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Livelihoods of small-scale rubber farmers: A comparative study of rubber agroforestry systems and monocropping rubber plots in Southern Thailand

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Abstract

This research compared six pairs of rubber agroforestry systems (rubber-AFS) and monocropping rubber plots (altogether twelve cases) in Songkhla, Phatthalung and Trang provinces in the following dimensions: 1) rubber plot management and socio-economic outcomes, using semi-structured and unstructured interviews, together with records of daily incomes and expenses from the plots during a 12 month period and 2) plant vertical structures and plant diversity. The research framework was based on the concept of five capital assets in the sustainable livelihoods approach (SLA) comprising natural, financial, social, human, and physical capital. The natural capital of the rubber-AFS owners was higher than that of the monocropping rubber plot owners in terms of diverse plant species and multiple vertical stratification and crown cover percentage. These could help reduce soil erosion. Higher numbers of plant species induced financial capital, due to higher average incomes (THB 1,875.46 ± 1,193.51 / day/rai) and lower average expenses in the rubber-AFS (THB 88.58 ± 148.36 /day/rai), compared to the monocropping rubber plots (THB 1,533.77 ± 443.67 /day/rai and THB 97.04 ± 104.14 /day/rai respectively). The social capital of rubber-AFS owners had been developed through co-learning experiences and social relationships between themselves and visitors interested in rubber-AFS. Increases in human capital in the form of the acquisition of knowledge and skills in managing their rubber-AFS with good health were found. An increase in physical capital was not yet evident.

Introduction

Rubber (*Hevea brasilliensis*) is a globally important economic crop. Most rubber supplies are exported from Southeast Asian countries, including Thailand (31%), Indonesia (30%), and Malaysia (9%). In Thailand in the past few decades, the implementation of government policies pertaining to rubber extension has led to vast expansions of rubber plots in the northern and northeastern regions—64,000 and 348,000 hectares, respectively. Ninety percent of the owners are smallholding rubber farmers (Jongrungrot, Thungwa, & Snoeck, 2014). Nevertheless, in the 21st century, the earnings and livelihoods of rubber farmers in Southern Thailand have been severely affected by economic fluctuations, drought, floods, and epidemics, as well as climate change (Sadudee, Limsakul, & Phaengkaew, 2012). Diversification in agricultural systems, including agroforestry, is highlighted as one example of an alternative way for farmers to increase resilience under the threats of climate change (Lasco, Delfino, Catacutan, Simelton, & Wilson, 2014; Lin, 2011). Nath, Inoue,

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and Zoysa (2013) concluded from their study of the livelihoods of small-scale rubber plot owners in India, Sri Lanka, and Bangladesh that due to economic risks in rubber monoculture plantation, rubber agroforestry seems to be the best alternative, as it reconciles economic and sustainable. uses of natural resources, as well as contributing to biodiversity conservation. Likewise, Fox, Castella, and Ziegler (2013) suggest that mixed-cropping systems based on the prevailing rubber plots would significantly enhance the owners' income and resilience during periods of economic uncertainty.

Literature Review

In Thailand, according to Kaewsin's (2001) study on four land-use systems (mono-cropping, mix-cropping, rubber agroforestry, and forest land) focusing on certain ecological characteristics at the plot level, the sustainable land-use systems were those with complex plant community structures, including forest, agroforestry, and mix-cropping rubber plots. At the societal level, Somboonsuke (2002) identified six types of rubber-based smallholding farms which rubber plot owners employed for their economic viability after the 1997 economic crisis in Thailand. It was recommended that government policy support for monoculture rubber smallholders be changed to support the more profitable rubber intercropping and rubber-fruit systems.

Two studies in this decade have emphasized the same issues. Simien and Penot (2011) studied five main rubber-based production systems in Phatthalung and Songkhla using the Olympe modeling software. The researchers concluded that it was not economically profitable to invest in small rubber monoculture farms on plots of less than 1 ha. According to Simien and Penot, small-scale rubber plot owners should diversify their farm incomes by adopting intercropping rubber or agroforestry systems to increase their resilience in a rubber price crisis. Likewise, Somboonsuke, Wetayaprasit, Chernchom, and Pacheera (2011) identified the diversification of a smallholding rubber agroforestry system (SRAS) in three hundred rubber farms in Thailand's southern, eastern and northeastern regions. The farms were classified into three main types (21 systems). The study recommended a number of SRAS development strategies in Southern Thailand to enhance the livelihoods of rubber smallholders.

A study of processes, outcomes, and impacts of 16 rubber-AFS in six Southern provinces classified the rubber-AFS into five types based on intercropping vegetation. All plots were sources of food products, timber, and supplementary income. The rubber-AFS owners could use the food products to enhance social relationships within the communities. The intercropping was not only significant in terms of the reduction of quantity and strength of run-off and increased biodiversity, but it also induced lower temperatures in the plots (Help Conserve Kho Hong Hill Project and Social Sciences for Environmental Management Research Unit, 2012). Similarly, according to Choonaem's (2014) investigation of 25 rubber-AFS in the southern region, most of the plots were intercropped with diverse trees. According to the rubber plot owners' perceptions, the organic matter and carbon dioxide absorption capacities and rubber yields in the plots were high. In addition, Jongrungrot, Thungwa, and Snoeck (2014) assessed the main trajectories of 12 rubber agroforestry farmers in Songkhla and Phatthalung who changed or were moving from monocropping to rubber-AFS. The study identified four different patterns of diversification, as well as the economic and environmental benefits of rubber-AFS.

The objective of this article is to present the findings of a comparative study of rubber-AFS, together with their six neighboring monocropping rubber plots in Songkhla, Phatthalung and Trang provinces in the following dimensions: (1) plot management and socio-economic outcomes, and (2) mosaic plant profile in terms of composition and biodiversity. The research framework was based on the concept of five capital assets: natural, social, human, financial, and physical capital. The capital assets are interrelated components of the sustainable livelihood approach, which is internationally employed as an analytical framework for sustainable living of households and communities (Department for International Development [DFID], 1999).

Methodology

The methods were categorized into two types according to the main issues.

Participants

Six pairs of small holding rubber-AFS and monocropping rubber plots (altogether 12 case studies) and their owners were selected. Four pairs were located in Songkhla, and the other two pairs were in Phatthalung and Trang, respectively. The plots of rubber-AFS were selected due to their diverse intercropping vegetation and the high degree of willingness of the plot owners to take part in data collection. Each neighboring monocropping rubber plot of the rubber-AFS was carefully chosen for similarity in terms of rubber tree age and topography.

Data Collection

Plot management and socio-economic outcomes

Data were collected for 12 months on plot management and socio-economic outcomes (late 2013–early 2014) based on semi-structured and unstructured interviews with the plot owners and their family members. Incomes from rubber and other products in the systems and expenses from the plot management from the rubber-AFS were recorded on a daily basis.

Plant profile structure

Data of plant profile diagrams were derived from mapping of the mosaic crown cover of trees in the target plots. Seven plant profile structures on a sample plot (5 x 40 meters) were conducted in six rubber-AFS and one monocropping rubber plot.

Data Analysis

Plot management and socio-economic outcomes

Analytical induction was employed in the analyses of qualitative data derived from the interviews, whereas descriptive statistics and the Mann-Whitney *U* test were used for the quantitative data of rubber product, incomes, and expenses.

Plant profile structure

The data analysis focused on the percentages of mosaic crown cover in terms of the density of plant species.

Results

Rubber Plot Owners and their Farm Management

Details of the six rubber-AFS owners in terms of their age, location, and attributes of their rubber plot are summarized in Table 1. Data on monocropping rubber plots are as follows: the ages of rubber trees and typology were not different from those of the rubber-AFS, due to our selection criteria. Rubber trees were the only dominant plant species in the plots, which had a low tree density. In terms of plot management, some monocropping rubber plot owners used a chemical fertilizer and herbicide, while most rubber-AFS owners used an organic fertilizer and an annual grass-cutting method in lieu of using a chemical herbicide.

All of the rubber-AFS and monocropping farmers learned about rubber cropping from their parents, as well as acquiring related skills about rubber plot management from the Office of Rubber Replanting Aid Fund (ORRAF) staff. The farmers' main income was from rubber latex and dry sheets. The rubber-AFS farmers sought knowledge and skills in self-managing their rubber-AFS, beginning with seeking and planting specific plant species, which were economically valuable and could grow well in the soil. Consequently, the farmers' achievements were attributed to their long-standing trial-and-error attempts to develop various methods of planting, extending, and improving soil quality. Thereafter, they shared their lessons learned with other people who were interested in rubber agroforestry. In addition to daily income from rubber products, the farmers also collected and sold a variety of products from the diverse vegetation in their plots and gave some to neighbors. The frequency of latex tapping was different depending on their management of time, as well as economic pressures. It was noted that their uses of chemical fertilizer and pesticide were minimal compared to those of the monocropping rubber farmers.

Socio-economic Outcomes of their Rubber Farms

The average rubber yield from both rubber-AFS and monocropping plots are compared in terms of quantity and monetary value in Figure 1.

Table 1 Attributes of rubber-AFS and their owners

Owner's name/age/province	Intercropping trees/ area of rubber-AFS (acre*)	Age of rubber trees (years old)	Soil property	Age of rubber trees when beginning inter-cropping (years old)	Number of plant species cropped & naturally growing (species)	Percentage of crown cover density (%)	Tree density (tree/rai or 0.4 acre)	Number of seedlings and poles (tree/rai or 0.4 acre)
Mr.Suchart Na Song-khla/72 yrs old/ Songkhla	Forest trees/ 5 acres	20	Sandy soil	7	20	More than 95	319	2,834
Mr. Rung-rus Kaew-on/49 yrs old/ Songkhla	Forest trees and fruit trees/1.8 acres	24	Sandy soil	13	6	More than 85	215	2,988
Mr. Kamon Sarm-huay/48 years old/ Trang	Forest tree/ 18 acres	30	Hard and compact soil	14	13	More than 85	158	2,237
Mr. Withoon Noosen/ 65 years old/ Phatthalung	Natural succession trees/1.8 acres	46	Sandy soil	31	28	More than 85	184	3,294
Mr.Khamnueng Nuanmanee/ 49 years old/ Songkhla	Snake fruit-Gnetum/ 1.8 acres	8	Clay soil & sandy soil	3	11	80	184	3,294
Mr.Chalin Thamma-waroe/39 years old/ Songkhla	Natural succession trees/ 2 acres	40	Clay soil	Leaving trees to grow naturally since the beginning	19	More than75	171	1,938

Note: *1 acre = 2.5 rais = 0.405 hectares.

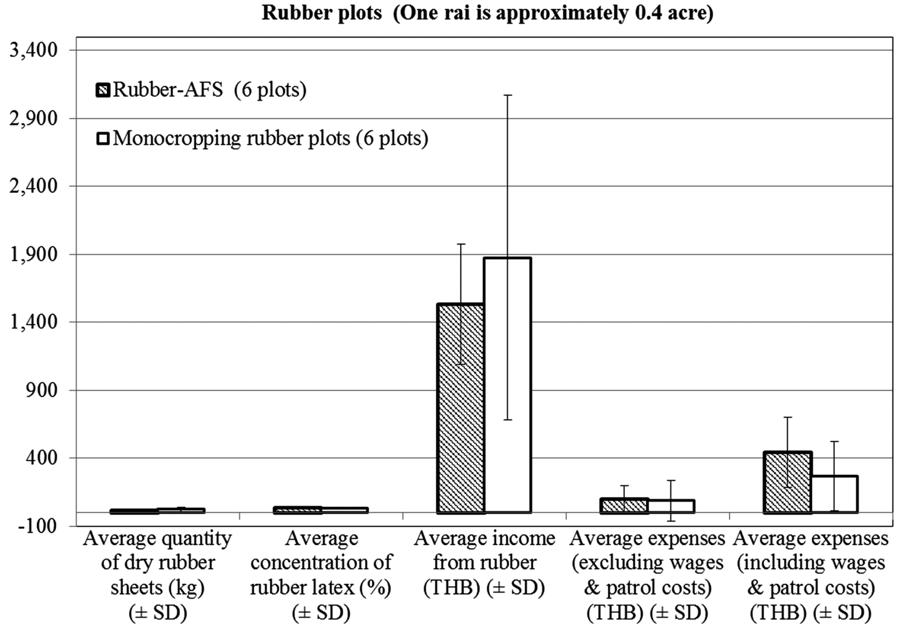

Figure 1 Comparison of average quantity of dry rubber sheets, concentration of rubber latex, income from rubber products, expenses (excluding and including wages and patrol costs) of six rubber-AFS and six monocropping rubber plots (per day per rai)

Note: The average price of rubber latex during 2012–2013 was THB 73.43 /kg.
One rai is approximately 0.4 acres or 0.16 ha.

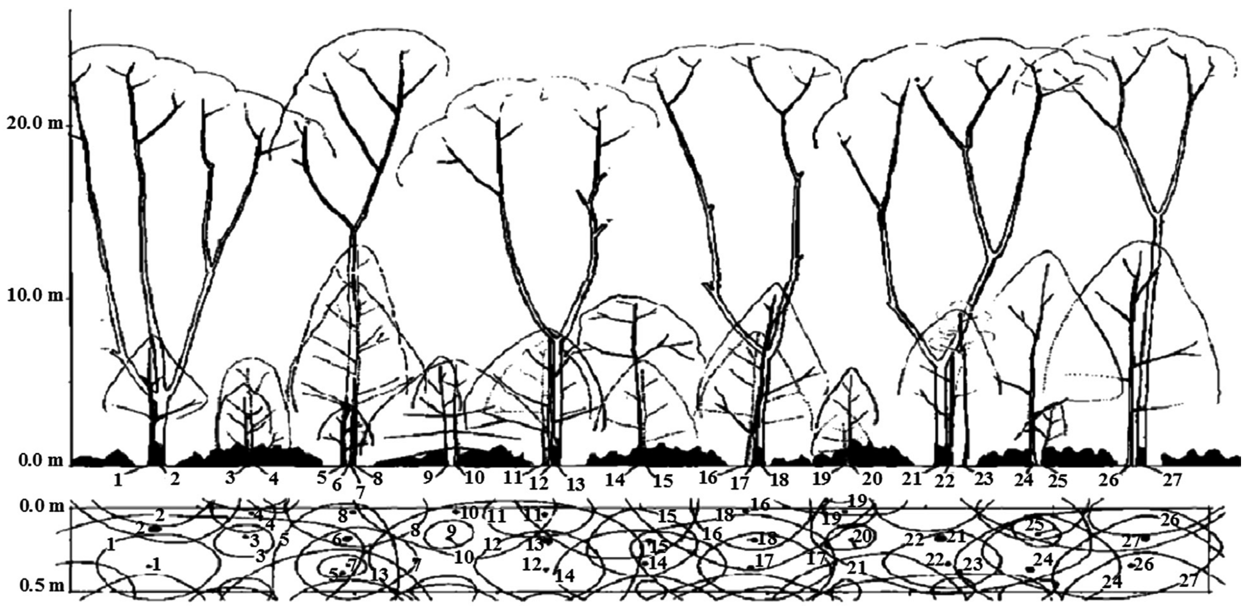

Figure 2 Vertical and horizontal transectional diagram of vertical stratification of plant species within an area of 1 rai of rubber-AFS owned by Mr. Suchart Na Songkhla

The average quantity of dry rubber sheets and concentration of rubber latex of rubber-AFS were higher by 19.51 percent and 1.43 percent, respectively, than those of monocropping rubber plots. The average income of rubber-AFS was 22.28 percent higher than that of monocropping rubber plots. The expenses including and excluding wages and patrol costs were lower by 39.53 percent and 8.46 percent than those of their counterparts, respectively. Although these outcomes were not statistically significant at the .05 level, the values of rubber-AFS are evident, compared to those of the monocropping ones. The rubber-AFS owners also gave various products from their rubber-AFS to neighbors and visitors on different occasions. Some of them gave seedlings and other products directly to different groups receivers, but others were unable to determine the frequency and quantity of their products which had been taken by unidentified visitors.

In addition, four rubber-AFS owners played a significant role as learning resources for people interested in the issue, as a large number of people came to learn about the rubber-AFS. Most of the visitors were inspired to apply what they learned in modifying their monocropping rubber plots into rubber-AFS, as well as keeping in contact with the rubber-AFS owners to share knowledge and information of rubber-AFS development.

Plant Community Structures and Biodiversity

A high degree of diversity of plant species in the rubber-AFS was evident (Figure 2).

With reference to Figure 2, the rubber-AFS area of 1 rai was mainly comprised of rubber trees as a top layer, with a height of 26 meters. The middle layer comprised eaglewood trees (*Aquilaria Crassn Pieerea*) and ironwood (*Hopea odorata* Roxb), 10 meters in height. The understory was dominated by seedlings and poles (>32 species). The total number of seedlings per rai was 2,834, which could be categorized into 22 species of seasonal fruit trees/wild animal feed, 18 species of edible plants, and 15 species of multi-purpose trees.

Based on maps of the mosaic crown cover of all rubber-AFS and one monocropping rubber plot, the average cover of plant species in the rubber-AFS and monocropping rubber plots were over 80 percent and 68 percent, respectively. The rubber-AFS owners had different choices in their selections of intercropping trees, most of which could provide food, herb, fuel wood, and timber, as well as seasonal fruits for both humans and wild animals.

Analysis of the rubber-AFS profiles on the sampling plot of 5×40 meters showed that the tree structures had great potential to preserve water and soil, due to the multiple levels of vertical stratification of plant species. This result was elated to Bumrungsri's et al. (2012) research findings of environmental dimensions in the same research areas that the amount of runoff in monocropping rubber plots was 0.3–5 times that of the rubber-AFS. The quantity of moisture in the rubber-AFS was 1.4 percent higher than in the mononcropping rubber plots. Litter fall in the rubber-AFS was 1.5–1.8 times that of the monocropping plots (Kittitornkool et al., 2014).

When asked what they gained from their rubber-AFS, the rubber-AFS owners ranked the outcomes as: natural, social, financial, and human capital, while physical capital was not noted.

Discussion

The vertical stratification and diverse plant species in the rubber-AFS could enhance its natural capital, including soil, biodiversity, water, ecosystem, and natural resources. It is likely that the multiple canopy layers of rubber-AFS reduce the degree of soil erosion, as the energy of raindrops dropping from the top level of canopy layers gradually decreases through the tree layers (Makaraphirom, Tangtham, & Khemnak, 1991). Waiyarat (2016) also concluded from her research in the same research areas that the quantities of nitrogen, phosphorus, and calcium in the rubber-AFS were 1.4–1.7 times those found in the monocropping rubber plots. According to Kaewwongsri (2005), these factors were of great use in watershed conservation, as they caused soil restructuring, which increased the water absorption capacity, as well as reducing the run-off strength. In addition, deep-rooted trees and shrubs could also decrease the degree of shallow soil erosion because their horizontally spreading roots could hold the surface soil layers together tightly (Hamilton, 2008; Sidle et al., 2006 as cited in Khidgarnmoh et al., 2014). Likewise, the study by Khidgarnmoh et al. (2014) in traditional intercropping rubber plots in Surat Thani showed that fruit trees in the plots, like forest trees, played a vital role in fixing ground soil horizontally and vertically.

Moreover, layers of vertical tree stratification and the quantity of litter in rubber-AFS induce microclimatic and microhabitat niches for diverse wild animals. Bumrungsri et al. (2012) found 25 species of birds and 11 bat species in a rubber-AFS in Phatthalung, compared to 17–22 bird species and 2–4 bat species in three adjacent monocropping rubber plots. The biomass of insects in the rubber-AFS was double that found in the monocropping rubber plots. These organisms could play vital ecological roles in nearby farmland with regard to pollination, seed distribution, and organic decomposition among others.

The rubber-AFS contributed not only to the enhancement of natural capital, but also to increases in other forms of capital, particularly financial capital. It was evident that the owners could use or sell a variety of products from their plots all year round, especially in the dry season when the rubber trees produced little of commercial value. In addition to collecting vegetables, fruits, and other products for household consumption, due to their high value and market demand, the rubber-AFS owners considered timber trees as their long-term investment for themselves and their children. These trees were also natural nurseries for young seedlings, which could be sold in the future. Litter from the intercropping vegetation increased the quantity of nutrient return to the soil and balanced nutrient cycling in the farm system.

Social capital, which includes networks of social relations and trust among members of a specific group or community, is another tangible result highlighted by the rubber-AFS owners. Four of them played a key role in providing knowledge of rubber-AFS to people who came to learn rubber agroforestry principles, techniques, and methods. Inspired by the owners' insights and concrete outcomes, a large number of visitors went back home with intentions to turn their monocropping rubber plots into rubber-AFS. The owners' open and vivid discussions in which they shared their knowledge resulted in the establishment of close connections between the visitors and the owners. They also kept in contact to learn together about how to develop their rubber-AFS, as well as having on-going co-learning activities. Four rubber-AFS owners felt proud that due to their long-standing rubber-AFS knowledge-sharing activities, they had broad social networks all over Thailand.

The learning process of rubber-AFS development has also gradually enhanced human capital-knowledge, skills and the health of the owners. In the beginning, their learning was based on consistent and close observations of the dynamics of nature and plant species, applying local wisdom transmitted by their ancestors, and persistent trial-and-error. The rubber-AFS owners developed their own wisdom derived from long-standing intensive practices and learning experiences in managing their rubber-AFS. Thereafter, they shared their wisdom with other people. The dynamic process of human capital development of the owners was based on sharing what they had learned by themselves about rubber-AFS as well as what they gained from discussions with visitors and through giving lectures to different people. Moreover, working in the shady and pleasant atmosphere of rubber-AFS and consuming organic products from their own plots resulted in good health for the owners.

Lasco, Delfion, Catacutan, Simelton, and Wilson (2014) concluded from their review of research in different regions that agroforestry was a sustainable use of land in multi-functional landscapes, as it provided multiple benefits: food provision, supplementary income, and environmental services, all of which were vital in enhancing farmers' abilities to adapt to climate change. In the context of Southern Thailand and other regions where rubber-based farming has been the main source of livelihoods, rubber-AFS can be a viable alternative farming system for small-scale rubber farmers in the current economic and environmental crises.

Conclusion

The research evidence indicated the economic, social, and ecological significance of rubber-AFS in terms of farm management patterns, as well as providing socio-economic outcomes and plant community structure. These factors could enhance the natural, financial, social, and human capital of the rubber-AFS farmers. The findings can be employed in the promotion process for small-scale rubber farmers to reassure them of the significance of rubber-AFS. However, there are a number of challenges for the promotion of rubber-AFS adoption in Thailand. First, research is required to investigate how and under what conditions smallholder households adopt the systems in response to climate threats. Second, new approaches are needed to overcome adoption barriers, such as secure land tenure and filling information gaps, and linking rubber-AFS to climate change, food security, and development policies (Lasco et al., 2014). In fact, since 2014 the Office of Rubber Replanting Aid Fund (ORRAF) has implemented a policy of funding intercropping rubber replanting (type 5) to reduce the economic risk of monocropping rubber plantation. In order to maximize the utilization of resources in the plot and to promote biodiversity in ecosystems, financial support is provided for replanting with two or more agricultural activities with 40 percent or less rubber trees or other economic trees as the main component (Office of Rubber Replanting Aid Fund [ORRAF], 2014). However, the major concern is how to provide support compatible with smallholding rubber owners with different needs and rubber plot conditions. It is also vital to assure the owners of the economic and environmental sustainability of rubber-AFS. As Lin (2011) recommended, stakeholder involvement and participatory research were useful tools in developing adaptation options for local communities. It is a challenging process for all concerned sectors in Thailand to collaborate in the process of enhancing the adoption of rubber-AFS for smallholders in the years to come.

Conflict of Interest

There is no conflict of interest.

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