayan alder is a deciduous, nitrogen fixing and fast-growing tree, which is most commonly under planted with large cardamom. In addition to providing shade, it is also used for fuel wood and timber. The old trees are cut and young plants coming up are allowed to grow in cyclic order. The quick decomposing leaf litter of *A. nepalensis* also supplements the nutrients required to the cardamom plants. As per the finding of research, the nitrogen added to the soil t is as high as 249 kg/ha. Large cardamom plants thrive well in a moist soil, which is maintained by water diverted from seasonal springs on the upper slopes. The system is well suited to conserving soil, water and tree cover of the characteristically steep slopes of the hills and mountain region. In addition, the management inputs required for growing cardamom are relatively low resulting into higher financial return compared with rice or maize. The shade trees used in the system are also a major source of fuel, fodder and timber[23].

The cardamom grown under the shade of alder had positive impact on cardamom yield compared with other tree species. This motivated the farmers to remove other tree species although they yield high quality timber than alder[22]. It is considered to be a low volume and high value commodity which do not require intensive labor for its cultivation. It is also non-perishable commodity compared with other agricultural crops. The nitrogen fixation capacity of alder as root nodule, and high voluminous foliose of cardamom and alder enrich the soil. Large cardamom agro forestry is almost a closed system of production which does not heavily depend on external inputs except human labor. Energy fixation, storage, net allocation in agro-economic yield and heat release from the alder-cardamom forest is higher than in any other type of tree-cardamom combination[22]. In general, the yield of crop in open field production system is more than agro forestry system which is not true in case of cardamom-based agro forestry system. Removal of other tree species and under-shrub plant reduced the plant diversity, which should have to be more vulnerable, but in order to create agricultural system, ecologically and economically sound, above-mentioned facts need to be considered[24].

The available evidences suggest that agroforestry is more profitable than forestry or crops alone. The principle of agroforestry could also be applied well in the development of Non-Timber Forest Products[12]. Large cardamom farming is one of the main sources of cash income for the small farmers of the mid-hills in Nepal. The numbers of farm families in large cardamom cultivation in Nepal are around eighty 80 thousand. The net income of the farmers involved in cardamom cultivation is significantly higher than that of competing crops such as paddy, maize, wheat and fresh vegetables[25].

**Agroforetry Related Policies and Strategies:** The Government of Nepal has taken initiatives to promote agroforestry through policies, strategies and programs in recent years considering it as an age old tradition. In this regard, the Forestry Sector Policy 2000 mentioned the agroforestry related aspects in various forms[26]. The long-term objective as envisaged by this policy was to support in meeting the basic needs of the people for fuel wood, timber, fodder, and other forestry products on a sustained basis and contribute to increasing food production through effective interaction between forestry and farming practices.

In order to meet those objectives, certain strategies related to agroforestry were formulated which include: i. Promotion of agroforestry techniques and practices such as the intercropping of fruit trees with medicinal and aromatic plants as well as adoption of other multiple land-use techniques to various farming systems and commercial plantations; ii. Management of livestock based on the amount of fodder production and improvement of highland pasture so as to improve forest management and increase the production of fodder by community efforts; iii. Conduct research on multipurpose trees, bamboo, shrubs, medicinal and aromatic plants, and grasses, in order to identify improved stocks for planting; iv. Design immediately an integrated national forage development program and develop an appropriate institutional mechanism for its implementation in order to complement the Master Plan for the Forestry Sector and the Agriculture Perspective Plan; and Co-ordinate research on and development of farming systems.

In relation to the above strategies, certain programs and projects were implemented on agroforestry in a limited scale.

The Forestry Policy 2015 has envisioned contributing to local and national prosperity through the sustainable management of forests, biodiversity, and watersheds[27]. Accordingly, various policies, strategies and working policies have been prepared to attain this vision. One of the policies states the integrated management of watershed areas for increasing land productivity through protecting land and water. The working policies related to agroforestry under this policy are the development and transfer of technology on low cost soil and watershed protection and agro-forestry system through action research and the implementation of soil conservation program by harmonizing between forest and agricultural system for contributing to food production and food security. Another policy mentions the creation of green employment through promoting forest- based enterprises, diversification of production and value addition through marketing. The working policy related to agro-forestry is to encourage the investment of private sector by availing forest area on lease (leasehold forest) for developing agro-forestry, eco-tourism and producing forest-based raw material.

The Forestry Sector Strategy of 2016 has emphasized the promotion of agroforestry in existing privately owned farmland and strengthening research and information generation in the agroforestry practices in addition to those conventionally pursued in forestry[28].

The importance of agroforestry to the economy and livelihood of the people has been realized recently by the policy makers and relevant stakeholders in Nepal. In this regard, the Ministry of Forests and Soil Conservation and Ministry of Agricultural Development in March 2015 have agreed to develop a National Agroforestry Policy for more focused and coordinated strategy and approach to promote agroforestry among various actors and stakeholders[29].

**Review of Adoption of Agroforestry Systems:** In the past, different types of models have been used to explain adoption decisions of innovations, technologies and practices by the households. However, no single model can embrace and explain all aspects of adoption and the attitude and understanding of smallholder farmers towards technologies. Rogers developed the adoption and diffusion of innovations theory, which has been widely used to identify factors that influence decisions to adopt or reject an innovation and defined an innovation as a "new idea, practice or object that is perceived as new by an individual or other unit of adoption" and said that the perceived newness of the idea for the individual is what determines their reaction to it[30]. In this regard, the relevant literatures on the factors affecting the adoption of agroforestry practices in Nepal and elsewhere have been reviewed and presented below.

A study was carried out in Nepal to identify the factors affecting the adoption of agroforestry system among project and non-project households. The results showed that male membership in local Non-governmental Organizations (NGOs, livestock population, level of education of female and farmer's positive perception towards agroforestry had significant positive effects, while the number of children below 5 years of age, number of males aged 10–59 years, male education, female's NGO membership, and respondents' age had significant negative effects on adoption of agroforestry among project households. Among non-project households, those with male membership to local NGOs and more livestock were found more likely to adopt, while the households headed by males were less likely to adopt agroforestry[31].

A review of adoption of agricultural and forestry technology by small holders in the Philippines revealed that the five categories of variables namely preferences, resource endowments, market incentives, biophysical factors, and risk and uncertainty explained technology adoption[32]. Similarly, a review of 69 case studies of the world on community forests revealed that the major variables influencing the success of community forestry were tenure security, clear ownership of the land, congruence between biophysical and socioeconomic boundaries of the resources, effective enforcement of rules and regulations, capability of local organization, anticipation of benefit and monitoring etc[33].

Studies conducted in Malawi[34] and Kenya[35] showed that the female-headed household did not adopt agroforestry technology compared to the male-headed farm household. Access to information on agroforestry, training opportunities, good quality seeds, and property rights on land, size of available land, flexibility and compatibility of agroforestry to existing farming systems among others were important factors affecting adoption of agroforestry[36]. Another study showed that the farmers who are involved in on-farm experimentation of agroforestry technologies with the researchers are more likely to adopt than those who are not involved[37, 38]. It was also recognized that the information and knowledge about a given technology as key to adoption of agricultural practices, especially ones associated with ecological benefits[38].

A study carried out in Zimbabwe revealed that the socio-economic factors such as age, years in education, and land size influenced adoption of agroforestry technologies. The likelihood to adopt agroforestry technologies was inversely related to age while positively related with the education level of the household head and the size of the land holding[39]. The adoption of traditional gum Arabic agroforestry system in Sudan was influenced by farm-specific, socio-economic and market related variables. It was revealed that farmers with less commercialization, access to credit, less fragmented land, more education, high gum Arabic farm gate price, located away from the markets, and with more years of experience in farming were more likely to practice the traditional gum Arabic agroforestry system. In contrast, the allocation of more working days for commercial sole crops production, more fragmented land, and higher commercialization index reduces the probability of gum Arabic agroforestry adoption[40].

A study on the factors affecting adoption of an agroforestry-based land management practice in the Dhanusha District of Nepal was conducted. The study found that farm size, availability of irrigation water, education of household heads, agricultural labor force, frequency of visits by extension workers, expenditure on farm inputs purchase, household's experience in agroforestry, and distance from home to government forest were major factors significantly affecting adoption[41]. Similar type of study carried out in Uganda showed that sex and age of the household head, household size, education level, distance to the market, group membership, access to credit, number of extension visits and presence of vermines were significant variables affecting the adoption of agroforestry[42].

The review of past works in Nepal and elsewhere on agroforstry adoption revealed that various social, environmental, economic and even cultural factors were important for influencing the level and intensity of the adoption of agroforestry system. Hence, this paper aims to assess the level of large cardamom based agroforestry adoption and identify the factors influencing this system in two hilly districts of eastern Nepal where cardamom-based agroforestry system is dominant.

## Methodology

**Data Sources:** This study has used the latest agricultural census data for 2011/12 collected by the Central Bureau of Statistics (CBS), Government of Nepal. Two districts in the eastern development regions namely Taplejung and Panchthar were purposively selected because of the existence of cardamom-based agroforestry system. The basic sampling methodology used was a two-stage area sampling, which is as follows: In the first stage, selection of a stratified sample of enumeration areas (EAs) with probability proportional to the expected number of holdings (stratified PPS sampling); In the second stage, within selected EAs, the selection of a sample agricultural holding using stratified systematic random sampling. The EAs were defined as wards (smallest administrative and political units) of Village Development Committees that contained less than 25 holdings or may be more than 25 but less than or equal to 30 holdings if wards are combined. Between 20 and 30 holdings were selected in each selected EA[43]. For this study, 18 EA from Taplejeung (number from 1 to 18) with holdings of 430 and 22 EA from Panchthar (number from 1 to 22) with holdings of 516 were selected with a total sample size of 946 agricultural holdings.

**Analytical Methods:** Many socio-economic, demographic and environmental features of farm households affect the area allocation under large cardamom based agroforestry system in the study area. In order to analyze the patterns and extent of area allocation, the limited dependent variable model also known as Tobit model is adopted. This is represented using an index function approach as below

$$V_i^* = \beta^T X_i + \varepsilon_I \quad (1)$$

$$V_i = 0 \quad \text{if } V_i^* \leq 0 \quad (2)$$

$$V_i = V_i^* \quad \text{if } V_i^* > 0 \quad (3)$$

where $V_i$, a limited dependent variable, is the perceived area under large cardamom-based agroforestry; $V_i^*$ is an underlying latent variable that indexes the area allocation; X is the vector of socio-economic, demographic and environmental characteristics of the farm household, $\beta^T$ is a vector of parameters to be estimated; and $\varepsilon_i$ is an error term. The Tobit model has an advantage in that its coefficients can be further disaggregated to determine the effects of a change in the $i^{th}$ variable on change in the probability and intensity of area allocation for this system.

The households that have allocated area for large cardamom, private forest (trees) and fodder trees plantation are considered in this study. Since the sample population's proportion of total area allocation to this AF system ranges from zero to one, the OLS estimation of the censored regression model generates biased and inconsistent parameter estimates. Therefore, the Tobit model was used to examine the factors influencing the household's decision to allocate area under this AF system. The STATA econometric package was used to derive the MLE estimates and marginal effects of Tobit regression analysis. The sign of the marginal effect coefficient indicates the directional effect of each individual variable, while the magnitude of effect can be judged from the value of the estimated coefficient. The value of marginal effect coefficient implies the changes in percentage of household's decision to allocate area for this AF system brought about by one unit change in explanatory variable *ceteris paribus*. The t-statistic was used to judge the significance of each explanatory variable while the Log-likelihood Ratio (LR) test was employed to judge the effect of all variables included in the model (overall fit of the model) on the proportion of area allocated for this AF system. The LR is computed as

$$W = -2\ (\log L_o - \log L_{Max}) \quad (4)$$

Where: Log $L_o$ = log likelihood function of the fitted model when all coefficients except the constant are constrained to 0; Log $L_{max}$ = log likelihood function of the fitted model which includes all the parameters constant terms ($\beta_1$) and all other parameters ($\beta_2$, $\beta_3$,..$\beta_k$).

## Results and Discussion

**Area and Production in Nepal:** Large Cardamom (*Amomum sabulatum*, Roxb.) is a perennial herbaceous spice crop which is native to India, Pakistan, Nepal, and Bhutan. It is world's third-most expensive commodity after saffron and vanilla. It is indigenous to moist deciduous and semi evergreen forests. This is mainly grown in the sub-Himalayan region of India and Nepal between an elevation of 600 to 2000 mean sea levels where annual rainfall is between 1,500 to 2,500 mm and the temperature varies from 8° C to 20° C[25]. It has been listed as one of the most potential crop for export under Nepal Trade Integration Strategy 2010[44].

It is climate sensitive crop as it strictly requires cool, moist soil, humid under shaded area, and a range of 700-2100 meter from above sea level for better performance[45].

It is reported to be grown in 40 districts of Nepal which occupy 14,847 hectares with productive area of 11,501 hectares and produces 5,225 tons with productivity of 0.45 tons per hectare (Table-1). The share of the eastern development region in area and production is over 90 percent. Eastern Region produces 4,907 tons which is 93.9 percent of total production[46].

**Table-1**
**Area, production and productivity of cardamom in Nepal**

| Year | Area (ha) | Production (ton) | Productivity (t/ha) |
|---|---|---|---|
| 1994/95 | 8782 | 3010 | 0.34 |
| 2000/01 | 10668 | 6080 | 0.57 |
| 2005/06 | 11498 | 6647 | 0.58 |
| 2009/10 | 11766 | 5232 | 0.44 |
| 2010/11 | 12584 | 5517 | 0.44 |
| 2011/12 | 11665 | 6026 | 0.52 |
| 2012/13 | 11434 | 5753 | 0.50 |
| 2013/14 | 11501 | 5225 | 0.45 |

**Area and Production in the Study Area:** In Taplejung and Panchthar districts, 33.3 percent and 26.2 percent agricultural holdings reported the cultivation of large cardamom and the cardamom area was 18.5 percent and 8.2 percent of the total area of holding, respectively[43]. Available data indicate that on an average per annum increase in cardamom planted area was 3.2 percent in Taplejung and 3.1 percent in Panchthar between 1997/98 to 2013/14 (Table 2). However, the productivity of cardamom declined over the years. This may be due to the incidence of viral diseases like *Chirke* and *Furkey* and poor soil conditions. Out of the total national productive area and production, these two districts share about 45 percent and 42 percent, respectively.

The large cardamom is cultivated in almost every Village Development Committees (VDCs) of Panchthar and Taplejung districts. It can be grown in both fertile and unproductive marginal lands irrespective of irrigation facilities. It is mostly grown under the shade of Alder (*Alnus nepalensis*) trees. Alder enriched soil is considered to be appropriate for large cardamom due to high nutrient content and shade loving nature. In recent years, the cultivation of large cardamom has been expanding and replacing areas suitable for growing main staple crops like rice and maize due to higher profitability.

**Total Area and Their Usage:** The average size of land holding was 0.88 ha which is higher in Taplejung compared with Panchthar. The analysis showed that the average area under temporary crops and permanent crops was 0.57 and 0.19 ha, respectively. On an average, 77.4 percent of the total area of holding belongs to upland (*Bari*) category, area under private forest, cardamom, fodder trees was 0.067 ha, 0.11 ha and 0.013 ha, respectively. About 8.6 percent of the total area was allocated for cardamom alone while 14.9 percent of the total area was allocated for cardamom, private forest and fodder plantation (Table-3).

**Socio-demographic Characteristics:** There was a negative population growth in Taplejung (-0.94%) and Panchthar (-0.39%) districts between 2001 to 2010[47]. On an average the age of the household head, family size, and education level of the household head was 47 years, 4.7 persons, and 3 years of schooling. The economically active population constituted about 64 percent of the total population. The dependency ratio, which is defined as the ratio of the dependent population (less than 15 years and more than 60 years) to the working age population was 0.57. It means a single working age population has to support 0.57 number of other population with regard to supporting livelihood (Table-4).

**Table-2**
**Area, production and productivity of cardamom in Taplejung and Panchthar districts**

| Year | Taplejung | | | | Panchthar | | | |
|---|---|---|---|---|---|---|---|---|
| | Planted area | Productive area | Production | Productivity | Planted area | Productive area | Production | Productivity |
| 1997 | 2575 | na | 1854 | 0.72 | 107 | na | 747 | 0.67 |
| 2003 | 3450 | na | 1711 | 0.50 | 1560 | na | 986 | 0.63 |
| 2005 | 3647 | 3324 | 2118 | 0.64 | 1590 | 1576 | 1016 | 0.64 |
| 2006 | 3647 | 3386 | 2165 | 0.64 | 1606 | 1590 | 1038 | 0.65 |
| 2007 | 3647 | 3386 | 2165 | 0.64 | 1605 | 1595 | 810 | 0.51 |
| 2008 | 4813 | 3850 | 2021 | 0.52 | 1615 | 1605 | 722 | 0.45 |
| 2009 | 3900 | 2925 | 1316 | 0.45 | 1615 | 1605 | 654 | 0.41 |
| 2010 | 4280 | 3900 | 1755 | 0.45 | 1615 | 1500 | 638 | 0.43 |
| 2011 | 3900 | 2925 | 1755 | 0.60 | 1615 | 1500 | 630 | 0.42 |
| 2012 | 3915 | 2952 | 1802 | 0.61 | 1620 | 1506 | 671 | 0.45 |
| 2013 | 4150 | 3112 | 1680 | 0.54 | 2081 | 1687 | 658 | 0.39 |

Note: Area in hectares; production in tones and productivity in tones per hectare, na – not available, Source: MoAD various years.

**Table-3**
**Area of holding and usage**

| Variables | Average | Taplejung | Panchthar | Difference between Districts (Probability level based on t Statistic) |
|---|---|---|---|---|
| Total Area of Holding (ha) | 0.885 | 0.986 | 0.799 | 0.005 |
| Area under Temporary Crops (ha) | 0.568 | 0.649 | 0.499 | 0.001 |
| Area under Permanent Crops (ha) | 0.187 | 0.200 | 0.177 | Non-significant |
| Percentage of Upland (Bari) | 77.4 | 70.3 | 83.4 | 0.000 |
| Area under Private forest (ha) | 0.067 | 0.089 | 0.049 | 0.006 |
| Area under Cardamom (ha) | 0.108 | 0.177 | 0.051 | 0.000 |
| Area under fodder trees (ha) | 0.013 | 0.010 | 0.015 | Non-significant |
| Percentage of total area under cardamom | 8.6 | 12.9 | 5.00 | 0.000 |
| Percentage of total area under cardamom, forest and fodder (combined) | 14.9 | 19.3 | 11.3 | 0.000 |

**Table-4**
**Socio-demographic characteristics of households**

| Variables | Average | Taplejung | Panchthar | Difference between Districts (Probability level based on *t* Statistic) |
|---|---|---|---|---|
| Age of the Household Head (years) | 46.7 | 47.1 | 46.3 | Non-significant |
| Family Size (no. of persons) | 4.7 | 5.0 | 4.6 | 0.036 |
| Economically active persons (15 to 59 years) | 3.0 | 3.02 | 2.98 | Non-significant |
| Food insufficient months from own production | 3.3 | 2.7 | 3.80 | 0.000 |
| Percentage of Female Headed Households | 21.3 | 24.4 | 18.7 | 0.000 |
| Education of household head (no. of years of schooling) | 3.4 | 3.2 | 3.7 | 0.036 |
| No. of Livestock | 6.6 | 7.4 | 6.0 | 0.007 |
| Distance from nearest road head (walking in minutes) | 132 | 182 | 91 | 0.000 |

**Factors Affecting Adoption in the Study Area:** The result of the Tobit regression (Table-5) showed that the proportion of the upland (*Bari* land), age and education level of the household head and the male headed household were significant at 1 percent probability level while the distance to road heads/ markets was significant at 10 percent probability level. All these variables contributed positively to the area allocation to cardamom based agroforestry in the study area. The likelihood ratio was found highly significant which implies that area allocated to the agroforestry was explained by the significant explanatory variables.

The higher the proportional area under upland owned by the household, the more the adoption of this type of AF system. The result showed that one percent increase in the upland area would result into the probability of an increase in area under this AF system by 7.3 percent. This finding is consistent with the findings carried out in the hills of Nepal[31]. The sex of the household head was an important factor influencing for the adoption and allocating area for this type of system. The result showed that the probability of area under this AF system would be higher (4.80 percent) for male headed households than the female headed ones. This is consistent with the findings in Malawi[34] and Uganda[42].

The age of the household head was positive and significant implying that the experienced farmers would adopt this system compared to the non-experienced one. Probably the younger ones look for other types of non-farm work and not prepared to utilize upland area for this type of AF system. The result showed that one year increase in the age of the household head would increase the probability of adopting this AF system by 0.17 percent. The education level of the household head was also a decisive factor for area allocation under this AF system. This is consistent with the findings of Uganda[42]. This implies that educated household would understand the economic, social and environmental benefit of utilizing upland area for cardamom-based AF system and allocate area accordingly. When all other factors are held constant, increasing farmer's education by one year increases the probability that a farmer would adopt this AF system by 0.79 percent. This is consistent with the findings of Nepal Terai[41] and of Sudan[40].

The distance to road heads/markets of the household was also an important variable. It was revealed that the households residing away from the road heads/markets would allocate more area for this system compared to the households residing near to road heads. Households' location at a walking distance of 1.5 hours from road heads would result into an increase in the probability of area under AF system by 0.7 percent. This is consistent with the findings of Sudan[40].

The other variables such as family size, no. of livestock population, and dummy for ownership of the land and household members having non-farm occupation were not significant variables affecting the adopting of cardamom-based AF system.

**Table-5**
**Factors influencing the adoption of agroforestry in eastern hills of Nepal**

| Variable | Marginal Effects Coefficient (a) |
|---|---|
| Constant | -0.2027 |
| Household head Dummy | 0.0479*** |
| Age of the Household Head | 0.0017*** |
| Family Size | 0.00005 |
| Proportion of Upland | 0.0725*** |
| Distance to markets (minute) | 0.00007* |
| Education level of Household Head | 0.0079*** |
| No. of Livestock | -0.0001 |
| Ownership dummy for land | -0.0024 |
| Other occupation dummy | 0.0266 |
| Likelihood Ratio (Chi-square) | -420.85*** |

*** and* indicate significant at 1 percent and 10 percent probability level. (a)Marginal effects refers to the partial derivatives of the expected value with respect to the vector of characteristics. They are computed at the means of the Xs.

## Conclusion

The cardamom-based agro-forestry system in the study area seemed to be very important in terms of supply of ecosystem goods and services. This system has also exhibited ways and means to balancing short-term needs of the people (food, fibre etc.) with long term goal of environmental conservation and management. Cardamom-based agroforestry is an age old tradition of the people living in the hills and mountains of eastern region. Such systems are considered to be unique in the mountain and hills in terms of ecological sustainability and economic viability.

Considering its importance, the Government of Nepal through various policies, strategies, plans and programs have focused its promotion and development. This AF system has expanded in 40 mountain and hilly districts of Nepal. However, the study districts account 45 percent of the total national productive area and 42 percent of total national production. The planted area under cardamom has increased by slightly above 3 percent per annum in these districts between 1997/98 to 2013/14. However, the productivity of cardamom declined over the years mainly due to increasing incidence of viral diseases like *Chirke* and *Furkey*.

In the study districts, 77 percent of the total area is under the upland category and the area allocated to this AF system was about 15 percent of the total area. The economically active population constituted about 64 percent of the total population. A Tobit model was used to identify the factors influencing the adoption of this AF system. It was revealed from the result that the proportion of the upland area, age and education level of the household head, the male headed household and distance to road heads/markets were significant factors influencing adoption. Farmers have rationally utilized the upland area for this type of system probably perceiving both the economic and environmental benefits of this system rather than considering the production of annual cereal crops.

The policy implication of this result would be to create further awareness about the importance of this system through trainings and extension and environmental education programs to the members of the households. Similarly, the households need to be supported in pre-production and post-production aspects through monetary and non-monetary measures. In addition, the constraints on adoption should be identified for the female headed households and special attention should be given in removing such constraints so that adoption could be increased. The investment should also be increased for developing quality physical infrastructures such as roads, markets and storage structures to support production and marketing of large cardamom in the study districts.

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## References


1. Singh S.P. (2002). Balancing the approaches of environmental conservation by considering ecosystem services as well as biodiversity. *Current Science*, 82, 1331-1335.
2. ICRAF (2006). World Agroforestry Centre. Southeast Asia web site, http://www.worldagroforestrycentre.org/sea
3. Brandle J.R., Johnson B.B. and Akeson T. (1992). Field Windbreaks: Are They Economical?. *Journal of Production Agriculture,* 5, 393-398.
4. Clason T.R. (1995). Economic Implications of Silvi-pastures on Southern pine Plantations. *Agroforestry System,* 29, 227-238.
5. Kurtz W.B. (2000). Economics and Policy of Agroforestry. In: Agroforestry: An Integrated Science and Practice, Reitveld, W. and H.E. Garrett, eds., American Society of Agronomy, Madison, WI., 321-360.
6. Louise E., James P. and Buck L.E. (2000). Development of Agroforestry as an Integrated Land Use Management Strategy. Garrett N H E, Rietveld W.J and Fisher R F (eds.) North American agroforestry: An integrated science and practice, American Society of Agronomy, Madison, WI, 1-29.
7. Vaast P. and Somarriba E. (2014). Trade-offs Between Crop Intensification and Ecosystem Services:

   the Role of Agroforestry in Cocoa Cultivation. *Agroforestry Systems*, 88, 947-956.
8. Nair P.K.R. (1993). An Introduction to Agroforestry. Kluwer Academic Publishers, The Netherlands.
9. Sayer J.A. and Maginnis S. (2005). Forests in Landscapes: Expanding Horizons for Ecosystem Forestry. J.A. Sayer & S. Maginnis, eds., Forests in landscapes. Ecosystems approaches to sustainability, London, Earthscan, 257.
10. Sinclair F.A. (1999). A General Classification of Agroforestry Practice. *Agroforestry Systems,* 46, 161-180.
11. Thapa G.B. and Paudel G.S. (2000). Evaluation of the Livestock Carrying Capacity of Land Resources in the Hills of Nepal Based on Total Digestive Nutrient Analysis. *Agriculture, Ecosystems and Environment*,78, 223-235.
12. Amatya S.M. (1999). Opportunities for Agroforestry in Nepal. *Nepal Journal of Science and Technology*, 1, 63-70.
13. Carson B. (1992). The Land, the Farmer and the Future: A Soil Fertility Management Strategies for Nepal. ICIMOD Occasional Paper, No. 2.1, ICIMOD, Kathmandu Nepal.
14. Yadav Y. (1992). Farming-forestry-livestock Linkages: A Component of Mountain Farmers' Strategies (Nepal). Jodha N. S., Banskota M., Partap T. (eds.) Sustainable Mountain Agriculture, Perspectives and Issues, 1, Oxford and IBH Publishing Co. Ltd, New Delhi.
15. Kang B.T. and Akinnifesi F.K. (2000). Agroforestry as Alternative Land-use Production System for the Tropics. *Natural Resources Forum,* 24, 137-151.
16. Benge M.D. (1987). Multipurpose Use of Contour Hedgerows in the Highland Regions. *World Animal Review,* 64, 31-39.
17. Young A. (1997). The Effectiveness of Contour Hedgerows for Soil and Water Conservation. *Agroforestry Forum*, 8 (4), 2–4.
18. Beer J., Ibrahim M. and Sinclair F. (2005). The History of Future Agroforestry Research and Development: Policy Impacts and Needs. Mery G, Alfaro R, Kanninen M, Lobovikov M (eds.). Forests in the Global Balance - Changing Paradigms. IUFRO World Series, 17, 151-160.
19. Adhikari B., Williams F. and Lovett J.C. (2007). Local Benefits from Community Forests in the Middle Hills of Nepal. *Forest Policy and Economics*, 9, 464-478.
20. Dhakal B., Bigsby H.R. and Cullen R. (2007). The Link Between Community Forestry Policies and Poverty and Unemployment in rRural Nepal. *Mountain Research and Development*, 27, 32-39
21. Sharma R., Xu J. and Sharma G. (2007). Traditional Agroforestry in the Eastern Himalayan Region: Land Management System Supporting Ecosystem Services. *Tropical Ecology*, 48(2), 189-200.
22. Sharma G., Sharma E., Sharma R. and Singh K.K. (2002). Performance of an Age Series of *Alnus*–Cardamom Plantations in the Sikkim Himalaya: Productivity, Energetics and Efficiencies. *Annals of Botany*, 89, 261-272.
23. Singh K.A., Rai R.N., Patiram and Bhutia D.T. (1989). Large cardamom (*Amomum subulatum* Roxb.) Plantation — An Age Old Agroforestry System in Eastern Himalayas. *Agroforestry system*, 9(3), 241-257.
24. Odum H.T. (2007). Environment, Power, and Society for the Twenty-First Century : the hierarchy of energy. NY: Columbia University Press, 418.
25. MoAD (2015). Trade Flow Analysis of Cardamom in Eastern Region. Ministry of Agricultural Development, Singh Durbar, Kathmandu.
26. MoFSC (2000). Forestry Sector Policy 2000. Ministry of Forests and Soil Conservation Singh Durbar, Kathmandu.
27. MoFSC (2015). Forestry Policy 2015. Ministry of Forests and Soil Conservation, Singh Durbar,

   Kathmandu.
28. MoFSC (2016). Forestry Sector Strategy. Ministry of Forests and Soil Conservation, Singh Durbar, Kathmandu.
29. ANSAB (2015). Kathmandu Declaration on Agroforestry. Asia Network on Sustainable Agricultural Bioresources

(ANSAB), http://www.ansab.org/publication/kathmandu-declaration-on-agroforestry/

**30.** Rogers E.M. (1995). Diffusion of Innovations. 4th ed., New York, USA: The Free Press.

**31.** Neupane R.P., Sharma K.R. and Thapa G.B. (2002). Adoption of Agroforestry in the Hills of Nepal: A Logistic Regression Analysis. *Agricultural Systems*, 72, 177-196.

**32.** Pattanayak S. and Mercer D.E. (1998). Valuing Soil Conservation Benefits of Agroforestry: Contour Hedgerows in the Eastern Visayas, Philippines. *Agricultural Economics,* 18, 31-46.

**33.** Pagdee A., Kim Y.S. and Daugherty P.J. (2006). What Makes Community Forest Management Successful: A Meta-study from Community Forests Throughout the World. *Society and Natural Resources,* 19, 33-52.

**34.** Thangata P.H. and Alavalapati J.R.R. (2003). Agroforestry Adoption in Southern Malawi: The Case of Mixed Intercropping of *Gliricidia sepium* and Maize. *Agricultural Systems*, 78, 57-71.

**35.** Sanchez P.A. and Jama B.A. (2002). Soil Fertility Replenishment Takes off in East and Southern Africa. Vanlauwe B, Diels J, Sanginga N, Merckx R (eds.), Integrated Plant Nutrient Management in Sub-Saharan Africa, CAB International, Wallingford, UK., 23-45.

**36.** Place F. and Dewees P. (1999). Policies and Incentives for the Adoption of Improved Fallows. *Agroforestry Systems*, 47, 323-343.

**37.** Phiri et. al. (2004). Who is Using the New Technology? The Association of Wealth Status and Gender with the Planting of Improved Tree Fallows in Eastern Province, Zambia. *Agricultural Systems,* 79(2), 131-144.

**38.** Keil A, Zeller M. and Franzel S. (2005). Improved Tree Fallows in Smallholder Maize Production in Zambia: Do Initial Testers Adopt the Technology?. *Agroforestry Systems*, 64, 225-236.

**39.** Mutambara J., Dube I.V. and Mvumi B.M. (2012). Agroforestry Technologies Involving Fodder Production and Implication on Livelihood of Smallholder Livestock Farmers in Zimbabwe. A Case Study of Goromonzi District. *Livestock Research for Rural Development*, 24(11), http://www.lrrd.org/lrrd24/11/muta24210.html.

**40.** Gibreel T.M. (2013). Crop Commercialization and Adoption of Gum-arabic Agroforestry and Their Effect on Farming System in Western Sudan. *Agroforestry Systems,* 87(2), 311-318.

**41.** Dhakal A., Cockfield G. and Maraseni T.N. (2015). Deriving an index of adoption rate and assessing factors affecting adoption of an agroforestry-based farming system in Dhanusha District, Nepal. *Agroforestry Systems*, 89(4), 645-661.

**42.** Basamba et. al. (2016). Enhancing Adoption of Agroforestry in the Eastern Agro-ecological Zone of Uganda. *International Journal of Ecological Science and Environmental Engineering*, 3(1), 20-30.

**43.** CBS (2013). National sample census of agriculture Nepal 2011/12. Central Bureau of Statistics, Kathmandu.

**44.** MoCS (2010). Nepal Trade Integration Strategy. Background Report, Ministry of Commerce and Supplies, Singh Durbar Kathmandu.

**45.** NSCDP (2009). Annual Report. National Spice Crop Development Program, Khumaltar, Lalitpur,

Nepal.

**46.** MoAD (2015). Statistical Information on Nepalese Agriculture 2013/14. Ministry of Agricultural Development,

**47.** Singh Durbar Kathmandu. CBS (2011). Population Monograph of Nepal 2010. Central Bureau of Statistics, Kathmandu Nepal.