Research article

Agroforestry Systems for Upland People in Lao PDR: Production, Benefit, and Farmers' Satisfaction Analysis

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Abstract With an increasing population and governmental land-use restriction, shortened fallow periods of some traditional farming systems have contributed to the reduction of agricultural production in the uplands of Lao P.D.R. In response, systems which integrate trees, crops, and/or animals, such as agro forestry have been applied. However, the promotion of agroforestry as an alternative choice for upland farmers has become very challenging as a result of long-term economic incentives. The objectives of this study were to identify agroforestry systems employed, cost and returns, and the satisfaction of farmers, aiming to promote more benefits of agroforestry. Information described in this paper came from a survey of 80 agroforestry farms under a project support in nine villages of two northern districts. The results implied that three main agro forestry systems, based on nature components, have been employed. 81 percent of farmers employed Agrisilviculture, where trees and crops were combined in the same parcel. 14 percent applied Agrosilvopastoral (trees, crops, and pasture/animals), followed by 5 percent who applied Silvopastoral (trees and pasture/animals). In terms of production cost, initial investment in Agrisilviculture cost on average US$ 575 ha^{-1}; while Agrosilvopastoral farmers spent around US$ 795 ha^{-1} and Silvopastural farmers, an estimated US$ 282 ha^{-1}. After three-years of establishment, most farmers achieved success meeting their food sufficiency needs and obtained additional income from extra production, with average returns from each system about US$ 186 ha^{-1}, US$ 632 ha^{-1}, and US$ 104 ha^{-1} respectively. With biological and economic advantages produced by natural components in each system, most of farmers were similarly satisfied. Although the systems could not provide immediate-profitable returns, they were able to sustain food production and were profitable for a long-term use. A particular attention and continual technical support from relevant agencies are still required to enhance application of agroforestry.

Keywords upland farmers, agroforestry systems, production cost and benefits, farmers' satisfaction.

INTRODUCTION

In Lao PDR, 80 percent of the land area is classified as mountainous, including much of the Northern region. This is a main obstacle for the development of social infrastructure. Still, the majority of upland population employs shifting cultivation as the main agricultural activity (Seidenberg et al., 2003). Along with the main shifting cultivation, agroforestry, an ancient process of cultivating trees and crops in combination with one another, has also been employed. These practices have been classified as indigenous or traditional agroforestry, practiced in home gardens, intercropping systems, and livestock grazing practices (Sodarak et al., 2004). Under population pressure and government restriction on deforestation, traditional shifting cultivation as well as indigenous agroforestry practices has faced the problem of shortened fallow periods, consequently contributing to the degradation of soil fertility and crop yield (De Rouw, 2005). In response, the government has im-

plemented policies and programs aiming at providing better options for sustainable agriculture in the uplands (GoL, 2004). One of those methods employed is alternative agroforestry. An integration of annual crop, upland rice, with medium-term fruit trees and longer-term fruit trees has been set up for upland farmers (Lai et al., 2004). After several years of introduction, it seems the extension of alternative agroforestry is still limited due to a lack of immediate returns. Thus, this study aims at analyzing the alternative agroforestry systems applied, production, benefits, and the farmers' satisfaction regarding the technology support. Information presented in this study is believed to be useful for farmers who are interested in applying agroforestry as well as development agencies involved in the promotion of agroforestry in uplands.

METHODOLOGY

The study was conducted in two northern districts, Namor in Oudomxay province and Phonxay in Luangprabang province, where alternative agroforestry has been practiced under field-based research of a foreign project. Hence, purposive sampling was applied to collect data. From a project document's review, 120 families had been in the agroforestry trials. However, after the real survey only 80 families continued applying this system, as some had stopped. Thus, the total number of samples interviewed was 80 families. The study used structured interview and randomly visited farms during 20 March to 03 May 2011 in both districts. Questions were asked mainly on agroforestry systems details, production cost and income, and satisfaction of farmers regarding advantages received. All data collected was processed by the computer program SPSS for Windows Version 17.0. Descriptive statistics were applied, such as percentage, means, and figures, to support the qualitative data. The farmers' satisfaction levels for agroforestry advantages were analyzed by using interval mean scores, dividing into five interval levels that were calculated by using the equation.

RESULTS AND DISCUSSION

Agroforestry systems and component species

From the data analyzed, three main systems of agroforestry, based on their nature components, have been employed (Table 1). Agrisilviculture, where only trees and crops including shrubs/vines integrated together, was mostly applied, accounting for 81 percent of agroforestry in the community. Among farmers applying this system, about half preferred to integrate fruit trees like prunes, pomelo, lychee, mango, longan, orange, and others. At least, two kinds of fruit trees were used in a same parcel. Woody trees like rubber tree, agarwood, and teak were also used, but only a single specy was planted with other crops or sometimes with fruit trees and a single crop. In this system, various kinds of crops were applied and the popular crops were pineapple, soybean, galingale, upland rice, maize, and others. Mostly, farmers liked to add only pineapple as it was easy to grow and needed less care compared to other kinds.

Table 1 Agroforestry systems applied

Agroforestry Systems	Percentage (%)
Agrisilviculture (trees and shrubs/tree, or and crops)	81.25
Agrosilvopastoral (trees, crops, and pasture/animals)	13.75
Silvopastoral (trees and pasture/animals)	5.00

Another prevalent agroforestry system found on farms was Agrosilvopastoral, a system in which trees, crops and pasture/animals are planted together, accounted for 14 percent. Within this system, several trees, crops, and animals were incorporated. Over half of the farmlands employing this method planted fruit trees, mostly litchi and longan. Woody trees such as rubber trees, teak,

and agarwood were also applied. With the integration of crops, farmers preferred to grow pineapple, galingale, soy bean, maize, and sesame. The most commonly raised livestock was poultry which was naturally free-grassing. Additionally, 5 percent of farmers employed Silvopastoral, where pasture land or animals are integrated in the tree plantation. The most popular trees were litchi, prunes, orange, and rubber tree, combining with some animals like pigs, goats, and cattle, mostly roaming freely in the day time and confined in a pen at night. As nearly all of the farmlands situated on hillsides, the most common cropping pattern applied in all systems was alley cropping in which trees are planted in rows at wide spacing with companion crops grown in the spaces between the tree rows.

Farm Production

In each system, the levels of production were dissimilar, in conjunction with the different amount of trees, crops and animals integrated. Analyzed data in Table 2 showed the average yield, and sale of extra production annually. Genarally, most farmers could harvest the production from fruit trees after three years of farm establishment. While only some rubber plantations were able to reap benefits from sales of rubber cup lump last year. In crop production, farmers could gain benefits within the first year of integration. Farmers indicated that they could sustain food self-sufficiency from harvested crops (i.e. pineapple, maize, soybean, galingale, and sesame) and could also sell some of the crops surplus to generate household income. Combined with animals, some families who raised cattle could generate a very good profit.

Table 2 Average yearly production, amount of consumption and sale per hectare

Systems and components	Yield (kg/ha)	SD	Sold (kg/ha)	SD
Agrisilviculture				
Woody trees	18.61	63.45	18.61	63.45
Fruit trees	129.91	182.16	86.33	168.04
Crops	1,635.68	2,921.40	465.61	702.61
Total				
Agrosilvopastoral				
Fruit trees	338.75	563.70	329.25	569.19
Crops	1,000.00	1,026.37	863.64	914.16
Animals	32.20	46.98	20.60	47.06
Total				
Silvopastoral				
Woody trees	16.50	23.33	16.50	23.33
Fruit trees	196.25	278.05	122.50	157.56
Animals	7.00	2.83	1.50	2.12

** Unit of animals yield was counted in head*

Among the families participating in Agrisilviculture trials, only few families could collect the production from woody trees, due to the fact that most of the rubber tree as well as teak and agarwood were not yet fully formed. Only a few rubber plantations were ready for tapping with the average yield of 18.61 kg ha^{-1}. As fruit trees were mostly grown to sustain food production, the average yield was 129.91 kg ha^{-1}, mainly from prunes, pomelo and lichee. Of these, some was used for home consumption and the extra yield was sold in the local market. The average yield gained from crops, such as pineapple, soybean, galingale, upland rice, maize, and sesame was 1,635.68 kg ha^{-1}. In Agrosilvopastoral, the number of farmers engaged in this system was smaller, so the average of production seemed higher than the first system. For fruit trees, farmers could harvest fruit about 338.75 kg ha^{-1}, largely from litchi, longan, prunes, and pomelo. The production from crops was 1,000 kg ha^{-1}, mainly from pineapple. Besides, several kinds of animals were raised, the most preferred being poultry, goat, and pig, with total offspring averaged from all kinds about 32 head ha^{-1}.

Chicken made up the highest proportion. In the mean time, the Silvopastoral farmers had obtained the production of some mature rubber trees, approximately 16.50 kg ha^{-1} of rubber cup lump. The fruit trees production was mainly harvested from litchi, prunes, and orange, and averaged a combined total of about 196.25 kg ha^{-1}. The most frequently used animals in this system were pig and goat, generally fed by free-roaming in the day time and confined in pens at night. Average animal production from both was about 7 head ha^{-1} $year^{-1}$.

Cost and benefits

Due to the use of various species components applied on each farm, the cost of production was analyzed by the three main systems of agroforestry. Table 3 shows average cost of production per hectare at the time of initial investment by each natural component (trees, crops, and animals), calculated from labor and material input costs. The labor inputs for each system were land preparation, planting, farm management, harvesting, and transporting. The total labor needed for each system varied due to the different amount of trees and crops planted. The material inputs were mostly seeds, including trees seedlings and crop seeds, followed by organic fertilizer, which was applied only in the first two years. The remaining expense was farm equipment, such as knives, hoes, shovels, and spades, which were purchased only one time. The material inputs for animals were different. They included medicine, forage, and fencing. The investment in animals only occurred at the time of the first acquirement.

Table 3 Average cost of initial investment by nature components and annual income

Systems and components	Amount integrated (ha)	SD	Initiative cost (US$/ha)	Annual income (US$/ha)
Agrisilviculture				
Trees (plant)	275	275	372	58
Crops (kg)	1,980	3,406	203	128
Total			*575*	*186*
Agrosilvopastoral				
Trees (plant)	329	305	313	170
Crops (kg)	2,065	2,070	262	146
Animals (head)	20	23	219	316
Total			*795*	*632*
Silvopastoral				
Trees (plant)	387	625	218	85
Animals (head)	7	7	64	19
Total			*282*	*104*

** 1 $UDS=8,000 LAK*

In Agrisilviculture where only trees and crops were integrated, the average number of tree seedlings used at the beginning was about 275 plants ha^{-1}, including both woody and fruit trees. The price of trees varied, depending on species. In fact, all trees were funded by the project. However, the cost of trees seedlings was still calculated as a material input. For intercrops, farmers were supported by the project in the first year. After that, farmers had to invest on their own for the annual crops, excluding pineapple. In total, the initial investment in Agrisilviculture was around US$ 575 ha^{-1}. In Agrosilvopastoral, the cost of production was higher due to the higher quantity of trees, crops, and animals used. Due to the variation of animals applied, the cost of animals was summed up and estimated in average including cost for relevant materials such forage, fencing, and medicine. Total initial expense, estimated for the use of 329 trees, 2,065 kg of different crops and a mixture of 20 animals, was about US$ 795. In Silvopastural, where there were only trees and animals, the initial investment was less compared to other techniques. The total expense was estimated

to be around US$ 282 ha^{-1} for the integration of 387 trees with 7 animals. Farmers stated that normally feed their livestock naturally by free-grazing, and as such, there was no expense for forage. The only fencing cost paid for was nails, as other materials like timber could be taken from the forest.

In each system, monetary returns were dissimilar due to the different amount of trees, crops and animals integrated. Most farmers established farms with the aim mainly to produce food for home consumption. However, they also used surplus fruit and crops harvested to generate additional income. Analyzed data in Table 3 also showed the average income gained annually from the sale of extra production. Among the families participating in Agrisilviculture trials, they could harvest the production from all components and make additional income equivalent to US$ 186 ha^{-1} $year^{-1}$. In the Agrosilvopastoral system, the average income was the highest, estimated at US$ 632 ha^{-1}, in relation to the higher amount of natural components combined, as well as the higher rate of production sold. Silvopastoral obtained the lowest profit, approximately US$ 104 ha^{-1} as the benefit could be reaped only from trees and livestock, particularly poultry. If comparing the cost of production and income in all three systems, although it seems that their cost of initial investment was higher than income, the yearly average return still gave the satisfactory benefits. Particularly, farmers claimed that they could sustain their food production and also increase household income, enabling their ability to purchase more food and daily goods for their families.

Farmers' satisfaction to the agroforestry advantages

This study also examined the differences of farmers' satisfaction with the agroforestry advantages generated by the interaction of its natural components through the use of Chi-square test of difference (Table 4).

Table 4 Satisfaction on biological and economic advantages of agroforestry

Agroforestry advantages	Percentage			N	Mean	SD	X^2
	Agrisivil-culture	Agrosilvo-pastoral	Silvo-pastoral				
Biological advantages							
Satisfaction on trees	81.25	13.75	5.00	80	3.46	.826	$.177^{ns}$
Satisfaction on crops	84.06	15.94	-	69	3.67	.852	4.429**
Satisfaction on animals	-	78.57	21.43	14	3.64	.497	1.479^{ns}
Economic advantages							
Crops production increase	81.25	13.75	5.00	80	3.36	.830	6.311**
Increase food production	81.25	13.75	5.00	80	3.46	.745	1.843^{ns}
Variety of farm production	81.25	13.75	5.00	80	3.20	.818	1.033^{ns}
Save household labors	81.25	13.75	5.00	80	3.53	.927	2.048^{ns}
Increase income	81.25	13.75	5.00	80	3.46	.810	1.034^{ns}
Various income from intercrops	81.25	13.75	5.00	80	3.34	.728	4.798^{ns}
Buy more goods and services	81.25	13.75	5.00	80	3.34	.762	4.123^{ns}

*Note: Differences are compared using Chi-square test; ^{ns} = Non-significant, ** Significant at 5%*

Investigated data indicated that the satisfaction to biological advantages from trees and animals were insignificant differences among three systems. Farmers were commonly satisfied with trees since trees and animals integrated were suitable to the environment. For satisfaction on animals raised, there was also an insignificant difference among three groups since farmers were largely satisfied with an increase of household income from sales of livestock. Nevertheless, there is a significant difference of 5% among farmers who integrated crops. The given reason by farmer who applied Agrisilviculture was that the combination of crops created a good environmental, con-

tributing to the increased of crops yield; meanwhile, farmers who employed Agrosilvopastoral claimed that crops were difficult to take care at the time of fruit-bearing due to damage by insects and rodents, often resulting in crops failure. In addition, some crops like pineapple were small in size and sour in taste, resulting in unsellable production. To economic benefits, the satisfaction of farmers of three systems was not significantly different. Mostly, they were satisfied that the variety of crops could not only sustain food supply but also could make additional cash income from surplus production to buy more goods and services supporting daily life. Yet, there is a significantly different satisfaction at 5% to the crops production increase as Agrosilvopastoral farmers reported differently that crops yield gradually decreased year by year.

CONCLUSION

Through the introduction of agroforestry for farmers in the hilly areas, three main agroforestry systems have been employed: Agrisivilculture, Agrosilvopastoral, and Silvopastoral. The most prevalent system was Agrisivilcuture where only trees and crops were put together in the same plot. In each system, various kinds of trees, crops, and animals were diversely incorporated. The initial cost of production was considerably dissimilar. Among three systems, Agrosilvopastoral farmers had the highest cost of production, due to the fact that all three main nature components, trees, crops, and animals, were integrated. In regards to the estimated profitable returns, all systems could provide levels of production to support the food sufficiency of families and gain additional income from sales of surplus production. The most profitable was Agrosilvopastural, since various kinds of species were applied. In addition, the differences of farmer's satisfaction on biological and economic advantages of all agroforestry systems are mostly non-significant. Only some showed their significant different satisfaction to the benefit of crops integrated, in accordance with the difficulty of farm management during fruit-bearing times as a result of insect and rodent damage, resulting in some crop failure. To this point, the need for farm management techniques are required to prevent the production loss as it is a key motivator to help the expansion of agroforestry systems. Moreover, some on-going technical and advisory assistance from related agencies, especially government and projects, is still needed to facilitate the application of technologies introduced and to provide information about solving problems on farms to enhance effectiveness. Hence, farmers will feel more confident with the new farming systems offered that could help them improve their food production and create better livelihood conditions.

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