

Agroforestry Livelihood Strategies and Factors Influencing Agroforestry Adoption in Nakai Resettlement Villages, Khammouan Province, Lao PDR

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ABSTRACT. The study characterized the agroforestry livelihood strategies of resettled communities and the economic benefits associated with these, discussed the socio-economic factors associated with the adoption of the agroforestry livelihood strategies, and examined the agroforestry livelihood strategies in relation to perceived food sufficiency. Data gathering methods employed were survey, key informant interviews, and transect walk. Randomly selected adopters of agroforestry served as main respondents. Data were analyzed through descriptive and inferential statistics. Results revealed that adopters practiced five different agroforestry livelihood strategies. Rice (*Oryza sativa*)-based livelihood strategies assured farmers of rice supply, vegetable-based provided the highest income, and pineapple (*Ananas comosus*)-based was the most diverse in terms of sources of income. Food consumption sufficiency is correlated with most livelihood strategies except for cassava (*Manihot esculenta*), which had the least agricultural production activity. The average income for all farming systems remained below the poverty line. The major factor influencing the adoption of various agroforestry livelihood strategies was the availability of farm labor. Understanding agroforestry livelihood strategies provides an analytical basis for the design of a sustainable livelihood framework. For resettled villages, it is important that livelihood projects incorporate policies and strategies related to the provision of extension education strategies and marketing support that would link farmers to buyers of their produce.

Keywords: *Agroforestry, livelihood systems, adoption, resettlement villages, forestry extension*

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INTRODUCTION

Dam building for domestic and agricultural use leads to the displacement of communities that are consequently resettled. Among the most serious effects of development-induced displacements is the impoverishment of people as they lose control of their livelihood (Cernea & McDowell, 2009 as cited in Dao, 2010). Resettlement is a stressful condition as the ways of living change, economic activities are disrupted, and social networks are disconnected. However, resettled communities must find ways of maximizing opportunities to enable them not only to survive but also to move forward. The construction of the dam by the Nam Theun 2 Power Company (NTPC) affected 1,149 local households in Nakai Plateau in Khammouan Province, Lao PDR due to inundation. NTPC is a large project funded by 27 international banks, including international financial institutions such as the World Bank, Asian Development Bank, European Investment Bank, and Francaise de Development (GIZ, 2013).

The Nam Theun 2 (NT2) project follows the general principle of compensating resettled communities by paying in cash, replacing their land, and providing livelihood opportunities through agroforestry. Thus, NTPC provided support to the communities in terms of giving direct compensation, farm area, technical training, and material inputs. In partnership with the government of Laos, NTPC provided interventions that sought to improve the health, education, and livelihood activities of the villagers. Various types of trainings in the areas of agroforestry, livestock raising, forestry, fishing, and handicraft-making were given.

The relocated households originally practiced a subsistence mixed economy that included swidden rice production; vegetable gardening such as cabbage (*Brassica oleracea* var. *capitata*), cucumbers (*Cucumis sativus*), tomatoes (*Solanum lycopersicum*), lettuce (*Lactuca sativa*), beans (*Phaseolus vulgaris*), and pumpkins (*Cucurbita moschata*); fishing; livestock growing; and hunting and gathering. While rice (*Oryza sativa*) was the main crop, only 17% of the total households produced sufficient rice for their consumption (World Bank, 2005). Provision of land planted with a mixture of plantation and fruit trees, vegetables, and crops was introduced to discourage swidden farming, reliance on forest timber as sources of income, and ensure diversified sources of income from a cultivated land area. However, an initial scanning among resettled households practicing agroforestry showed that relocated households continued to plant mainly rice in their fields and a significant number have not adopted agroforestry production.

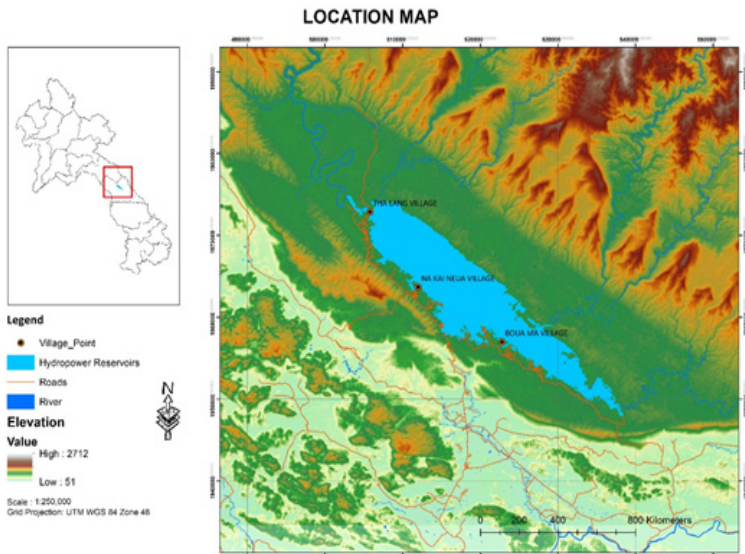
Agroforestry is the "intentional integration of woody vegetation, such as trees and shrubs, with crops and/or livestock simultaneously or sequentially on a land management unit" (Brown et al., 2018, p. 2). Agroforestry has many environmental benefits, such as carbon sequestration, biodiversity conservation, soil enrichment, and air and water quality improvement (Jose, 2009). In his review of the determinants of agroforestry adoption, Kassie (2017) grouped the determinants into economic incentives, access to infrastructure and institutions, resource endowments such as farm size, secured perception on land security rights, and non-farm income. Kassie (2017) also found that farmers prefer to shift to tree plantation because it is more weather-resilient than seasonal crops and has better marketability, which leads to more income. Pandit et al. (2019) documented an increase of up to 48% in income resulting from market-oriented agroforestry intervention that can provide food for 6 months for the families. Despite the promise of agroforestry to diversify income and food sources, reduce the occurrence of slash and burn practice, and improve soil condition of the farms, its adoption in the resettled areas remained low.

To understand the situation of resettlers in Nakai Villages, a study on agroforestry adoption and benefits among the resettled communities was conducted. Specifically, the study characterized the agroforestry livelihood strategies (ALS) of resettled communities and the economic benefits associated with these, discussed the socioeconomic factors associated with the adoption of ALS, and examined the ALS in relation to perceived food sufficiency.

METHODOLOGY

The study was conducted in Nakai resettlement villages in Khammouan Province, Lao PDR. The climate of Nakai is influenced by southwest monsoon (wet season) from May to October and northwest monsoon from November to April. Rainfall is seasonal with over 88% between April and September while only 12% during October to March (World Bank, 2005). The province is vulnerable to alternating flood and drought.

The three study areas Thalang or Talang, Nakaine, and Bouma or Buama, represent the lower, middle, and upper portion of Nakai, respectively (Figure 1). The three villages were selected to represent the three different areas of the resettlement villages. The study sites are similar in terms of topography and climate and have the highest number of adopters based on key informant interviews with extension workers.



Source: Sommay Lorvanhbong, Department of Agriculture and Forestry Office, Luangnamtha Province, Lao PDR

Figure 1. Map of the study site

Talang is characterized by rugged terrain with steep slopes. Its location is far from the town, with an approximately 20 km asphalt road located at the left side of the reservoir. Nakaine is located in the central zone, with a peri-urban community along the shore. It is 3 km away from the market. Buama, on the other hand, is situated at the southern zone, at the shoreline of the reservoir with a large hinterland and is just 5 km from the town market through a mud-dirt road.

In the selected three villages, random sampling (5% error) was employed to determine the sample size. There were 260 farmers who participated in the agroforestry program. However, there was no list of adopters and non-adopters. Hence, from the computed sample size of 158 potential respondents, the fishball technique was used to randomly determine the final set of respondents. All of the 158 randomly selected respondents were visited and only 82 were determined to be adopters. There were 18 respondents from Buama, 9 from Nakaine, and 55 from Talang. In this study, adopters refer to those who followed the technical recommendations to plant plantation crops such as bamboo (*Bambusa vulgaris*) or rattan (*Calamus rotang*), fruit trees with vegetables, root crops, high-value crops and/or cereals as maize (*Zea mays*) or rice within the 0.66 ha land area distributed to each resettled family.

Data gathering methods employed were survey, key informant interviews, and review of documents. Interviews were conducted in the latter part of 2016. Transect walk was employed to determine the layout of the farms. Descriptive statistics such as frequencies, percentages, means, ranges, and standard deviations were used to describe the data. Pearson's chi-square test was used to determine the relationship between socioeconomic characteristics and adoption of agroforestry.

RESULTS AND DISCUSSION

Demographic Characteristics

Almost half (42%) of the respondents belong to the adult age group of 40-59 years old, and female (Table 1). While the Laos population is relatively young, the upland farmers belong to an older generation. The major ethnic groups are Makong, Bor, and Lao, while Buddhism is the dominant religion of the respondents. The World Bank (2005), however, notes the difficulty of distinguishing the ethnic grouping because of intermarriages and the adoption of Laos language and culture.

In terms of educational attainment, more than half (55%) of the respondents were elementary undergraduates. The low educational attainment had been observed by the Social Development Plan for Nakai (World Bank, 2005) where majority had no schooling and a third were able to attend only primary schooling. Based on the interviews, the villagers understood the importance of education but had little opportunity to support their children's education. There were instances when schoolchildren had to miss classes so they could collect non-timber forest products (NTFPs) or plant rice. The parents also averred that only the schools in large villages were functioning; thus, this situation made schools difficult to access for the young children. In many of the villages on the Nakai Plateau, either there was no school or the village schools had not been functioning for the past years. Some of the functioning schools were co-financed by the villagers themselves, as the local government had insufficient funds to run the school.

While there were households with no males, the ratio of male to female did not differ much from the Laos Census of 101.6 in favor of males. The farm household size of 6 is similar to the data of the Laos Census, which recorded a drop of 6.1 to 5.7 farm household size [Ministry of Agriculture and Forestry (MAF), 2014].

Table 1. Respondents' demographic characteristics

DEMOGRAPHIC CHARACTERISTICS	BUAMA (n=18)		NAKAINÉ (n=9)		TALANG (n=55)		TOTAL (n=82)	
	F	%	F	%	F	%	F	%
Age								
Teenager (13-19 years old)	-	-	-	-	11	20	11	13
Young adult (20-39 years old)	7	39	2	22	22	40	31	38
Older adults (40-59 years old)	10	56	5	56	19	35	35	42
Old age (60 years old and over)	1	5	2	22	3	5	6	7
Sex								
Female	7	39	6	67	47	85	60	73
Male	11	61	3	33	8	15	22	27
Ethnic Group								
Makong	16	89	-	-	8	15	24	29
Bor	2	11	-	-	20	36	22	27
Lao	-	-	9	100	12	22	21	26
Meuy	-	-	-	-	11	20	11	13
So	-	-	-	-	4	7	4	5
Religion								
Buddhism	18	100	9	100	37	67	64	78
Traditional	-	-	-	-	18	33	18	22
Educational Attainment								
High school undergraduate (10-12 years)	1	5	-	-	4	7	5	6
Elementary graduate (4-5 years)	-	-	3	34	9	16	12	15
Elementary undergraduate (1-3 years)	14	78	3	33	28	51	45	55
No formal education (0 year)	3	17	3	33	14	25	20	24

Reasons for Adoption of Agroforestry Farming System

As compensation for their displacement, the respondents were provided with a house and lot; and access to electricity, roads, agricultural training, and agricultural input support. The resettled households originally engaged in swidden farming, vegetable gardening, fishing, livestock raising, and NTFP collection, with the latter estimated to contribute to almost half of the household income (World Bank, 2005). Large areas of Khammouan are classified as forest land and Nakai District is found on the northeast of this area. NTFPs refer to timber, fuelwood and charcoal, vegetables and tubers, medicinal plants, fish, and wildlife. Foppes and Ketphanh (1997) provide an analysis of the importance of NTFPs among Laotians and enumerate the kinds of NTFPs normally collected in the forests.

Shifting cultivation is being practiced among the upland farmers (Roberts, 2015). Swidden farming persisted among the upland cultivators despite many interventions to discourage its practice (van Vliet et al., 2012). However, given the increased population resulting from resettlement, swidden agriculture may eventually become problematic as there are fewer available areas for shifting cultivation. These upland areas used to be common and open to all. With the resettlement, a portion of these areas was distributed to farmers; thus, decreasing the common areas for swidden farming. The resulting decreased fallow cycles normally leads to soil degeneration and reduced biodiversity, which can further lead to lower yields and increased poverty levels (Baird & Shoemaker, 2007). Lao PDR has specifically translated the negative perceptions about swidden farming into policy documents such that those involved in swidden cultivation are tagged as *lower quality people* (van Vliet et al., 2012). It is along this line that the Nakai Resettlement Office introduced agroforestry to counteract swidden farming, ensure food sufficiency, and provide an alternative cash flow to NTFP collection.

To encourage diversification of food sources and farm income, and discourage swidden farming, the respondents were given a 0.66 ha farm area with access to irrigation. It should be noted that 33.5% of farm areas in Laos are between 0.5 and 1.49 ha (MAF, 2014). Most respondents (90%) cited diversification of sources of income as a reason for adoption while the rest believed the move would increase household food sources (Table 2). Based on the key informant interview, the irrigation facility, free agricultural training, and input support were key factors in their decision to adopt the agroforestry farming system.

Table 2. Reasons for adoption of agroforestry

REASONS FOR ADOPTION	BUAMA (n=18)		NAKAINE (n=9)		TALANG (n=55)		TOTAL (n=82)	
	F	%	F	%	F	%	F	%
Source of income and livelihood	14	78	5	56	55	100	74	90
Increase food sources for family consumption	4	22	4	44	-	-	8	10
Total	18	100	9	100	55	100	82	100

All of the respondents from Talang adopted agroforestry in their irrigated lands of 0.22 ha. They were given a 0.66 ha farm area with access to water facilities such as irrigation. Talang residents were given an extra 0.22 ha farm area, as the 0.66 ha land area provided could not be irrigated because it was far from the reservoir. The 0.22 ha was also near their residences. According to the respondents, this made planting of various fruits and crops easier. On the other hand, even if the 0.66 ha was far from the residences of resettlers in Buama and Nakaine, irrigation was accessible because water pumps were distributed. Nevertheless, the key informants complained that during the dry season, no irrigation water could reach some of the 0.66 ha farms. It appeared that access to irrigation systems was a factor that negatively affected the adoption of agroforestry.

The multiple economic, social, and environmental benefits of agroforestry are well documented (Jose, 2009 as cited in Jerneck & Olsson, 2013; Brown et al., 2018). However, understanding the factors affecting its adoption is complex compared with its component technologies as agroforestry requires a combination of strategies, and therefore, a combination of skills, labor requirements, and financial investment. Nevertheless, several studies underscored the factors which facilitate adoption such as income and participation in learning opportunities (Phiri et al., 2004; Keil et al., 2005, as cited in Kabwe et al., 2009). Specifically, these authors found that farmers who were involved in on-farm experimentation of agroforestry technologies with the researchers were more likely to adopt new agroforestry technologies than those who did not participate in any on-farm experimentation.

The key informants in this study stressed that the promise of income diversification and increased food sources, coupled with attendance to training and provision of technical advice and input support, motivated them to adopt agroforestry. While Jerneck and Olsson (2013)

explained that the distant future of benefits owing to agroforestry make adoption decision a complex process, the resettled communities who have limited livelihood choices resorted to the adoption of agroforestry farm practices.

Agroforestry Livelihood Strategies

Given the unsustainability of swidden farming due to increased population in the upland areas, agroforestry became a priority program of the local government as a strategy to diversify sources of food and income and improve soil fertility. This study investigated the ALS, which looked into farm and non-farm income sources implemented by the respondents. The ALS were seen as important given that farm-based activities alone may be inadequate for the family. Thus, studying the combination of livelihood strategies may help in understanding how farmers can maximize opportunities and derive benefits from these.

Results showed that the respondents practiced five different ALS such as rice-based (46%), pineapple-based (22%), cassava-based (22%), maize-based (4%), and vegetable-based (4%) (Table 3). Determining the ALS was based on the contribution of the income from the agricultural crop production to total agricultural income, not total household income. Rice-based agroforestry farming system meant that in terms of agricultural income, rice was the biggest contributor. All ALS combinations are seen in Table 3.

Rice-based Agroforestry Livelihood Strategy. The rice-based ALS is practiced by 46% of the respondents and is the most popular as farmers want to ensure that they have rice for consumption. There are three combinations of rice-based agroforestry crop production referred to here as *Ra*, *Rb*, and *Rc*. *Ra* is common to all plots where rice, fruit trees, rattan, and bamboo are planted, while *Rb* added cassava and *Rc* added vegetables to the farm lot. Supplementing the farm activities are NTFP collection and fishing while *Rb* and *Rc* include cattle raising. Only *Rb* has non-farm income as the respondents engaged in selling dry goods (entrepreneurship). With very small farmlands, cattle raising is very limited and cash-strapped farmers may not have the opportunity to put up small stores nor have the time to engage in selling the produce. *Ra* is practiced by 28% of the farmer-respondents, followed by *Rc* (12%), and *Rb* (6%). Most of the respondents come from Talang.

Figure 2 shows the layout of the most common rice-based crop combination. Fruit trees such as lychee (*Litchi chinensis*), longan (*Dimocarpus longan*), and mango (*Mangifera indica*) are planted in

Table 3. Agroforestry-based livelihood strategies

AGROFORESTRY LIVELIHOOD STRATEGIES	FREQUENCY (n=82)	PERCENT
Rice-based	38	46
Ra = Rice + Fruit trees + Rattan + Bamboo + NTFP + Fishing	23	28
Rb = Rice + Cassava + Fruit trees + Rattan + Bamboo + NTFP + Entrepreneurship + Fishing + Livestock	5	6
Rc = Rice + Vegetable + Fruit trees + Rattan + Bamboo + NTFP + Fishing + Livestock	10	12
Pineapple-based	18	22
Pa = Pineapple + Rice + Fruit Trees + Vegetable + Rattan + Bamboo + NTFP + Fishing + Entrepreneurship	9	11
Pb = Pineapple + Fruit Trees + Rattan + Bamboo + NTFP + Fishing + Livestock + Entrepreneurship	8	10
Pc = Pineapple + Rice + Maize + FT + Bamboo + Rattan + NTFP	1	1
Cassava-based	18	22
Ca = Cassava + Fruit Trees + Rattan + Bamboo + NTFP + Fishing	13	16
Cb = Cassava + Fruit Trees + Rattan + Bamboo + NTFP + Fishing + Entrepreneurship	5	6
Maize-based	4	4
Ma = Maize + Rice + Fruit trees + Rattan + Bamboo + NTFP + Fishing + Wages	2	2
Mb = Maize + Vegetable + Fruit trees + Rattan + Bamboo + NTFP + Fishing	2	2
Vegetable-based	4	4
Va = Vegetable + Fruit Trees + Rattan + Bamboo + NTFP + Fishing	2	2
Vb = Vegetable + Maize + Fruit Tree + Rattan + Bamboo + NTFP + Fishing	1	1
Vc = Vegetable + Cassava + Fruit Tree + Rattan + Bamboo + NTFP + Fishing	1	1



Figure 2. Layout of the rice-based crop combination (Ra)

between the rice crop. It should be noted that fruit trees of all farmer-respondents were not yet fruiting and were expected to bear fruits in 2017. Surrounding the farm are rattan and bamboo. Compared with the other two rice-based livelihood strategies, the rice-based ALS is more popular as the second and third strategies require a grazing land for the cattle (livestock) and a capital to put up a small enterprise (entrepreneurship). Based on observations, this farm layout differs from the usual farming practice of upland farmers where rice is planted with various vegetables for consumption and commercial purposes, as also pointed out by Roder et al. (1996), as cited in Roberts (2015).

Upland rice cultivation is discouraged in Nakai as upland areas are constrained by acidic soil, low water holding capacity, and low light intensity because of shades from trees, resulting in poor yield (Muhidin et al., 2013). Nevertheless, rice production remains popular because it is the traditional crop of the resettled communities and remains a default crop to ensure food availability. Based on the survey, rice production in Nakai yielded an average of 500 kg/ha, way below the documented 800 kg/ha for upland rice (GIZ, 2013). Based on the plans of the National Agriculture and Forestry Institute (Roberts, 2015), planting of upland rice, which remains dominant in Nakai, is envisioned to be eliminated because of poor soil quality. Extension workers share that there is no provision of inputs from the Nakai Resettlement Office to promote rice production. Additionally, agricultural extension workers contend that with the growth of fruit trees and fence trees, rice yield will be further negatively affected by their shades.

Pineapple-based and Cassava-based Agroforestry Livelihood Strategies. Pineapple-based and cassava-based ALS are the second most popular ALS, both representing 22% of the total respondents. Pineapple production started in 2013 when a private company promoted this crop and offered to buy pineapple fruits. Common among the three pineapple-based ALS are the planting of fruit trees, rattan, bamboo, and NTFP collection. *Pa* is the most popular cropping pattern where rice is planted between mangoes and rows of vegetables. Fruit trees such as mango, longan, and lychee are planted in between rows of pineapple. The whole farm is bordered by rattan and bamboo (Figure 3).

The first pineapple-based livelihood strategy is the more crop-diverse farming system. The respondents aver that this farm diversification provided them with food sources for the households. It was noted that operating a small store (referred to as *enterprise*) is common, which is proved to be profitable for those who have extra money and better mobility access. Adopters of this livelihood strategy are mostly from Buama, which is 5 km away from the market. The road going to the market, however, is mud-dirt, such that the people would rather buy from the nearby small stores.

Cassava production started in 2013 in partnership with a Vietnamese private company. The farmers entered into a contract agreement and were provided production and marketing support. There are two cassava-based ALS, referred to as *Ca* and *Cb*, which have the same crop combinations. Cassava was intercropped with mango, lychee, and longan; and the whole farm was fenced with bamboo on one side and



Figure 3. Layout of the pineapple-based crop combination (*Pa*)

rattan on the other. The two ALS also involve NTFP collection and fishing and are differentiated only in the involvement in the selling of dry goods by *Cb*. Of all the agroforestry crop combinations, this is the least diverse as adopters maximize their land area for cassava production. Planting pineapple and cassava also reflects the transitioning of the farmers to a more commercial-based farming system as they engaged in high-value crop production.

Maize-based and Vegetable-based Agroforestry Livelihood Strategies. Four respondents practiced the maize livelihood strategy, two from Buama and two from Talang. The difference in the crop combinations is that *Ma* incorporates rice in the farm layout together with rattan and bamboo. *Mb*, on the other hand, incorporates vegetables. Fruit trees such as lychee, longan, and mango were planted in between rows of maize while rice, which was mainly for household consumption, was planted at the periphery of the farm, near the acacia trees and rattan (Figure 4).

In some parts of Laos, the planting of maize has grown rapidly over the years as a response to increased market demands for feeds in Thailand (MAF, 2014). However, as rice eaters, the respondents in the areas preferred to plant rice more than maize even if the extension workers say that rice crop suitability is not favorable. The extension workers had been promoting maize planting and with increased demand, they foresee more farmers engaging in this crop in the future.



Figure 4. Layout of the maize-based agroforestry crop combinations

Only 5% of the respondents adopted a vegetable-based livelihood strategy as it was found to be laborious and needing irrigation. There were three kinds of vegetable-based cropping patterns where all have fruit trees, rattan, and bamboo. *Va* planted only vegetables while *Vb* added maize and *Vc* added cassava to the vegetable farm plot together with the fruit trees, rattan, and bamboo. The farmers contended that during summer, water was a problem that those far from the source of irrigation could not access water.

While farmers are familiar with vegetable farming as they used to plant cucumber, pumpkin, taro, chilies, sesame, smooth loofah, sweet potato, beans, peanut, eggplant, Job's tears, ginger, sorghum, yam bean, and sun hemp (Roder et al., 1996, as cited in Roberts, 2015), poor access to irrigation remains a major impediment to this livelihood strategy.

Common to all ALS was the gathering of non-timber forest products. NTFPs are biological materials (excluding timber) collected from natural or man-made forests and riverine habitats used to support local livelihoods (National Agriculture and Forestry Research Institute, 2007 as cited in MAF, 2016). The same document says that there are over 700 species of wild plants and fungi used for food and other purposes. Among these species are wild vegetables, bamboo shoots, tubers, wild fruits, sugar palm, mushrooms, medicinal plants, and more than 1,000 species of wild animals, which include numerous species of mammals, fish, frogs, snakes, shrimp, soft-shelled freshwater turtles, crabs, and insects. NTFP collection plays a crucial role in upland areas as it significantly contributes to the households' food and income.

Part of the resettlement agreement is the granting of rights for forest management, which allows the community to manage and harvest NTFPs. The restriction is in timber harvesting for commercial purposes. The whole forest area on the southern side of the Nakai reservoir has been allocated as a resettlement area to be used by Nakai resettlers as a community forest for sustainable commercial harvesting and timber utilization (World Bank, 2005). The forests of the resettlement area have been identified as belonging to four main forest ecotypes, namely: dry dipterocarp, dry evergreen, mixed deciduous, and mixed broadleaf and pine, with the latter being the most common (World Bank, 2005).

Foopes et al. (1997) reported the significance of NTFPs among the Nakai Plateau residents and reported kisi, rattan shoots, cardamom, bong barks, wildlife, and rattan canes as the most commonly harvested NTFPs. This study further confirmed the importance of these NTFPs to the resettled communities. Aside from its economic importance, bamboo

is also used for housing and furniture needs while rattan is used as a replacement for woods collected in the forested areas.

Economic Benefits from Agroforestry Livelihood Strategies

Crop income comes from a minimum of three activities for rice (*Ra*), cassava (*Ca*) and vegetable-based (*Vc*) to a maximum of six from rice-based (*Rb*) and pineapple-based (*Pa*). The diversity of income sources, however, does not determine the amount of income earned as vegetable-based (*Vb*), with five income sources derived the highest income while rice-based (*Rc*) with also five income sources derived the lowest income.

Of all the crop-based activities, vegetable farming provided the highest income, although, as already pointed out, this is not an option for many who may not have the household help to manage the farm nor access to a year-round irrigation. Vegetable-based crop combinations also represented the highest crop income source for all crop-based activities, representing 15%-35% of total household income (Table 4). This is understandable given that the farmers are familiar with vegetable farming and marketing, and that Laotians are vegetable eaters.

Cassava is also a promising crop-based income source. Cassava producers are engaged in contract farming and, thus, maximize the use of their farm to this crop. The contribution of this crop to total household income is 14%-15%.

Income from rice production contributed 9%-13% of the total household income. Those who produced maize added 5%-8% contribution to household income. Nevertheless, considering that rice was estimated to comprise 18% of the household expenses in Nakai (Foopes et al., 1997), those engaged in rice-based farming systems contended that they did not have to worry about where to get the food for the next meal. However, the low productivity due to degraded soil, lack of extension support, and increase in shade cover in the farm may reduce rice yield in the future.

Rice and maize production represented the lowest income contribution from among the agro-based income strategies. Maize growing is not popular but it is steadily gaining acceptance among the farmers as a result of increased demands for feed producers in Thailand. While livestock production was introduced by NTPC, it remains a minor engagement of most farmers. Fishing, on the other hand, a traditional source of food and income, remains a dominant activity of most farmers.

Table 4. Annual income from agroforestry livelihood strategies (ALS), 2015

ALS	RICE	MAIZE	PINEAPPLE	VEGETABLE	CASSAVA	LIVESTOCK	FISHING	NTFP GATHERING	ENTREPRENEURSHIP	WAGE	TOTAL (n=82)
Ra	5,052,391	-	-	-	-	-	9,640,000	23,845,435	-	-	38,537,826
Rb	4,388,889	-	-	-	555,556	2,555,556	2,111,111	28,877,778	6,222,222	-	44,711,112
Rc	2,500,000	-	-	833,333	-	583,333	3,000,000	20,333,333	-	-	27,249,999
Pa	1,922,222	-	2,428,889	844,444	-	-	4,844,444	32,225,556	1,333,333	-	43,598,888
Pb	-	-	2,175,000	-	-	1,000,000	6,975,000	30,625,000	41,875,000	-	82,650,000
Pc	4,000,000	3,000,000	5,000,000	2,000,000	-	-	-	26,000,000	-	-	40,000,000
Ca	-	-	-	-	5,238,461	-	6,276,923	23,536,923	-	-	35,052,307
Cb	-	-	-	-	6,200,000	-	1,800,000	25,620,000	3,200,000	7,200,000	44,020,000
Ma	2,733,333	3,000,000	-	-	-	-	333,333	31,400,000	-	17,333,333	54,799,999
Mb	-	2,500,000	-	1,000,000	-	-	5,000,000	22,000,000	-	-	30,500,000
Va	-	-	-	8,000,000	-	3,500,000	1,000,000	38,500,000	-	-	51,000,000
Vb	-	5,000,000	1,000,000	34,000,000	-	2,000,000	-	53,300,000	-	-	95,300,000
Vc	-	-	-	21,000,000	16,000,000	-	2,000,000	34,000,000	-	-	73,000,000

Note: USD 1 = LAK 8,145.95 conversion rate; average household size is six

Reservoir fisheries is part of the package of livelihood intervention of NTPC.

Currently, there is no income from fruit trees nor from rattan and bamboo because they are not yet harvestable. NTFP collection remains a major contributor to household income, ranging from 37% to 75%. Those engaged in the operation of small dry goods stores had less reliance on NTFP collection for food and income, while those engaged in vegetable production, with less engagement in fishing, had the highest reliance on NTFP collection for food and income sources. In a participatory rural appraisal exercise in Nakai (Foopes et al., 1997), 76% of the average family income from five villages surveyed came from NTFP collection, with resin, cardamom, and wildlife as the most important products sold. The same study mentioned that rattan shoots were for food while rattan stems were for handicraft and furniture, which was commonly harvested, did not appear in the NTFP collected products since the sources have been depleted. The planting of rattan in the farm periphery is supposed to address this problem.

A promising engagement is in the operation of small businesses which represents the highest income source for the respondents as represented by those in *Pb*. Most of these respondents are located in Buama, which is only 5 km from the town proper but is currently difficult to access because of the muddy dirt road. Nevertheless, for those with capital and mobility, the opportunity to run a small dry goods store proved profitable. The operation of a small dry goods store represented 50% of the total income.

It should be noted that the average annual household income of respondents, with an average of six household members, is below the annual GNI per capita of Laos for 2014 of USD 1,600 (United Nations Population Fund, 2015). The highest per capita earning of the respondents was represented by the vegetable-based agroforestry farming system (USD 1,178.5) while the lowest came from the rice-based agroforestry livelihood strategy (USD 564.96). For all livelihood strategies, NTFP collection remained a major source of income, representing up to 75% of the total income of the household. Despite the diversity of income sources, the farmers remained at subsistence level (Table 4).

Socio-economic Factors and Adoption of Agroforestry Livelihood Strategies

Test of association using Pearson chi-square showed that respondents' socio-economic characteristics including age, ethnicity,

household size, and availability of farm labor are associated with certain livelihood strategies (Table 5). Ethnicity influenced the choice of rice varieties (Roberts, 2015), but there had only been a few published articles in Laos to explain the association between ethnicity and adoption of agroforestry. Roberts (2015) also explained that there is no strong correlation between cash crop preference and ethnicity. Household size is moderately significant with vegetable livelihood strategy. The labor intensiveness of assorted vegetable production needs combined skills and forces. For all agroforestry cropping systems, only the availability of household farmworkers is consistently associated with all cropping systems. Irshad et al. (2011) noted that bigger household size positively influenced tree cultivation while household farm labor definitely influenced the adoption of agroforestry given the labor intensiveness of the enterprise.

The result of Pearson chi-square showed that income was associated with the type of cropping systems practiced by the farmers such as pineapple-based and vegetable-based ALS (Table 6). Vegetable-based ALS provided the highest income and pineapple-based proved to be the most diverse in terms of income sources. This supports the respondents' reasons to adopt agroforestry as a livelihood strategy where they said they expected to have diversified sources of income, which essentially can translate to higher income sources. This corresponded with some literature that cited economic benefits as influencing the adoption of agroforestry systems (e.g., Kassey, 2017; Pandit et al., 2019).

Results also showed that the availability of household farm labor was highly significantly related to rice-based ALS and moderately related to all other livelihood strategies. Buyinza et al. (2007) found a positive association between the number of family labor force and agroforestry system adoption. This can be attributed to the agroforestry system being labor-intensive compared with monocropping. Buyinza et al. (2007) noted that this could be due to the combined skills and forces exerted by

Table 5. Average annual household income (LAK) from agroforestry livelihood strategies, 2015

PARTICULARS	RICE-BASED (n=38)	MAIZE-BASED (n=4)	PINEAPPLE-BASED (n=18)	VEGETABLE-BASED (n=4)	CASSAVA-BASED (n=18)
Buama (n=18)	33,622,222	29,250,000	44,500,000	74,000,000	32,000,000
Nakaine (n=9)	10,200,000	64,200,000	44,960,000	63,000,000	33,350,000
Talang (n=11)	39,016,071	n/a	48,290,000	35,800,000	38,673,333
Average	27,612,764	46,725,000	45,916,667	57,600,000	36,674,000

Note: USD 1 = LAK 8,145.95 conversion rate; average household size is six

Table 6. Results of the Pearson Chi-Square Test of relationship between socio-demographic factors and adoption of ALS

SOCIO- DEMOGRAPHIC FACTORS	ADOPTION				
	Rice- based	Maize- based	Pineapple- based	Vegetable- based	Cassava- based
Age	-	-	-	-	0.043*
Ethnicity	0.000**	-	0.004*	0.033*	-
Sex	-	-	-	-	-
Educational attainment	-	-	-	-	-
Household size	-	-	-	0.018*	-
With regular household farm labor	0.000**	0.002*	0.007*	0.004*	0.032*
Total income (2014)	-	-	0.039*	0.009*	-

Legend: **Highly significant

* Moderately significant

- Not significant

a greater number of people to lessen the difficulty in implementing the agroforestry system, particularly in the initial stages.

Association of Agroforestry Livelihood Strategy to Perceived Food Sufficiency

Considering that food sufficiency is a major consideration of the respondents, the association of the various ALS to perceived food sufficiency was determined. Food sufficiency was classified into sufficiency of food products, level of food sufficiency, sufficiency of food stock, and food consumption sufficiency. Rice-based ALS is significantly associated with sufficient food stock and moderately associated with sufficient food products, level of food stock, and food consumption sufficiency. For adopters, the rice-based ALS was the only livelihood strategy that exhibited association with all indicators of food sufficiency. This is because the respondents are primarily rice eaters and having rice on their table means that they do not have to worry about regularly sourcing out food for their next meal. Having a ready supply of rice reduces the economic pressure for households as rice is the staple food of Laotians (Foopes et al., 1997). Pandit et al. (2019) also found that the agroforestry system improves household food availability through increased income and improved access to the food supply.

Rice-based, maize-based, pineapple-based, and cassava-based ALS adopters were likely to consider their sufficiency of food stock as high (Table 7). Vegetable-based adopters were likely to only have sufficient

Table 7. Results of the Pearson Chi-Square Test of relationship between agroforestry cropping system and benefits

VARIABLES	INCOME (P-Value)	FOOD SUFFICIENCY (P-Value)			
		SFP	LFS	SFS	FCS
Adopters					
Rice-based	-	0.001*	0.001*	0.000**	0.001*
Maize-based	-	0.025*	0.041*	0.048*	0.001*
Pineapple-based	0.039*	0.033*	-	0.013*	0.001*
Vegetable-based	0.036*	-	-	-	0.005*
Cassava-based	-	0.010*	0.020*	0.010*	-

Legend:

SFP – sufficiency of food products

LFS – level of food sufficiency

SFS – sufficiency of food stock

FCS – food consumption sufficiency

** Highly significant

* Moderately significant

- Not significant

food products. Adopters of rice-based, maize-based, and cassava-based ALS were more likely to have enough level of food sufficiency. Pineapple-based and vegetable-based adopters were likely to have a sufficiency of food products and food consumption. Sufficiency of food stock is likewise expected for rice-based, maize-based, pineapple-based, and cassava-based adopters. Highly sufficient food consumption is more likely for most livelihood strategies except for those who practice cassava-based agroforestry.

CONCLUSION AND RECOMMENDATIONS

A number of Nakai farmers are now engaged in agroforestry production in the resettled areas. Clearly, the government's distribution of farmlands with irrigation support, provision of training, and farm inputs such as fruit tree seeds and seedlings have influenced the change in practices from previously shifting cultivation to permanent cultivation of farmlands. Adopters combine fruit trees, plantation crops, NTFPs, crop production, livestock raising, and fishing to supplement their income. The change to diversified farming is evident in the layout of their farm area as evidenced in the transect walks conducted. NTFP gathering, however, remains to be the highest source of income.

Agroforestry is a complex system that requires investment in time, finances, and labor. A major contribution of this study is the classification of the agroforestry livelihood strategies based on the combination of crops as determined by the households themselves. The

ability of the farmers to determine the best combination of crops for their small plot shows their reflexivity and creativity in determining what is best given their resources and needs. Similar to other findings, the significant influence of income on the adoption of agroforestry systems was highlighted. An agroforestry livelihood strategy that ensures higher income and food sufficiency influences the decision of the farmers to adopt this farming system. Because of the classification of ALS, the researchers were able to determine that the planting of staple crops such as rice ensures food availability while maize and cassava, for example, are cash crops that secure the availability of money.

The result of Pearson's chi-square test showed that income and food sufficiency were associated with the type of livelihood that farmers practiced. In terms of income, adopters who were into pineapple-based and vegetable-based agroforestry strategies were likely to generate higher total household income as compared with other ALS. Rice-based ALS, while exhibiting the lowest income, was associated with all categories of food sufficiency.

Rice-based agroforestry farming system was the most common farming system among the adopters. These adopters combined the growing of fruit trees and plantation crops, NTFP gathering, and fishing to supplement their income. However, these adopters had the lowest cash income and are likely to be even more negatively affected in the future due to increased shade from fruit trees. Farmers were slowly being integrated into the market as they engaged in cash crops such as cassava and pineapple.

While the social, environmental, and economic benefits of agroforestry are well-documented, adoption remained low in Nakai, Khammouan, Lao PDR. Even with the adoption of agroforestry among some of the resettled farmers, adopters currently live on a subsistence level and still rely on NTFP collection as the major source of income. Despite the multiplicity of livelihood strategies, agroforestry adopters remained below the poverty line. There is a need to link farmers to the market to showcase their own products, and, consequently, to reap the benefit of agroforestry farming system. A good marketing system that shows an increase in income may increase the number of adopters. Training on the processing of fruits should be a priority as well because this can give added value to their produce.

The farmers are faced with the need to provide for their families; hence, they are concerned with the immediate, rather than the long-term

environmental and economic benefits associated with agroforestry. It is important to highlight the success of the adopters so that this may inspire the non-adopters to practice agroforestry also.

The characterization of ALS in this study could serve as basis for designing a sustainable livelihood framework, which the extension workers in Nakai can implement. Improvement of agroforestry farming should include projects to increase irrigation accessibility, as well as increase partnership with the private sector for marketing purposes. An analysis of the livelihood strategies of non-adopters should also be conducted to further sharpen the analysis of the decision-making of farmers in the adoption of agroforestry. Moreover, while the respondents reported household food sufficiency, there remains a need to investigate the quality and quantity of food intake.

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