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REGULAR RESEARCH ARTICLE

Agroforestry rubber networks and farmers groups in Phatthalung area in Southern Thailand: A potential for an innovation platform?

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ABSTRACT

The study took place in southern Thailand, in Phatthalung province, and is part of "Heveadapt," a Franco-Thai research project. The aim of this project was to show how smallholder rubber plantations can adapt and remain sustainable in the face of variable climatic conditions and deep changes in socio-economic context. Among the various types of cropping systems, agroforestry practices were identified as promising. Rubber agroforestry systems (AFS) are economically more productive than rubber monocrop plantations and give more flexibility to smallholders, in particular when rubber prices are low, which has been the case since 2013. However, adoption of AFS during the mature period of the plantations is very low in Thailand. The policy to boost rubber agroforestry practices still needs to be developed with all local stakeholders. The objectives of the study were to identify the possibilities and capacities to use current AFS dynamic networks as a basis to set up a rubber agroforestry innovation platform. The research team studied: i) farmers' collective organizations, groups or networks with rubber AFS partially or entirely and ii) the social dynamic enabling the sharing of knowledge and know-how. An individual producer's grid, with original farmers or strong knowledge with ease of sharing, was also studied. The role of local institutions involved in the promotion of rubber AFS was also analyzed. This allowed us to design an innovation platform and to define activities that suit the socio-economic context of Phatthalung province. The main aims of the platform are to promote cooperation among innovative producers and the transmission between them of knowledge and know-how about rubber AFS. This could an efficient tool that Thai rubber institutions could set up to encourage the adoption of rubber AFS by farmers.

KEYWORDS

Agroforestry; innovation platform; group; network; interactions; knowledge and know-how transmission; rubber.

1. INTRODUCTION

Since 1991, Thailand has been the top producer and exporter of natural rubber in the world, with 4.3 million of tons produced in 2014 (RRIT, 2015), which represents 35% of the world production (IRSG 2015). Exports account for 87% of its production. Those volumes are constantly increasing from one year to the next, mainly because of the rubber market demand. Therefore, natural rubber plays a key role in the Thai national economy. In the south, rubber contributes to 15% of the cropped area (Delarue & Chambon, 2012) and is the traditional natural rubber cradle: some farms are starting their third successive production cycle. As a result, this region concentrated 72% of the national production in 2014 (Lehoux et al., 2019). 90% of Thai natural rubber is produced by small family farms of less than 8 ha (Somboonsuke & Wettayaprasit, 2013). Besides, natural rubber prices have always been fluctuating, but never as much as in the beginning of the 2010's. Natural rubber prices even reached a record price of 5.56 USD/dry kg (SMR20 in Kuala Lumpur) in February 2011. However, this golden age

stopped at the end of 2012 and the natural rubber price has been decreasing since. As farm gate prices are indexed on world prices, they directly impact farmers (Andriesse & Tanwattana, 2018).

Rubber agroforestry systems (AFS) appear these days as the diversified systems most suited to overcome price volatility, in particular for smallholders specialized in rubber in Phatthalung who have a limited planting area (on average 3 ha/farm). Several studies of the diversity of rubber-based AFS in Southern Thailand have been implemented since the 1990's. In 2005, Simien characterized socio-economically and modeled rubber farms in Southern Thailand. In 2011, Somboonsuke et al established a typology of existing AFS in Songkhla province. In 2014, Jongrungrot and Thungwa evaluated the technical and economic aspects of those systems and modeled them in Phatthalung and Songkhla provinces, as did Stroesser in the Phatthalung area in 2015 (Penot, Stroesser and al, 2016).

Whereas previous studies focused on describing those systems and evaluating their economic performances (Longpichai 2012), (Onanong 2012) (Wibawa and al, 2006) , the current study focused on a dynamic analysis of how AFS farmers have formed AFS groups and networks in Phatthalung province in the last 30 years. The final objective was to explore the possibility of using such experiences in AFS to boost AFS adoption by local farmers through an innovation platform.

So far, rubber AFS represent only 10% of the total area of rubber plantation in southern Thailand (Chambon et al., 2021). However, the farmers that developed these rubber AFS did it for very specific reasons. There is now solid knowledge together with diversified and innovative systems thanks to the publication of several studies in the last ten years (Somboonsuke et al., 2011; (Jongrungrot 2014); (Stroesser et al., 2018); (Tongkaemkaew et al., 2020). Agroforestry has a set of advantages and positive externalities: income diversification and consequently greater resilience of farmers, agricultural income increase, better soil fertility after 30 years and better water management, carbon storage, etc. So now it seems interesting to transfer this knowledge from farmer to farmer, and why not through an innovation platform.

1.1 A short history of rubber agroforestry systems in Thailand

Agroforestry is defined by Torquebiau et al. (2000) as: "the cultivation of the soil with a simultaneous or sequential association of trees and crops or animals to obtain products or services useful to man". In the local context, this definition can be refined thanks to previous studies on AFS, whose main component is the rubber tree: Somboonsuke et al. (2011), Jongrungrot et al. (2014) and Charernjiratragul (1991) in Southern Thailand.

Historically, rubber trees were grown from seeds and without grafting in family rubber plantations, alongside a wide diversity of fruit and timber trees. The jungle rubber used to be the most complex system, but its rubber yield was very low: a maximum of 300 kg per hectare per year. In the 1960's, the Office of Rubber Replanting Aid Fund (ORRAF) launched a replanting program in Thailand: it promoted the plantation of clonal trees (grafted seedlings), without associating other trees during the mature period and even forbidding it. These measures aimed at increasing rubber yield, in order to improve farmers' income, and thus their livelihood. The replanting program has been especially efficient: the yield reached 1,700 kg per year on average in 2018 (Lehoux and al, 2018). Almost all rubber plantations in Thailand are now clonal (RRIM600 essentially). Moreover, 90% of mature plantations are monoculture (Somboonsuke & Wettayaprasit, 2013 – quoted by Jongrungrot, 2015).

However, the agroforestry tradition did not completely disappear in Thailand in the 1960's. It is even a rather common practice during the first three or four years of the immature phase: 65% of plantations, spread across 10 provinces in Thailand, are concerned (Delarue and Chambon, 2012). Growing food crops between tree rows can

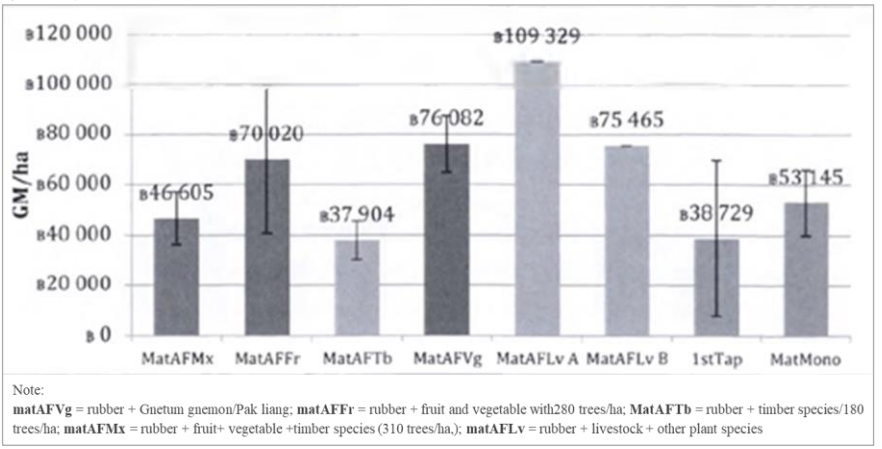
generate income, while waiting for the new plantation to become productive. In the 1980/90's, a minority of farmers kept cultivating AFS by choice, and in spite of the ORRAF ban. Located in the south, these farmers associate clonal rubber trees with 2 to 3 other perennial species on average (fruit trees such as durian, mangosteen and longan and timber trees such as teak, mahogany, etc.). A few rare "jungle rubber" systems can still be observed in Phatthalung province (first author's personal observations, 2017), as well as in Phang Nga province (Penot & Ollivier, 2009). Those farmers are usually organized in associations or informal networks to share their knowledge and experiments and to promote their systems (Jongrungrot, 2015). ORRAF officially lifted its ban in 1992, while maintaining interest in and funding for replantation for rubber monoculture. In 2001, some AFS trials were established by ORRAF and AFS was officially promoted by the rubber act. AFS were really promoted in practice after 2015 to overcome low rubber prices. However, there is an old tradition of agroforestry under specific conditions; AFS currently remain a marginal practice.

The Rubber Authority of Thailand (RAOT, new organization including ORRAF and RRIT the rubber research institute) recently changed its policy and began to promote AFS practices in 2015 as an attempt to overcome the strong negative impact of rubber price volatility on farmers' income.

Some AFS farmers promoted a different approach to rural development, through His Majesty the King's "New Theory of Agriculture", which later became the "sufficient economy philosophy", which is socially very important for these farmers' communities. The downward trend of rubber prices in the last 8 years certainly also played a part in farmers' attitudes. Rubber AFS definitely come within the scope of this new approach.

1.2 Expected advantages of agroforestry systems

There are three main cropping systems with mature rubber trees: i) Monoculture plots, ii) Agroforestry plots with a "simple AFS" (rubber trees and a few other perennial species), iii) Agroforests, or "complex AFS" (rubber trees and many other perennial species).



Note:
matAFVg = rubber + Gnetum gnemon/Pak liang; **matAFFr** = rubber + fruit and vegetable with280 trees/ha; **MatAFTb** = rubber + timber species/180 trees/ha; **matAFMx** = rubber + fruit+ vegetable +timber species (310 trees/ha,); **matAFLv** = rubber + livestock + other plant species

Figure 1. Gross margin per hectare and per year for different kinds of rubber agroforestry systems and comparison with rubber monocrops (Source: Stroesser, 2018)

We chose to focus on complex AFS with mainly tree or shrub intercropping during the mature phase, with many different species. We did not take into account mature rubber-based AFS with trees only on the edge of the plot (hedgerow systems) or with a density below 30 associated trees per hectare within the plot. Researchers have already proved the greater productivity of rubber AFS compared to rubber monocrop systems:

Stroesser in 2018 (figure 1), Jongrungrot & Thungwa et al. (2014) and Somboonsuke et al. (2011) have shown better soil productivity, with a higher net margin/ha for AFS combining fruit and rubber trees.

Moreover, some farmers are already farming according to agroforestry theory. Stroesser reported more than 43 different AFS in Phatthalung province, associating from one to 30 species (Stroesser, 2018) as well as Jongrungrot in 2014.

Resilience is the propensity of a farmer to keep his farm structure and productivity even in turbulent times. Farm diversification increases farmers' economic resilience. Stroesser (2018) showed that when rubber prices are low, AFS (with fruits or vegetables) maintain farmers' income and compensate rubber price volatility. This price volatility quickly raised awareness among farmers of the advantages of AFS. Agroforestry is a multifunctional way of farming with eco-systemic services as well as positive social and institutional advantages. Advantages are now recognized and well known as shown in figure 2 and have been promoted in Thailand since 2015. We observe that the same trend occurs also in Indonesia.

Ecological	*Economic*	*Social and institutional*
- reduced soil erosion - high soil organic matter content - buffered soil moisture and temperature - closed nutrient cycling - improved soil physico-chemical properties - efficient use of light and water - high wild plant and animal biodiversity - use of endogenous resources - contribution to on-farm production of wood and fuel wood - high soil biotic activity - better scope for evolution and diversification of economic plants - differentiated vertical and horizontal management zones and related ecological niches - potential for organically grown products	- significant use of endogenous resources - high safety factor against marketing and seasonality hazards - reduced cash needs - high and diversified bio-physical outputs (plant and animal food, medicines, fibbers, etc.) - socio-economic outputs diversified and distributed over time - balance between subsistence and cash income - building up of capital - boosting rural industries and employment - adjustment to varied contexts - yield stability - management flexibility (intensive vs. extensive) - economic resilience (value as "land reserve")	- reduced and flexible labor needs - contribution to nutritional security - contribution to community socialization - preservation of traditional knowledge - biodiversity linked to traditions and practices - key role of women - equitable distribution of products - land reserve function (for alternative land-uses) - maintenance of access rights to common goods (e.g., fruits) - flexibility of ownership (private vs. communal)

Source: Adapted from Torquebiau (1992), Penot (2003), and Kumar and Nair (2004).

Figure 2. Social, economic and ecological advantages of agroforestry systems

1.3 A recent context with extremely volatile world prices since 2012

During the last 10 years, rubber prices have experienced unprecedented variations (Figure 3): after two peaks in 2006 and 2008, prices crashed in 2008-09 (for SMR 20/Standard Malaysian Rubber). Then, they quickly recovered to a new significant peak in 2010-11, since when they have been constantly decreasing. The price over the last 4 years has been around 1.3 US$/kg.

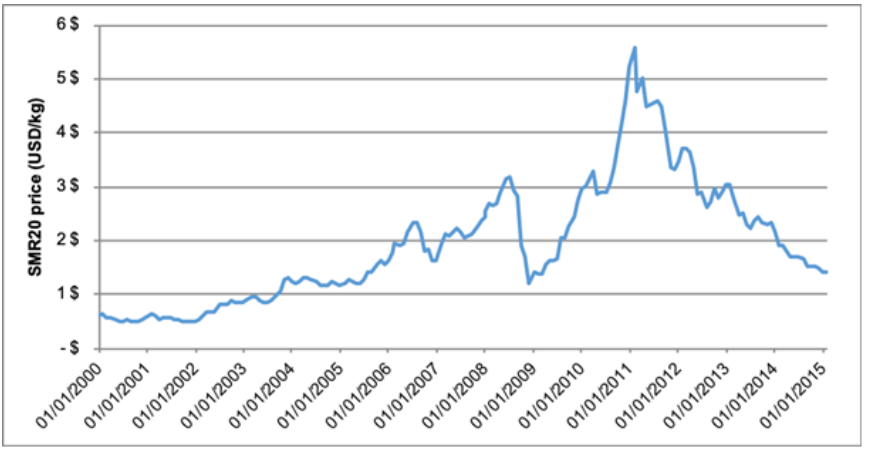


Figure 3. Evolution of prevailing prices of natural rubber (SMR20, Kuala Lumpur)

The natural rubber market is linked to the global state of the world economy and transportation in particular. Several factors can explain rubber price volatility: changes in offer/demand, oil price and ratio with synthetic rubber (substitution effect), impact of a low rubber price period on replanting with a delayed effect of about 10 years, climatic variations, impact of currency fluctuations, policies and actions of various players (effect of new plantations in China, Cambodia, Vietnam and Laos, for instance). Since 2013, low rubber prices have pushed farmers to search for new more diversified agro-systems to tackle long-term rubber price depreciation (Nicod et al., 2020), in particular for rubber AFS (based on clones). Agroforestry is still not widely adopted in Thailand; it represents only 10% of rubber fields (Jongrungrot and al 2014), whereas in Indonesia it represents more than 30%. Farmers used to monoculture suffer from a lack of knowledge and know-how on agroforestry practices. Farmers using agroforestry practices are relatively isolated, as not officially recognized by ORRAF/RAOT before 2015, and most develop such systems initially for social reasons (Stroesser, 2018). The main question is how rubber AFS farmers are structured. It seems necessary to identify the type of networks, farmers' interactions and the organizations that do exist today.

In view of the favorable sociopolitical context for agroforestry in the context of rubber prices crisis, the time seems right to launch a regional innovation platform (IP) to promote rubber AFS in Phatthalung province. Therefore, it required to explore local organizations to assess the feasibility of the development of such IP to encourage he transmission of knowledge and adoption of agroforestry practices on a large scale.

2. MATERIAL AND METHODS

The study area is Phattallung province in southern Thailand, the historical rubber production area. We will first present the conceptual approach and then detail the sample and surveys implemented.

2.1 The conceptual approach

We focused on the reviewing adoption of agroforestry practices in the two local types of communities: farmers' groups and AFS networks with different types of organization and links. According to Merton (1973), "the concept of group defines a set of persons in interaction but following established rules. Mullins said the group begins when the persons begin to draw a boundary around all the people who want to work together on the same topic, the group has a name, and share a history and the same references."

A network does not imply a common definition by the members. Networks are almost built by the observer. Each member has his own perception of the network. Observation of relationships and interactions between persons around a specific topic indicates a structural organization. A network is built from a set of relations following a theme generated by members of the network.

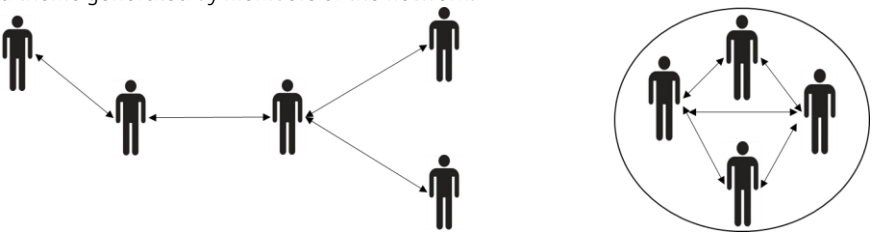


Figure 4. Different types of actors regroupment (Lazega, 1994).

2.1.1 From groups/networks to Innovation Platform

The final objective is to move from existing groups and networks to the creation of an IP, the concept of which is recent and still quite open. Even though this concept is flexible (Tittonell et al., 2012), we can still define it as a tool which brings together stakeholders from different environments and with different professional skills in order to talk, to organize, to implement a new idea or practice. These ideas are born from interactions and creativity in order to solve a problem or to reach a common specific objective. The aim of the IP is an interactive approach which explores opportunities and solutions (Nyikahadzoi et al., 2012). It is a place to exchange knowledge and practices, through experiments, observations, evaluation, and discussions (Nyikahadzoi et al., 2012). Stakeholders transmit their know-how and knowledge multidirectionally to each other (Tittonell et al., 2012). The IP is a social tool, stimulating collective actions and discussions. It increases people's ability to innovate (Tenywa et al., 2011). An IP is always evolving, along with its environment and members.

An IP involves different stakeholders (farmers, researchers, institutions, technicians, companies, carriers, etc.) with different profiles and different objectives. But they can find a common solution to problems through discussion. Everyone defines his opportunities and weaknesses and his part in the work. Everyone can act on one or more points of the chain. Partners need a serious collaboration to solve problems and develop innovations: they decide together. An IP can be implemented at different scales: local, regional, and national, as according to the scale the stakeholders and their involvement are different (Nyikahadzoi et al., 2012). The present study focused on the identification of a regional IP with a focus on rubber AFS.

Farmers' knowledge and know-how are well recognized in a regional IP. But in political terms, the institutional framework and the participation of local leadership are also essential. The challenge is to strengthen the capacity for innovation of the group by creating strong relations in the IP, and by improving everyone's understanding. Group skills evolve over time. Every stakeholder should feel concerned about and involved in the IP and its topics. At the beginning, researchers can be facilitators, defining the potential, characteristics and responsibilities of every stakeholder in order to boost farmers' participation and share. The IP can design a stakeholder's diagram. The IP is the forum for the sharing of knowledge. In concrete terms, in a regional IP, sharing working days on the farm with several farmers can be implemented through sessions with a farmer-to-farmer approach, training courses, specific agroforestry events, regular meetings, etc. In the present study, we clearly focus on what seems to be best suited to the Phatthalung area.

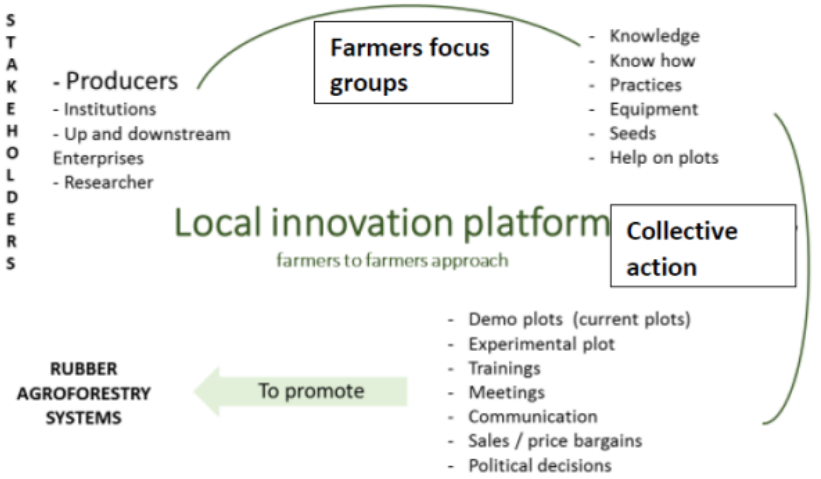


Figure 5. Regional Innovation Platform concept.

2.2 Sampling

Phatthalung province was selected based on previous studies by local universities (TSU and PSU) showing many AFS systems in the area.

Figure 6. Map of studied districts in Phatthalung.
[Source: www.mapofthailand.org, consulted 08/09/2017]

Based on the results of preliminary interviews with local institutions (RAOT, provincial agricultural offices, department of agricultural extension), we focused to

implement surveys on 9 districts out of the 11 of the provinces. The aim was to contribute to build a dense, diverse and broad network of farmers all around Phatthalung province (figure 5).

A total sample of 54 producers were investigated through individual interviews following a selective local sampling after discussion with local key informants in a preliminary information village meeting. Due to large dissemination of potential AFS farmers, a classical representative sampling method was not operational leading to a selective sampling. The criterias were based on RAS representativity and groups recognition. It consisted of 8 producers for the Banna agroforestry community (Sri Nakarindra), 5 from the Lung Toon network (Tamod), 9 from the Lung Boonchu network (Pa Phayom) and 29 individual producers outside groups and networks considered as "pure" individuals out of any structuration. The idea behind the selection of groups, networks and satellite farmers was to be relatively representative of the province for rubber AFS in order to set up a future IP rapidly at the regional level (CF table 1).

The study was conducted to obtain a good geographical distribution of the groups and individual producers throughout the area. The distribution is relatively homogeneous from the north to the south of Phatthalung province and is concentrated on the western part of the province (Figure 6). The distribution can be justified by topographic conditions. The land is higher near the mountains, in the west. In the east, the land is low and easily flooded, so it is used to grow rice, even if some plots at higher elevations have been converted into rubber plantations.

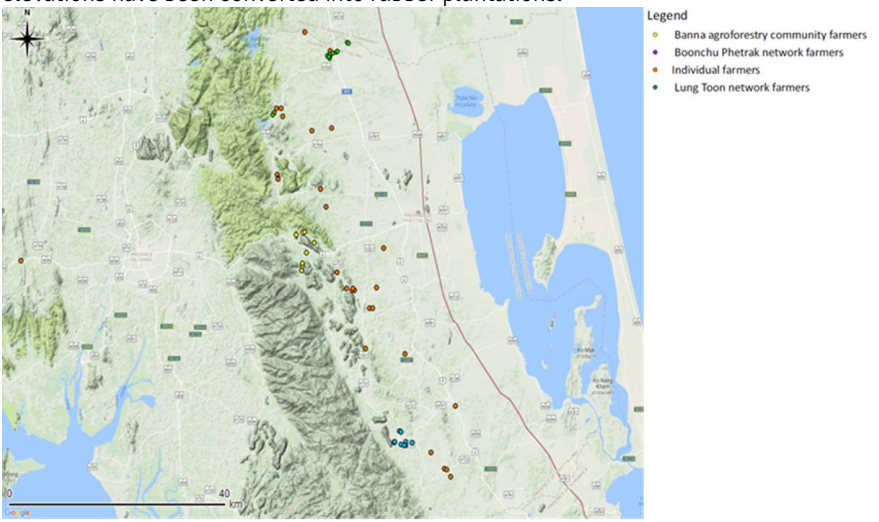


Figure 7. Distribution of networks, groups and producers in Phatthalung province (our study).

2.3 Surveys et traitements des résultats

Meetings with local institutions (RAOT, Provincial Agricultural Office/ Department of Agricultural Extension) were done in order to collect global information about existing AFS groups

Surveys were implemented with individuals and communities, groups and network members using a focus groups approach. Data were collected through semi-directive surveys of farmers, farmers' organizations, and local institutions. Surveys about groups and networks were implemented by Theriez (2017), under the supervision of CIRAD and TSU researchers. The information collected on 3 groups concerned: the leader, the characteristics of the group, how the group was created and how it functioned, what

are the relationships inside the group and outside the group (with other groups, institutions etc.). Interviews with individual farmers allowed collecting ata on the characteristics of the farms, the activity system, the agroforestry practices and their drivers, the reasons for and the interest of joining a group.

One main constraint has been the difficulty of bringing together the members of a group or a network and of accurately defining them as the borders of groups and networks can be fuzzy. The description of networks may therefore be partial: the need for an introduction to everyone through an advisor and lack of time did not allow for an in-depth study. Description of the networks or groups focuses on how they could be used later in an IP. The real network may often be larger, as this survey focused on agroforestry practices. The questionnaire was based on linkages and structuration identification, description of AFS cropping systems, links with fruit/timber value chains and farmers global strategies identification.

Data were processed on Excel Sheet. No particular statistical software was used as most data were manually processed. A mainly qualitative step by step analysis was used to issue all tables and graphs in particular to understand links between people. This type of qualitative data is not adapted to a particular statistical process.

3. RESULTS AND DISCUSSION

3.1 Characteristics of Producer organization in Phatthalung

Table 1 displays the groups and networks selected in this study, as well as satellite individual farmers.

Table 1. Formalization of studied organizations in Phatthalung.

Name	Banna agroforestry community	Lung Boonchu network	Lung Toon network	Satellite farmers
District	Sri Nakarindra	Pa Phayom	Tamod	9 districts
Focus	Agroforestry	Diversification	Agroforestry	Diverse
Type of structuring	Group	Network		Agroforestry innovative farmers
Characteristic	- Established list of members. - Regular meetings. - Share financial support - Share an identity, a history and values.	- Not all members know each other. - No regular meetings. - No delimitation.		- Farmers who talk about agroforestry with: neighbors, family, friends, groups but not specialized in AF. - Producers spread all over the territory and not affiliated with any group or network.

All groups have their own network (table 2) or an interaction network between neighbors (only at the village level) with whom they have been able to share government support of a local project. In the end, they all interact with a social network, albeit often limited to the village level. Satellite producers may also have a DOAE (Department of Agricultural Extension) learning center on specific practices on their farm. Finally, every producer has at least one intra-village network and is not isolated.

The three local groups/networks surveyed are presented in table 2 to cover different existing communities in the area.

Table 2. Identity card of the studied groups.

Name	Banna agroforestry community	Lung Toon network	Lung Boonchu network
Leader	Lung Jay	Lung Toon	Lung Boonchu
Leader's age	67	69	64
Date of birth of the collective	1995	1993	2004
Subdistrict	Banna	Tamod and Kong Yai	Pa Phayom
Villages	Moo 2, Moo 5, Moo 8	Tamod: Moo 4, Moo 9 Kong Yai: Moo 2	Moo 5, Moo 6, Moo 7
Greatest distance between two members	6.3 km	3.3 km	4.5 km
Members	8 members	> 10 members	> 10 members
First objective	To preserve local species.	Increase forest area by preserving local species and natural resources.	Access to more agricultural knowledge to increase farmers' incomes.

The “pioneers farmers” began intensive agroforestry as soon as in the 1990s. The number of network members was not originally fixed, but is tending to stabilize now. The difference between networks and groups relies on the perception of a group of people with reciprocal interactions, where new people can be easily integrated. In contrast, in a group, the framework is more rigid: a fixed list of members and participation in events or meetings is often a prerequisite for organization. Finally, such groups/networks extend over several villages, but rarely beyond neighboring sub-districts. Only the Lung Toon network, but located on the Tamod sub-district border, extends over two sub-districts. The objectives of each group/network are presented in Table 3.

Table 3. Objectives and activities organized by the groups/communities

Name	Objectives	Tools and activities
Banna agroforestry community	- Develop new markets for producers. - Increase producer income. - Share knowledge. - Have good environmental practices.	- Join government activities. - Group production to negotiate prices. - Visit farms. - Lead projects to obtain funding.
Lung Boonchu initial group	- Decrease dependency on inputs. - Crop diversification. - Find innovative species to mix with rubber trees. - Develop networks for knowledge.	- Training organized by the government. - Set up local markets. - Visit farms. - Make organic compost. - Group production to obtain good prices and new consumers. - Join together to apply for funding.
Lung Toon initial group	- Plant as many trees as possible. - Cultivate organically. - Convince as many people as possible to plant trees and have organic farming practices	- Help each other with hard tasks. - Allow everyone to obtain free seedlings from the forestry department. - Write a book about agroforestry. - Organize crop diversification activities.

These 3 groups are representative of what do exist in Southern Thailand. AFS are linked with other development activities such as poultry, fish pond, apiculture, fruit production, timber planting, remaining forest protection and global crop and income diversification. AFS is different from “integrated farming” but very close in terms of strategy. AFS is the combination of several production on the same plot, also the results of the fact that land is becoming scarce with family generational transmission of patrimony. AFS appears as a key strategy among other potential alternative for income diversification.

DOAE organizes inter-village or even inter-district training, where producers can discuss their farming practices in learning centers. These activities are sometimes limited to village DOAE leaders, but sometimes allow some producers with a learning center and/or on a DOAE list to expand their network and even get to know members of other groups. A huge interaction network does already exist in Phatthalung. Even though we found only one formalized agroforestry group, two dense networks of intra-village farmers have been developed beside. The long history of agroforestry practices is recorded since a description in the Ph.D of Kheowvongsri (1996). Originally, Lung Toon and Lung Boonchu were leaders of groups and not networks. Lung Toon is a leader of a center for learning on Buddhist agroforestry, and Lung Boonchu, leader of the eponymous network, heads a center for learning on self-sufficiency and subsistence farming within the framework of the King of Thailand's theory of economy. The general objectives are set out under cognitive and environmental themes. For each group, the initial goal was first defined by the leader, who tried next to gather around him farmers who were thinking along the same lines. The communities aim to respond to economic and environmental issues and to help local farmers obtain government support, but also to participate in field activities.

In 2016, the Banna agroforestry community was no longer active due to lack of funding for further common activities. Many producers pointed out that they no longer participate in the meetings or organize activities because they no longer have funding. Lung Boonchu's original group is still active, but its activities are largely dependent on government support: purchase of compost and marketing equipment, or participation in DOAE activities. The Lung Toon network has also developed projects to benefit from free seedlings for timber from the Forestry Department and funding for activities at the learning center. In addition to access to funding, the leaders are also responsible for promoting the values of the collective group, expanding the network and capitalizing on the information to which they have access. They are the mouthpieces of crop diversification and agroforestry. It seems however that local farmers see their implications in group activities limited if funding is lacking. Meantime, there is plenty of small local activities and mall projects funded by regional organization.

3.2 Producers' reasons for joining a collective action

Farmers generally gave several reasons for joining a group/network according to social link and economic expectations. We will explore these reasons for the different groups.

3.2.1 The Banna agroforestry community

The Banna agroforestry community was originally formed by the conviction of the original leader and his ally, a neighbor with whom he has been sharing the same ideas. They then sought interested agroforestry producers to set up a group to access funding for some government projects. Some took the opportunity. Members are eager to share their knowledge, in the sense of teaching. Everyone has a high performance and is economically efficient on his AFS. They want to make it known and help producers in difficulty. This is a very important characteristic for the future IP. The network of Lung Jay, the leader of the Banna agroforestry community, also interacts with researchers

and various government institutions through his knowledge of local plants, medicines and agroforestry. He interacts with a wide range of professions (figure 7). He is the leader of the "Sri Nakarindra Model" project, which brings together 12 villages around agro-tourism, the development of herbal medicines and the transformation of production. His group could actively participate in an IP to visit existing agroforestry plots.

The 3 main reasons for joining the Banna group are: i) to share knowledge, teach and learn from discussions (7/20), ii) to obtain governmental support (3/20) and iii) to obtain support for product marketing (3/20). Marketing remains a very important feature for actors in order to provide an output for local AFS products. If there is obviously national local markets for fruits and timber for instance, it is necessary to organize them at local level.

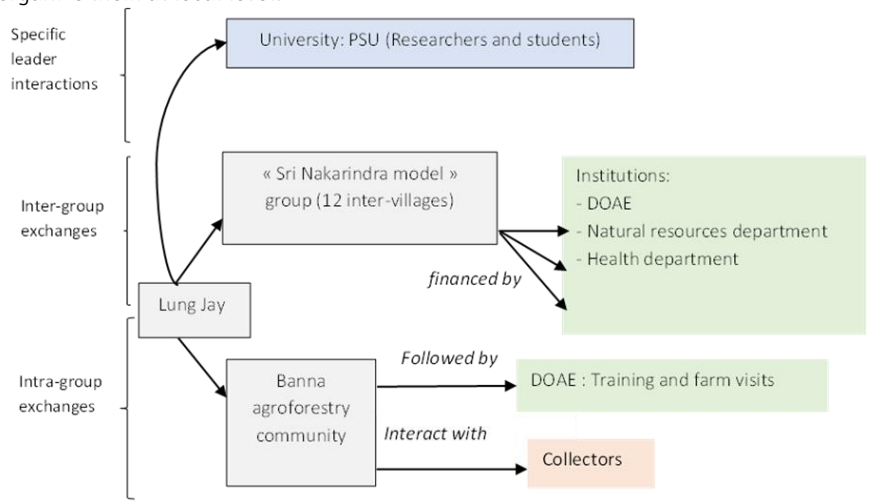


Figure 8. Lung Toon interaction grid.

3.2.2 The Pa Phavom self-sufficiency agroforestry northern network

Lung Boonchu created his own group in his village, to have access to more knowledge to diversify production and to be less dependent on market fluctuations. Rapidly, they invited other producers willing to master new crop practices to join them, and to obtain funding and support for export crops (figure 8). Originally, the main reason was to access external funding for technological change and to share knowledge. Phatthalung farmers are dynamic and generally seize opportunities for change. The 3 main reasons for joining the Lung Bunchu group are: i) to share knowledge through discussions (8/20), ii) to obtain governmental support (4/20) and iii) to obtain more information on improved agricultural practices (2/20).

Lung Boonchu, the leader of the Pa Phayom northern network, is a dynamic, dedicated and federating producer. His network is locally rooted strongly in the sub-district community, the informal education center and various groups of farmers. The network offers new market opportunities for producers. Lung Boonchu is responsible for drafting projects and reporting activities in order to obtain funding from the SAO (Subdistrict Administrative Organization), the ALRO (Agricultural Land Reform Office), which also grants land from 0.16 ha to 0.8 ha, and the DOAE. He also receives teachers and especially students who come to observe his plantation.

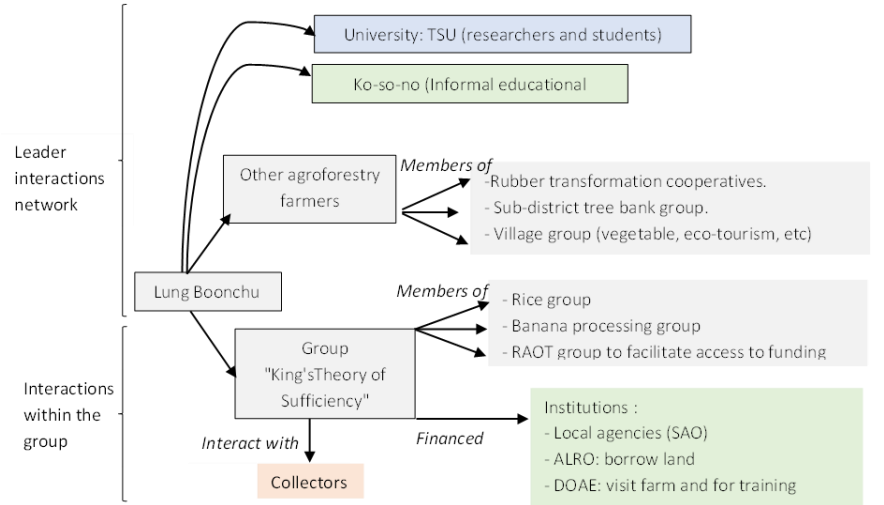


Figure 9. Lung Boonchu interaction network.

3.2.3 The Tamod Buddhist agroforestry network

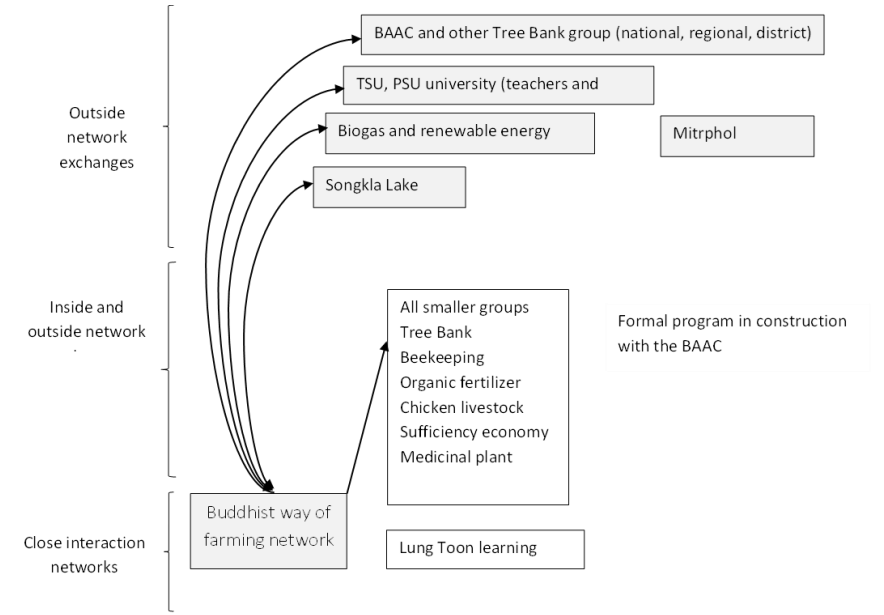


Figure 10. Lung Toon interaction grid.
Note: Mitrphol is a private company producing biofuels.

Lung Toon, the leader of the Tamod network, is an emblematic character. He is the spokesperson for the southern region of the Tree Bank program[1]. He also undertakes nationwide trips for this program. At the same time, he is carrying out renewable energy projects and traveled to Germany to discover different methanization units. He is also a

[1] The state-owned Bank for Agriculture and Agricultural Cooperatives (BAAC) has raised the maximum loan under its Tree Bank scheme. Members of its tree bank program can apply for loans of up to 80% of the collateral value for both the land and high-value trees. Some 6,000 communities with 150,000 farmers growing over 11 million trees are members of the Tree Bank scheme.

privileged interlocutor of the Forestry Department and thus facilitates access to free clones from the government nursery for the farmers of its network. Researchers and a doctoral student even carry out agroforestry research projects on his land (figure 9).

3.2.4 Enrichment by interactions outside the network and multi-affiliation of collective leaders.

The leaders of these 3 groups are quite well known in Phatthalung province. They develop small networks to organize activities, find funding or set up new development projects. Finally, the advisors through their multi-partner position bring a wide network of knowledge and local partners in to carry out various projects or activities. Collectives are open to the outside through dynamic, autonomous and proactive leaders. They open up rich interaction networks. Table 4 displays the pros and cons for each group of being part of an IP.

Table 4. Pros and cons for each network/group that might later be included in an innovation Platform

Banna Agroforestry community	Lung Toon Network	Lung Boonchu Netwrok
Not really active anymore Sri Nakarindra Model project Nursery with native rare plants	*An increasing network* 2 learning center facilities Tree Bank project	*Ist learning center facility* A success story for smallholder
High willing to share knowledge Innovative and dynamic farmers Demonstration plots Ability to set training for marketing, plant association, crop management techniques, and native medicinal plants	*High willing to preserve natural resources* strong minded, convincing and innovative farmers Demonstration plots Ability to set training for organic farming, timber production and fruit trees management	*High willing to follow the theory of sufficiency of the king Agroforestry systems* Demonstration plots Experimental plots Ability to set training for livestock, fishery and organic farming.

3.2.5 Producers' group profiles and a territorial dynamic facilitating the emergence of an innovation platform.

Sharing knowledge on AFS is a common feature for all groups and constitute a social important feature for the members of these groups with the important social feeling of being "knowledge carriers" in a particular way compared to other farmers who focus on monoculture.

3.2.6 Outcomes from the groups/network analysis

We observe a large variety of activities including AF practices of these groups (as sometimes AF is not always the main topic of the group), in concordance with previous studies by PSU/TSU researchers and missions implemented by the first author in the area or similar areas (Songkhla area) in 1996 and 2006(ICRAF/CIRAD reports). In other words, if agroforestry practices with clones are well developed for some smallholders since the 1990's, the study of these groups shows the constant interest of farmers for that technology, in particular in period of low rubber price. To that respect, a better resilience to rubber price volatility and the income stability thanks to diversification are key elements in farmers' long run interest in agroforestry.

A similar trend is observed in West Kalimantan with Dayak farmers in Indonesia (Penot, 2001), in India with a very large type of cropping patterns (fruits, spices, timber) in a context of high population density and Sri Lanka with tea and banana associated to rubber (Rodrigo et al., 2001).

3.3 A diversity of farm types as well as AF cropping patterns

A wide variety of farm types is observed (table 5). Only two out of the three farm types of the typology identified by Chambon et al. (2021) are present: family farms and family business farms. Family farms are mainly present in the Lung Boonchu network; and family business farms (characterized by the use of permanent paid labor, mainly to tap rubber trees, to complement the family labor partly involved in technical work) are mainly present in the Banna agroforestry community. Producers, mainly individuals and from Lung Toon's network, have two jobs. There is a diversity of profiles from small farms, ranging from 0.64 ha, with no outside labor force and low investment capacity, to larger farms of up to 21.8 ha, employing labor for almost all the work. More than a half (51%) of farmers adopt agroforestry on their entire plantation, whether in a family business farm or family farm. Agroforestry could be therefore an appropriate cropping system for various profiles.

Those who had the opportunity to access post-high school studies, a bachelor's degree, a master's degree, or engineering school, have a dual asset and do not necessarily have time to promote their systems. The double profession of planters also allows them to invest and take risks on innovative and more original agroforestry plantations.

Table 5. Producer profiles in AFS groups and networks

Name	Banna agroforestry community	Lung Toon network	Lung Boonchu network	Associated satellite farmers
Average age	64 years	63 years	60 years	55 years
Average farming area per member.	0 ha; 1,9; 3,4; 6,7; 7,9; 10 ha			
Share of rubber area per farm	50 %; 65; 68; 82; 89; 100 %			
Agroforestry initiation year	1995; 1996; 2003; 2004; 2007; 2010			
First farmer to do rubber agroforestry	1978; 1979; 1987; 1992; 2002; 2005			
Plantation type	0 % FF/FBa; 17 %; 25 %; 48 %; 89 %; 100 % FF/FBa			

Lung Boonchu network
Individual producers
Lung Toon network
Banna agroforestry community

FF: family farm
FBa: Family business farm type A

AF rubber cropping patterns have been already well described by Simien (2005), Stroesser et al (2018), Jongrungrot et al (2014), Tongkaemkaew et al. (2020).

3.4 Development of agroforestry in rubber plots: origins and motivations

3.4.1 The social origin of agroforestry practices

Given the dense network of interactions studied above and the early initiations of agroforestry from 1979 by the pioneers of the study, we may wonder what are the origins of agroforestry practices. Survey and discussion show the low importance of collectives in agroforestry innovation for the rubber crop. Agroforestry came from the collective for only 8% of the producers surveyed, (i.e., 1 producer out of 12). The role of the family circle in innovation is crucial. Producers trust their family members. Advice often comes from the previous generation. Planters are also reactive. During a journey

or any other trip, they may see an agroforestry plot along the way and try to obtain information and knowledge about these innovative systems. They visit and have contact with the farmer, and even buy seeds or seedlings directly to develop their own AFS. Finally, the government is also convincing. Many farmers adopted agroforestry after a visit from the DOAE, which offered them free seedlings of plants to associate with rubber trees.

3.4.2 The major motivations to adopt rubber agroforestry systems

39% of planters with limited land took advantage of crop intensification between rows of rubber trees. Another reason was to benefit from the high prices for some crops or to diversify income when rubber prices are low. The economic factors are now in order of priority: i) increasing incomes, ii) diversifying incomes and iii) more optimal land use with associated crops. Finally, cognitive and environmental factors are also cited: the desire to experiment, to reproduce forest systems by allowing plants to spread naturally, or by planting forest species, etc.

The important historical social role previously shown by Stroesser (2018) was no longer considered important. The producers practice agroforestry for self-consumption, income generation through selling part of the production and to invest for future generations as already mentioned in previous studies (Jongrungrot, 2015). Agroforestry would also increase their social security by strengthening communities: better quality of life, better health by reducing the use of chemicals, better level of knowledge in agriculture, and respecting the Thai tradition of donating (fruits mainly) as well as a better economic output with the increase for 20 to 40 % of gross margin/ha in average.

3.4.3 Different categories of AFS diversification

Six diversification categories, corresponding to different benefit and constraint frameworks, were identified. The farms are diversifying through the following;

- The association of forest species (20 species), and/or fruit/timber species
- The association of local fruit species (21) and/or export fruits
- Combination of vegetable (11) and/or ornamental (7) species and/or
- Association with cash crops (coffee, palm oil or pepper), not so common,
- Livestock or fish integration or,
- Forest wood/timber planting for fuel wood and valuable timber (minimum of 10 native species listed in the annex).

Producers associate one or more diversification pathways on their plots and generally practice more than one type of AFS. Each AFS defines a framework of specific advantages and constraints for each farmer, to be identified and considered before planting, in order to respond to producers' differing expectations. The main motivations for agroforestry mentioned in surveys are i) lack of land and necessity to develop intercrops (21/142), ii) experiment with new practices and develop sustainable cropping conditions (35/142).

3.4.4 The labor requirement induced by the AFS choice

Four modalities of labor constraints have to be taken into account: i) the difficulty of harvesting fruits at tree heights, ii) the frequency of labor, such as for instance the daily collection of "pakoout" ferns (Diplazium esculentum) or the concentration of labor for fruit harvesting, iii) the time requirement such as for flower-by-flower pollination for the salak palm tree (Salacca zalacca) and iv) a sufficient return to labor to pay off labor harvest cost for fruit production. Such constraints might represent a real limit to agroforestry practices over a large area, and iv) finally, the level of technical skills and prior knowledge required to carry out an efficient agroforestry system (tree pruning for instance).

All groups and networks develop a shared vision of the clear advantages of agroforestry practices. Advantages commonly cited by the majority of growers are a higher humidity in the plots with agroforestry practices, especially with the forest recruitment system, better soil quality (texture and littering effect) and easy crop combinations.

3.5 Proposition to develop a regional innovation platform for rubber agroforestry systems as a new tool to better promote AFS among monoculture smallholders.

We should consider the fact that the current existing groups and network as described in this paper are clearly not sufficient to create a real boom in AFS adoption to a very large extend. All conditions do exist for such AFS boom: i) existing groups and farmers with AFS plot that can be used as demo plots for other farmers, ii) a real knowledge and basic AFS practices mastered by farmers with a real willingness to share that knowledge and iii) the economic necessity for most rubber farmers to increase their gross margin /ha trough diversification in a context of long-time low rubber price period. What is lacking is a regional organization able to transform local opportunities into real challenges for larger communities. The political capacity does exist trough the local very large active administration in the fields such as RAOT and Ministry of agriculture and forests. The potential tool to implement such challenge is a regional innovation platform. What remain to be done in the political willingness to support it and allocate funds to initiate the process.

3.5.1 The choice of a regional scale

The regional scale was initially chosen because of the non-uniform distribution of agroforestry practices in Phatthalung. Farmers who want to convert their system can find a large panel of farmer profiles and farmer practices according to their convenience. Moreover, production conditions—climate, markets, topography—are almost the same from north to south of Phatthalung. Moreover, the aim is to invest in all kinds of institutions interested in agroforestry and all private companies linked to commercialization of agroforestry production. The regional scale is a good organizational scale to achieve this goal.

Because of potentially increasing diversification in associated products, it is necessary to be careful regarding the evolution of the market for fruits. If the promotion of agroforestry is efficient and people produce more fruits, wood/timber and vegetables, this may later on obstruct the market due to over-production. The fruit chain and wood chain should progressively be re-organized in the province to absorb new products. A good point is the presence of the large city of Hat Yai as an economic hub in Southern Thailand. Rubber AFS may potentially spread rapidly in the province. Research may help develop new crops according to market opportunities and possibly transformation activities.

3.5.2 Proposed Innovation Platform

The platform presented in figure 11 would encompass many stakeholders. The main stakeholders are the farmers, the donors and the governmental agencies (RAOT and DOA), supported by researchers from local universities (PSU and TSU) who provide knowledge, and the local institutions and their technicians who advise farmers and the private sector (trading and transformation). The key point is the regularity of meetings of all stakeholders to discuss further actions, organize and plan activities and share the results with other stakeholders. The IP is the place to share, decide and implement AFS activities, to develop value chains of products and to discuss AFS policies.

A digital center could be developed (Facebook page, website with documents) in order to pool and share reports and activities to keep people informed about activities and training courses, with e-learning, published articles, demo videos about their

agroforestry plots, etc. a forum inside the website can also be developed.

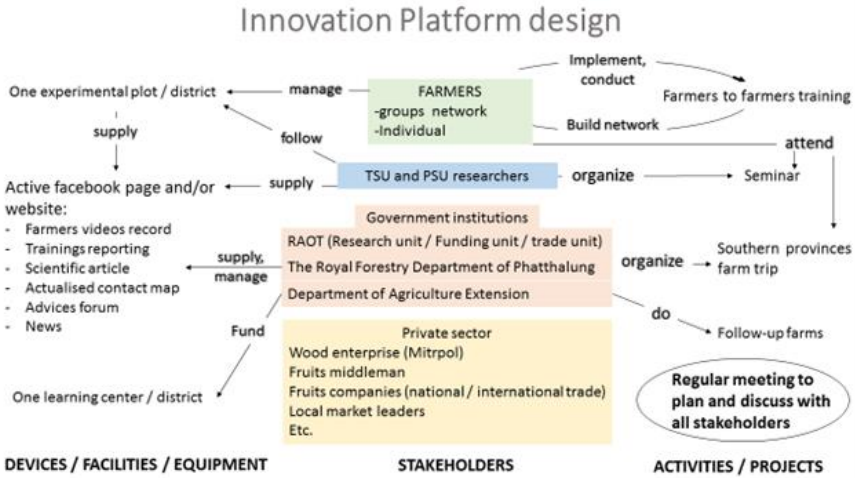


Figure 11. Innovation platform proposition (Theriez, 2017).

The main axis of the proposed IP is focused on farmer-to-farmer training courses about agroforestry practices. Some existing AFS plantations can be selected as "demo-plots" for training purposes. New plantations could be monitored by researchers as on farm trials for comparison (there are already two farmers who are leading experimental plots), in particular to test double spacing systems for instance or patterns prioritizing associated crops and rubber, as it could be the case with well marketed fruits such as mangosteen and durian. The wide variety of fruits that can be associated with rubber (as well as timber) required to look at local markets for each product. But the high variety of products generate a market diversification that obviously diminish risks of over production.

Training to convert farmers from mono-cropping to agroforestry practices is a key component for rubber AFS transfer, as has already been implemented by PSU on a small-scale basis, promoting agroforestry farmer groups following a specific route (see figure 12).

One group of farmers per semester would follow this training. At the end, the IP could be supplemented by those new converted farmers.

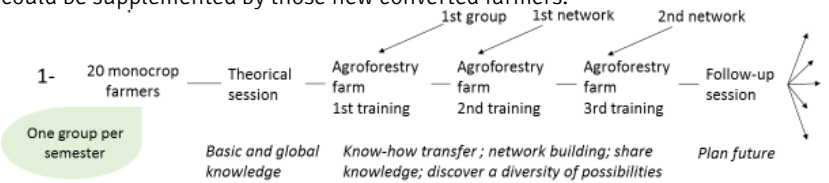


Figure 12. Training route for farmers who want to convert their system.

3.5.3 Management of the Innovation Platform

Even if all stakeholders are equal partners in an ideal IP, it will be necessary to launch and manage it at least at the beginning. The lead could be provided by RAOT and other associated local institutions (DOA) to profit from their very large regional coverage. Later on, the IP could be managed according to new dynamics and new options according to partners' evolution, with governance moving to farmers. A first "launch organization" should be implemented in order to take the first decisions with representatives of each kind of stakeholder and initiate activities (RAOT, forestry department, DOA, farmers' groups and network, NGO). This limited structure organizes

contacts, selection of AFS farmers and AFS plots for demo-plots, meetings, visits, training, events and a yearly program. Preliminary meetings could be organized to launch the IP in order to identify responsibilities. Local institutions seem to be genuinely interested in setting up an IP, but they are waiting for a national decision.

The study also showed a diversity of AFS patterns in the Phatthalung area depending on the local context. The local farm profiles are also very diverse in terms of UAA (Useful Agricultural Surface), investment capacity, employment opportunities, and the farmers' level of agricultural knowledge. Some farmers are ready to contribute significantly to the promotion of agroforestry using their agroforestry plots as demo plots for training and are ready to share their know-how.

Finally, rubber AFS are highly diversified, but most farmers adopt some specific AFS systems on a large scale (based on Gnetum, mangosteen or timber trees). An awareness-raising campaign about the potential volatility of market prices and incentives to plant more diversified systems is needed, in order to organize AFS development without disturbing fruit markets. The IP must be launched progressively taking precautions in order to avoid negative effects.

The fruit market, like the rubber market, depends on national and global market fluctuations, as well seasonal price variation, as is the case for instance for the bitter bean Parkia speciosa. In 2017, the price for this bean was 2 Thai Baht/pod in the producing season and 5 Thai Baht/pod outside that period. Access to contracts for exportation can also guarantee fruit production marketing, as with banana: in 2017, price 30 Thai Baht/kg on the export market and 7 to 10 Thai Baht/kg on the local market. Fruit markets per product require detailed value chain analysis to assess marketing potential and adapt offer to demand. The risk with large-scale AFS development is rapid overload of fruit markets leading to price shrinkage. The same issue applies to the developing timber market.

Fruit market analysis and constant monitoring are key to the organization of harmonious development without killing local value chains. Recent experiences have shown that fruit production should be organized. In 2017, all farmers wanted to cut down their longan trees in AFS in order to plant durian, as durian prices are constantly high. But durian requires 7 to 10 years to produce and nobody can foresee durian prices in 10 years' time. Such an uncontrolled trend is very risky. Discussion about fruit production organization in AFS could be effectively implemented through IP activities.

3.5.4 Other Innovations Platform in the world

The concept has been well developed and implemented in Africa (Adekunle and al, 2010) (Kikeluand al 2013) (Schut and al, 2016).. For instance, around Alaotra Lake in Madagascar, the IP is designed to encourage farmers to share farming innovations such as conservation agriculture (ABACO project). In Rwanda, an IP solved milk chain problem: milk prices were low because of an unstable market with an unorganized milk chain. Cooperatives, industry, local institutions, researchers, technicians gathered in order to find a suitable solution (Tenywa et al., 2011). These examples show the adaptability and flexibility of an IP, which can address many kinds of problems and lead to various innovations, according to local conditions, history and stakeholders.

In fact, it is observed that there is almost no real Innovation Platforms developed in countries where there is existing agroforestry practices and traditions: Thailand, Indonesia, India, Sri-Lanka and to a less extend, Nigeria and China. Most agroforestry systems have been originally developed by local farmers with an extensive system more adapted to their economic conditions at that time in particular with the famous "jungle rubber" from 1910 to 1960 in Southeast-Asia (but not in West- Africa as the rubber development appears far later in the 1950's). It appears that research institutions have sometimes accompanied farmers (Sri Lanka) but in fact AFS was not generally

recognize recently by public institutions (until the mid-2010's). It has been officially allowed very recently officially in the 2010's in Indonesia and 2015 in Thailand. By opposition, public services were generally in favor of AFS such as India, Sri Lanka and may be China.

In other words, proposing an IP multi-actor to boost AFS adoption at large scale such as the one presented in that paper in southern Thailand is quite innovative and potentially rather new for local institutions and a real opportunity to boost at large level AFS adoption.

4. CONCLUSION

This study shows that there is real potential for the emergence of an Innovation Platform (IP) on rubber AFS in the Phatthalung area as well as a real demand from local offices of RAOT, relatively close to farmers though replanting program. There is a possibility of developing a real offer of training and RAS technology transfer from existing RAS farmers and groups to other farmers. However, to implement such an IP in Southern Thailand, there is a need for a real political decision on top institutions such as RAOT (when forestry institutions seem to be very keen to contribute as well).

The IP is a social tool designed to implement new ideas, promote new systems (in a rubber-growing world where monoculture still dominates) and to innovate quickly. In Phatthalung, the aim would be to co-design rubber AFS with producers, researchers, development and funding agencies (RAOT, Ministry of Forestry, agricultural extension/DOA, local banks) and the private sector (fruit sector). Producers' groups, organized around neighborhood networks, have existed for more than 20 years and are ready to train other farmers and to innovate in agroforestry practices. The study shows that there is an important inter-producer interaction network despite the lack of a detailed study of dialogue between producers regarding networks that still lack AFS advisers, the frequency of meetings between peers, and the geographical distances over which people interact. In other words, we still need a complete overview of the social and geographical dynamics of the flow of information, knowledge and techniques in agroforestry in Phatthalung.

For farmers, joining a group is a way to join a big network, share knowledge and find government support. The group provides ways to participate in many local activities and to share knowledge. The group could be monitored by government agencies: RAOT, DOA, natural resources department, health care department, livestock department etc. All local stakeholders lead actions and special events to help farmers promote their systems and sell products. Some also provide specific funding. Universities, in particular PSU and TSU, contribute to the dynamic of the sector. Teachers/researchers visit farmers and set up farm trials. In association with government agencies, they exchange with other groups during official government activities, which concern more than 300 groups from 11 districts in Phatthalung. The role of RAOT is central to the organization of meetings and to transfers of knowledge and know-how between farmers' groups in the future IP. Meetings, visits and training are essential activities promoted by the IP, but internet access to knowledge could be efficient as well.

A study of the attendance rate and the type of audience of the "Ko-so-no" (alternative education center) where computers are freely accessible would make it possible to determine whether this infrastructure can compensate for the current lack of farmers' equipment.

A strong interactive network of identifiable reference farmers is an essential prerequisite for the fast and immediate operation of a regional IP involving the main institutions of rubber development, such as RAOT, researchers, rubber collectors and buyers, timber, vegetable and fruit collectors.

There is a need for further studies of local fruit value chains and for an analysis of the fruit and timber market. For the fruit sector, it is imperative to know the saturation levels of the current market and its potential expansion if AFS should develop. Today, the timber industry is still obscure due to illegal trade in the national and global timber markets. An entire sector has to be reorganized, with the establishment of sawmills, local timber industries, and a serious study of the market and the potential for expansion of the legal timber trade.

Finally, the pre-existence of such AFS networks, the sum of immediately exploitable knowledge and know-how and the goodwill of local AFS producers, research and regional institutions create a climate that is particularly favorable to the establishment of a rubber agroforestry IP.

Institutions have also taken into account the importance of supporting agroforestry with the Rubber Authority of Thailand, the forestry department under the supervision of the Ministry of Environment and Natural Resources, and the agricultural extension departments. These are all stakeholders with converging interests, positively engaged in the promotion of AFS and therefore partners for the emergence of an IP for rubber agroforestry innovation. A complete sociological survey is needed at the regional level, to identify and understand AFS groups and networks.

An IP is a social object that changes constantly depending on the stakeholders who compose it and contribute to its activities. All the required conditions are now in place to create an IP. What is missing is political support from the national government authorities and complementary economic and social studies to promote AFS efficiently.

The need for more global sustainability in agriculture, a better biodiversity conservation, more income stability and the necessity to be environmentally friendly will push institutions to move for RAS and boost agroforestry practices, in particular in we consider that there is already 15 % of farmers who do have already RAS and constitute a real opportunity of local knowledge to be shared. The global current environmental challenges constitute a very positive context for RAS promotion and IP implementation.

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