

Households' livelihood strategies facing market uncertainties: How did Thai farmers adapt to a rubber price drop?

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Abstract

Tree crop growers are particularly sensitive to commodity price fluctuations. Since 2012, rubber prices have been decreasing. This article provides a comprehensive analysis of how Thai family farms responded to that continuous decrease in rubber prices. The originality of this work was to combine a farming system approach for decision making with the sustainable rural livelihoods' framework for resource endowment and strategies to benefit from the complementarities of these two theoretical approaches. An existing database was used characterizing the rubber farms and farmers' practices in 2011 when the rubber price was at its maximum. A subsample of farmers was interviewed again in 2017 after six years of price decreases to characterize the new situation and to identify and explain the changes. Fifteen flexibility mechanisms to face the crisis were implemented at three different levels: rubber cropping system, farming system and activity system. Combinations of these mechanisms identified eight strategies of adaptation to the crisis, classified on the reversibility of the changes. Three major types of strategies were identified: (i) reversible adjustments at the level of activity system variables, (ii) mobilization of available production factors to be invested in an activity that allows, over a longer time perspective, compensation for the disturbances caused by the crisis. This type of adaptation was reversible, but its implementation expressed motivation in the medium and long terms; (iii) reallocation of the production factors already mobilized at the level of the rubber cropping system toward other activities, to compensate the disturbances caused by the crisis. This last type induced a deeper transformation in the distribution of the production factors in the activity system and was anchored in a long-term vision. The first type corresponded to a dynamics of disturbances absorption to maintain the smallholders' systems and overcome the crisis; the two other types corresponded to dynamics of compensation with more or less reversible changes.

Overall, this study confirmed the capacity of adaptation of family agriculture when facing shocks. It also showed that the flexibility of these households relied greatly on rubber cropping systems through possible technical change and through the adaptation of the share-tapping labor contract. This highlighted the importance of considering farmers' practices (and changes of practices) to understand their strategies.

Highlights

- Family rubber farms were resilient to market shocks
- Flexibility mechanisms were adopted from cropping system to activity system levels
- Adaptation of the rubber cropping system offered high flexibility to the households
- The strategies of adaptation included different degrees of reversibility
- Both dynamics of absorption and compensation for the crisis were observed

Key words

Family farming; Flexibility; Strategy; Price fluctuation; Rubber tree; Thailand

1. Introduction

Agriculture is taking place in a changing environment. Changes in the economic environment include long term trends and short term shocks (Killick, 1995). In particular, agricultural products are subject to price volatility and cycles are key characteristics of the evolution of the commodity prices. This has important implications for the earnings of developing countries who are dependent on commodity exports and for the producers' income (Cashin et al., 2002). The impacts for producers of tree crops such as cocoa, coffee, or rubber are even more acute as they have to face price fluctuation in the short and medium terms when they are engaged in the long term with their perennial crops that usually require high investment to establish. As a result, price is a major concern for many tree crop producers and a major driver for production strategies and livelihood change (Shively, 1999; Eakin et al., 2014). An issue for tree crop-based producers, particularly when this crop is dedicated to the market, is to find ways to cope with the periods of low commodity prices.

Family agriculture is by far the main form of farm organization in the world (Graeub et al., 2016; Lowder et al., 2016). It is characterized by: i) the organic and structural relationship between the productive assets and family patrimony; and ii) the predominance of family labor for the management and field operations (FAO, 2014; Belières et al., 2015). Tree crops are not an exception. Smallholders represent 90% of the world rubber holdings and they contribute 85% of total natural rubber production, being mainly located in Southeast Asia (IRSG, 2017). Thailand alone produces more than one-third of world production and around 90% of the Thai rubber plantations belong to smallholders owning less than 8 hectares, with an average of 2 hectares (RRIT, 2013 cited by Somboonsuke & Wettayaprasit, 2013).

Rubber price has always fluctuated over time (Figure 1). Recently, rubber producers experienced a decreasing rubber price after a rubber boom during the second half of the first decade of the 2000's with a historical peak in 2011.

Figure 1: Evolution of natural rubber current price from 1988 to 2017



Description: Rubber (Asia), RSS3 grade, Singapore Commodity Exchange Ltd (SICOM) nearby contract beginning 2004; during 2000 to 2003, Singapore RSS1; previously Malaysia RSS1

Source: <https://www.indexmundi.com/commodities/?commodity=rubber&months=360>

The drop in the rubber price affected rubber farmers worldwide. In India, they reduced the labor involved in harvesting and the use of inputs with consequences on the productivity of rubber (Pareed & Kumaran, 2017), some farmers shifted to other crops and some had to reduce family expenses (Karunakaran, 2017). In Indonesia, the severe reduction in rubber income led farmers to develop more of their own non-agricultural business activities and off-farm employment (Kubitza et al, 2018). In Laos, many types of responses to the falling rubber price were observed. Some farmers stopped tapping, waiting for the rubber price to increase again while others replaced hired labor with family labor for latex harvesting. Some growers (mostly the poorest and the smallest) had no choice but to sell their land when others could lease land often resulting in conversion to other crops. Farmers also tried to develop collective action (cooperatives) to increase their marketing bargaining power and thus the rubber price (Vongvisouk & Dwyer, 2016). In Thailand, the decrease in the rubber price since 2012 resulted in an important reduction in the income from rubber (Kumse, 2014). A recent study analyzed the coping mechanisms adopted by rubber farmers in South Thailand facing rubber price volatility but focusing only on diversification and community development (Andriesse & Tanwattana,

2018). The aim of the present article is to provide a comprehensive analysis of how farmers responded to the continuous decrease in the rubber price in the number one country for natural rubber production. The originality of this work was to combine a systemic agronomic perspective for decision making with the sustainable rural livelihoods framework for resource endowment and strategies to benefit from the complementarities of these two theoretical approaches.

2. Materials and methods

2.1 Scientific approach

We used an existing database providing a characterization of the structure of a sample of rubber households in 2011 (data collected in 2012). That year corresponded to the period when the rubber price was at its highest level. Interviews were conducted with a subsample of farmers from the 2011 database to characterize their farms' structures in 2016 (data collected in 2017). That year corresponded to a low rubber price which had been decreasing since 2012. Comparing the structure of each farm between 2011 and 2016 allowed identification of the changes that had happened during that period. This basis was used to analyze the strategies adopted by each household to face the decreasing rubber price.

In 2017, we used a mixed quantitative and qualitative method, with a sequential approach in two steps. Each household was interviewed twice. First, a quantitative approach was used to ask closed questions inducing answers that remained within the frame of the questionnaire. These data were used for the comparison between the two different temporal situations (2011 and 2016) and for the identification of the changes. Second, the qualitative approach with open questions allowed understanding of the mechanisms of change identified through the quantitative approach (Creswell,

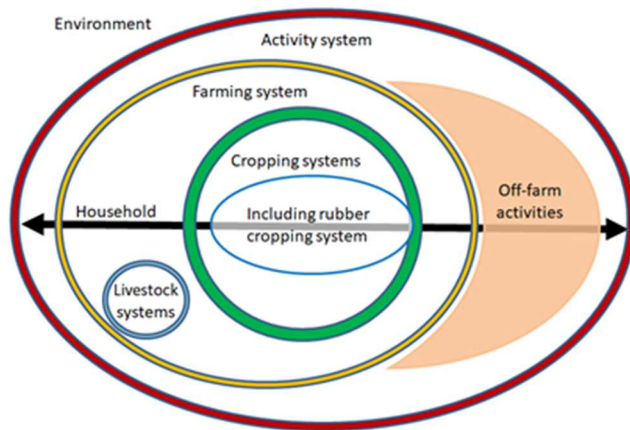
2014). With the qualitative approach, focus was on the rationality of the households and the mechanisms of decision making.

2.2 Conceptual framework

For the quantitative approach, we used the Sustainable Rural Livelihoods (SRL) framework to provide a diagnosis of the rubber smallholders' characteristics in 2016. The first step was to identify the livelihood resources (i.e. the combination of natural, social, human, physical and economic or financial capitals) as well as capabilities (knowledge and know how) that the households could mobilize for their livelihood strategies when facing a commodity price decrease. There are several outcomes for the strategies adopted such as resilience or increased vulnerability that need to be highlighted (Scoones, 1998).

For the qualitative approach, we used the conceptual framework of the activity system (Gasselin et al, 2012). The farming system's concepts are not sufficient to understand the decisions of the farmers who are rarely mono active. An activity system is more appropriate since it includes all the productive activities of the farm and the family. Consequently, off-farm activities of family members are considered when analyzing the strategic objectives of the household and understanding the rationality of the farmer and his family, notably for family labor allocation. However, the agronomic concepts of a cropping system (Sebillotte, 1990) and a farming system (Reboul, 1976) were useful to analyze the farming subsystem (figure 2).

Figure 2: Activity system and its subsystems with a focus on agriculture



The SRL framework focuses on the available resources for households' livelihood and the result of their mobilization. The activity system framework focuses on the combination of activities, the flux of production factors and the decision making process; it added some dynamic dimension to the SRL (Gasselin et al, 2014). The complementarities of these two approaches justify their combination to study family farms (Sourisseau et al, 2014). It is worth noting that these two conceptual frameworks are both quantitative and qualitative despite the fact that, for the fieldwork, one was mobilized for the quantitative step of the study and the other one for the qualitative step.

Last, we identified the adaptation strategies as a combination of several adaptation mechanisms adopted by the household to overcome the crisis. We mobilized the concept of flexibility defined as the capacity for a system to adjust its goals and resource allocations according to the changing constraints and opportunities (Killick, 1995). In other words, flexibility is "the ability of a system to maintain coherence within a changing environment" (Bathfield et al, 2013, p.357; Gasselin & Bathfield, 2013). This concept is useful to study the link (i) between short term decision making and long term strategies or (ii) between the need to adapt to uncertain context and the maintenance of some stability. Analyzing the farmers' response to the crisis through flexibility mechanisms reflects the mobilization of flexibility potential (Bathfield et al, 2013). Each mechanism is characterized by i) a gradient of reversibility giving information on the temporal character of the adoption and ii) the resources mobilized.

2.3 Empirical data

2.3.1 Sampling

The study was conducted in three provinces of Thailand representing the different historical dynamics of rubber development and the different characteristics of the rubber smallholdings (Table 1). The objective was to cover the diversity of situations and environments which could affect decision-making by the farmers.

Respondents were selected from the sample of farmers interviewed in 2012 to characterize the farms in 2011. The 2012 study was conducted at the level of the country by one of the authors. To cover the diversity of situations in the different rubber producing areas, a zoning of the provinces was done considering the development of rubber plantations (historical zones *versus* new rubber producing areas) and the recent dynamics of rubber development for the five previous years (expansion, stagnation, regression). This was based on the analysis of the national statistics (Office of Agricultural Economics¹ website) completed by individual interviews with staff from the Rubber Authority of Thailand (RAOT) in Bangkok and consultation of academic staff specialized in socio-economy of the rubber farms in Thailand. From this zoning, 14 provinces were selected for the study. In each province, individual interviews with key informants able to provide information on the local situation (Rubber Authority of Thailand in the provinces, rubber cooperatives, nurseries and traders) were conducted. This allowed the final validation of the provinces (10) and the selection of the districts to represent agronomic and socio-economic diversity. Random sampling of the farmers was not possible (no exhaustive list of the rubber farmers available) which is often the case for this kind of study. So the first contacts were often given by the Rubber Authority of Thailand, the nurseries or the traders. Then snowball-sampling method was used. The total sample size was 317.

¹ <http://www.oae.go.th/view/1/Home/EN-US>

These 317 households distributed in 10 provinces served as a basis for the sample in 2017. We selected three provinces. They were considered as representative of the dynamics of rubber development in Thailand and of the diversity of the rubber-based households. A purposive sample was done using five criteria: 1) presence of at least one mature plantation in 2012 sample; 2) typology of the rubber farms based on the kind of labor used (Belières et al, 2015): family farms using only family labor and family business farms employing at least one permanent hired labor usually for latex harvesting; 3) districts that could be discriminating in terms of opportunities for the rubber households; 4) diversity of the characteristics of the rubber-based households (age of the head of the farm, landholding, crops diversification, income diversification); 5) possibility to find the households (incomplete name registered, no phone number available). Finally, a total of 48 rubber farmers was interviewed.

Table 1: Sample distribution and characteristics

Region (province)	Northeast (Buriram)	Centre-east (Rayong)	South (Phattalung)
Sample size	16	14	18
Distribution of the sample in the typology based on labor*	Family farms: 7 Family business farms: 9	Family farms: 8 Family business farms: 6	Family farms: 18 Family business farms: 0
Development of rubber plantations	New area (since 1990s)	Historical area (more than a century)	Historical area (more than a century)
Ratio rubber / total farming area for the province	6%	63%	72%
Land	Available; relatively large landholdings	Still available but expensive; large landholdings	High land pressure; small landholdings
Activities	Mainly farming, on-farm diversification	On-farm diversification and off-farm activities	On-farm specialization on rubber but off-farm diversification
Environment	Strong institutions, cassava and sugar cane factories, no	Industrial zones (land pressure), urban	Government recommendations for on-

	rubber factory	development (job opportunities), rubber factories	farm diversification, competition with tourism (land pressure)
Rubber practices	Intensive fertilization; rather low intensive latex harvesting (122 tapping days/year)	Medium intensive fertilization; rather low intensive latex harvesting (122 tapping days/year)	Low intensive fertilization; relative high latex harvesting intensity (161 tapping days/year)

Sources: (Agricultural Census, 2013), (Chambon, et al, 2016), (Chambon, et al, 2017)

* Distribution of the farms in the typology was based on their characteristics in 2011. Due to the composition of the initial sample and field conditions (mainly small holdings), it was not possible to include family business farms in Phattalung province.

2.3.2 Data collection

Data collected in 2012 concerned the socio-economic characteristics of the farm with a focus on land and labor, the description of the practices in the rubber plantations and the activity systems.

In 2017, all the 48 farmers were interviewed twice. For the first interview (quantitative phase), the questionnaire recorded the available resources: natural, human, physical and financial assets. Social capital, which is difficult to quantify, was included in the second interview (qualitative phase). Data to characterize the rubber cropping systems and the farming systems were also collected during this first phase. The questionnaire used for this phase can be viewed using this link: <https://ee.kobotoolbox.org/x/#YX8a> and a synthesis of the data collected in 2012 and 2017 is presented in supplementary material (Table 1).

The second interview (qualitative phase) was carried out after a preliminary analysis of the data collected during the first interview. Comparing the same rubber smallholders' characteristics over the six year interval (2011 and 2016) revealed points of change and no change between the initial and final states for each rubber smallholder. An interview guide was designed to collect information to explain the changes observed as well as options which were not used by the households. The interview guide was structured on the activity system and all its subsystems to get closer to

smallholders' decision-making' consistency, understand their choices, and to identify what could and could not be linked to the rubber price crisis (Table 2, supplementary material).

2.4 Data analysis

Comparing the characteristics of each household in 2011 (available from 2012 study) and 2016 (2017 interviews of quantitative phase), we were able to identify the changes (or non-changes) at the plots, farm and household levels. Analyzing farmers' discourses recorded during the qualitative phase of 2017 study, we could identify farmers' choices related to rubber price decrease and finally bring out the different flexibility mechanisms adopted to face falling prices. Each farmer could have adopted several flexibility mechanisms. In order to classify the smallholders according to the combinations of these mechanisms, we implemented a multiple correspondence analysis followed by a hierarchical classification using the open access R software. The multiple correspondence analysis allowed transforming nominal variables (the flexibility mechanisms adopted by each smallholder) into continuous numerical data that were used for the hierarchical classification analysis. The hierarchical cluster analysis using Ward's minimum variance algorithm allowed building a dendrogram. Some odd-distributed variables which influenced too much the results of the statistical analysis were not considered (Escofier & Pagès, 1988). The dendrogram was cut using a qualitative approach, at a level where resulting clusters could be characterized in accordance to the field reality. Within a cluster, the combination of flexibility mechanisms allowed to highlight the strategy adopted corresponding to the means used to reach a given objective here, to cope with the rubber price crisis.

We collected and analyzed some data to understand the economic logic behind the farmers' behaviors. However, we have chosen to simplify the presentation of the results and focus on the strategic mechanisms and the main dynamics of rubber households.

3. Results

3.1 Flexibility mechanisms

The 15 mechanisms identified were classified based on the levels where they applied: rubber cropping system, farming system and activity system. The number of farmers who adopted the mechanism is mentioned in brackets. This cannot be read as a frequency of occurrence since the sample was not representative of the rubber smallholders' population but was intended to cover the diversity of their situations. Thus, it only gives an idea of the mechanisms most adopted in our sample. One household could have adopted several flexibility mechanisms (and they usually did), these will be later synthesized through defining different types of strategic behaviors.

Six mechanisms, all reversible, were implemented at the rubber cropping system level.

1. Rubber fertilization management (24): some households reduced fertilization expenses. They were sensitive to the decline of the productivity of the capital invested and could rely on other resources to compensate for a possible decrease in rubber income. When reducing fertilization, smallholders expected a decrease in production but not proportional to the savings they made on fertilization expenses. This adjustment allowed households to adapt in the short term, without impacting on the farm structure.

2. Change in the total number of harvesting days (3): this mechanism was adopted in different ways. In the first one (2a), two smallholders increased the total number of tapping days either by resuming tapping earlier than usual after the defoliation period or by increasing the harvesting frequency. This increase was temporary as both farmers realized that it did not increase the quantity of rubber produced and only increased the workload, therefore decreasing labor productivity. In the second one (2b), one farmer reduced the number of tapping days to reduce the workload for harvesting that has relative low labor productivity when the rubber price is low. Finally, this mechanism could respond to a search for income maximization through a more intensive exploitation of the rubber

tree, or to a better valuation of the labor through a workload reduction. The change in harvesting had a quick economic effect on income. Even if this was not the main motivation for the farmers to change the number of tapping days, this also had a long-term effect on the tree capital.

3. Stop hiring labor for latex harvesting (2): this mechanism aimed at reducing the cost of production from rubber activity. Family labor was mobilized for latex harvesting previously done by hired labor. Households did not have to reallocate resources since family labor was already available offering flexibility. Unlike the reduction in fertilization costs, the productivity of the rubber tree was not threatened by this adjustment. This reversible mechanism may not be restored to its original state when rubber price increases.

4. Change of the form of rubber sold (7): rubber can be sold in different forms and each form has a specific price, workload and collecting and sale frequencies. This mechanism was adopted with two different rationales. First (4a), below a certain price (not specified since each household set its threshold price based on its own workload capacity), some smallholders considered that the workload was not worth the additional remuneration it generated. They changed the form of rubber product to a less labor-consuming one which freed labor that could be better valorized with other activities. Second (4b), some smallholders were primarily motivated by a higher income frequency, low income being less viable when it is received at too long intervals. Therefore, some smallholders changed the form of product to a high selling-frequency one.

5. Change of the share-tapper contract's clauses (10): the share-tappers have an oral contract with the owners of the plantation usually including three parts: production sharing ratio, costs sharing ratio and side benefits. These smallholders changed the contract clauses (production and/or cost sharing ratio) to create sufficiently favorable conditions to discourage the tappers to seize other opportunities for higher paying jobs. Therefore changes were to the benefit of the hired tappers. The contracts were generally decided for the duration of a crop cycle and could be reviewed at the beginning of the new cycle if the rubber price changed. These adjustments had a cost for the owners but this was also in their own interest; if the tappers left the farm for other activities, the owners

could no longer make full use of their rubber plantations, and could lose more than what they paid to convince their hired tappers to stay.

6. Lend money to the share-tappers (3): the owners lent money to their share-tappers without any interest or repayment term. These mechanisms aimed at improving the tappers' living conditions to encourage them to remain working on the farm which consequently limited the loss in the owner's income.

Five mechanisms, with different degrees of reversibility, were implemented at the farming system level.

7. Provide other work to the share-tappers (2): this mechanism follows the same logic of improving the hired tappers conditions to encourage them to continue working in the plantation. The owner gave the share-tappers the opportunity to work on other crops allowing them to get additional income. This could be combined with other mechanisms such as changing the form of rubber production to reduce the workload on rubber activity and free time for other remunerative activities. This mechanism allowed the owner to exploit the maximum potential of the farm's plantation.

8. Develop other crops (18): Some smallholders extended non-rubber crops and/or diversified the existing crops. Both approaches aimed at improving the distribution of risk on the various agricultural activities, and at strengthening self-consumption capacity and/or income from non-rubber crops. The extension was possible due to the available land that the smallholders owned and kept as a land reserve since such areas were usually far from the house. Another type of extension concerned small areas at the edge of the dwelling used for market gardening activity with high land productivity. These small areas were previously unused and were conducive to intensive work because of their proximity to the house, and allowed an adjustment involving the family workforce and little financial means. Crop diversification sometimes resulted from a change in the areas allocated to non-rubber crops (developing crops with higher added value). However, the land use change never affected the rubber plantations.

322 9. *Temporary agricultural land increase through a credit-land contract (3)*: "jamnong" is a loan of
323 money with interest in the form of a right to use some land for a productive crop. The lender is
324 assigned a right to use a productive plot, over a period attached to the duration of the contract itself
325 dependent on the repayment time of the capital borrowed (maximum five years observed in our
326 sample). The smallholders surveyed were always the lenders. This contract allowed them to invest
327 their savings in a temporary agricultural extension, with, in principle, the assurance of recovering
328 their initial investment at the end of the contract. In the cases found during the study, the extension
329 did not induce any deep and definitive structural change; "jamnong" was just a temporary structural
330 adjustment.

331 10. *Renew rubber plantation (6)*: with this non-reversible mechanism, smallholders took the
332 opportunity of the period of low rubber price to renew rubber plantations. Some farmers anticipated
333 replanting by two or three years. Replanting during a period of low rubber price was a way to
334 minimize the inevitable loss of income during the immature phase of a new plantation. In addition,
335 the sale of timber often generated income allowing the household to regularize its situation if it had
336 loans to refund, and put it back in a favorable economic position to cope with possible future
337 disturbances.

338 11. *Sell a mature or immature rubber plot (3)*: this non-reversible mechanism was implemented by
339 smallholders who owned several plots of mature rubber plantations. They could sell a plot without
340 sacrificing too much their rubber income, which remained the main source of income for the
341 household. The sale of a productive plot generated an additional income which allowed the
342 household to directly find a more comfortable financial situation. It also allowed investing in another
343 long term activity such as off-farm business or new land for expansion and diversification of cash
344 crops. Therefore, the transaction had two temporal levels: the response to a direct financial need,
345 and a will to diversify the household sources of income in the long term: it was a decapitalization to
346 reinvest in the household's capital.

Four mechanisms were implemented at the activity system level. One was easily reversible (14) and the three others could be reversed but they engaged the household in the medium or long term.

12. Hire share-tappers (3): some smallholders hired labor to harvest all or part of their plantations to relieve the family workload engaged in rubber activity. This allowed a reallocation of family labor to other activities. The loss of income generated by the sharing of production was at least compensated by a better valorization of family labor possible due to the time released.

13. Develop off-farm activities (13): some smallholders invested in off-farm activities. There was a huge diversity of types of activities. This mechanism required investment and was therefore often combined with other mechanisms that allowed a reallocation of production factors (time invested, workload, capital invested, frequency of rubber income), impacting the working capital of the new activity.

14. Decrease in expenditure related to household consumption (25): this adjustment did not concern the basic food basket and education expenditures. It related to expenditure on transport costs, new clothing, alcohol, ice cream and soft drinks, and expensive foods. It allowed the household to absorb part of the reduction of rubber income and for some, to preserve their savings used to invest in more profitable activities.

15. Use of loans to maintain the standard of living (6): households with the greatest financial difficulties did not sacrifice the schooling of their children and maintained a standard of living that met basic needs. For that, since the beginning of the crisis, they have contracted several loans. Credit was not only for income-generating activities, but also for repaying previous loans and for consumption and education expenditures. The smallholders without access to official financial products (no official land title) had to borrow money from usurers whose interest rates were around 15% per month when the interest rate from a bank was only 7% per year.

The 15 mechanisms could also be classified based on their objectives (Table 2). Only one mechanism fits in the combination of objective with level of implementation.

374 Table 2: Classification of flexibility mechanisms based on level of application and main objective

Level Objective	Rubber cropping system	Farming system	Activity system
Reduce expenses	Rubber fertilization management (24); Stop hiring labor for latex harvesting (2)		Decrease in expenditure related to household consumption (25)
Secure harvesting labor to limit income loss	Change of the share-tapper contract's clauses (10); Lend money to the share-tappers (3)	Provide other work to the share-tappers (2)	
Anticipate price increase		Renew rubber plantation (6)	
Free family labor from rubber for higher valuation	Reduce the total number of harvesting days (1); Change the form of rubber sold to reduce labor use (4)		Hire share-tappers (3)
Diversify sources of income		Develop other crops (18)	Develop off-farm activities (13)
Compensate for income loss	Increase the total number of harvesting days (2); Change the form of rubber sold to increase income frequency (3)	Temporary agricultural land increase through a credit-land contract (3); Sell a mature or immature rubber plot (3)	Use of loans to maintain the standard of living (6)

375 The figures in brackets correspond to the occurrence of the flexibility mechanisms observed in our sample

376

377

3.2 Classification of coping strategies adopted by households

Analyzing the combination of the 15 flexibility mechanisms, eight types of farmers' strategies were identified.

A: Maintaining rubber income by keeping hired tappers in the farm

Smallholders were very dependent on rubber activity and on their hired tappers. This constituted rigidity in their system since they had to ensure a certain level of income for their tappers and absorb the fall in their own rubber income. The smallholders' financial margin allowed them to make some concessions to the hired tappers without impacting their household consumption expenses.

Improving the conditions of hired tappers could be achieved through: a change to the clauses in the share-tapping contract for production and/or cost-sharing percentages (mechanism 5), the shift from one form of rubber product to another one (mechanism 4), the possibility for hired tappers to work on other crops (mechanism 7) or getting loans from the owner with indefinite duration and no interest (mechanism 6). All these flexibility mechanisms allowed the hired tappers to: limit the loss of their income, reduce the workload and release time, diversify their farming activities and income sources, have the possibility to keep working and stay in the village without having running interests on debts. Keeping hired tappers on the farm allowed the owner to continue exploiting his plantation, and thus limited the decline in his rubber income. These adjustments were reversible; a rubber price increase would cause a return to the initial state. The farm's structure was not changed. This strategy has a temporal footprint limited to the crisis period.

B: Hiring new tappers to reallocate family labor to other activities

These farmers hired new tappers (mechanism 12) to release family labor that could be invested in on-farm diversification (mechanism 8) and/or in the development of off-farm activities (mechanism 13). The owners sacrificed part of their rubber income to invest family labor in an activity that would

404 supplement their income and reduce the vulnerability to rubber price fluctuations. This strategy had
405 a long term footprint because the off-farm activities were, according to the smallholders,
406 opportunities that once mobilized would last. A rise in the rubber price would not cause a rollback.
407 The households who adopted this strategy did not reduce their consumption or rubber fertilization
408 expenditures. These owners often had entrepreneurial profiles or had permanent non-farm
409 employment. However, they depended on the rubber activity and could not afford to completely
410 sacrifice this income, which was why they maintained the level of investment in fertilization.

411
412 ***C: Lender-tenants mobilizing household savings into temporary agricultural diversification***

413 To absorb the decrease in income, these households reduced consumption expenditure by getting
414 food from their own garden and by limiting everyday non-basic expenses (mechanism 14). However,
415 they did not reduce their children's education, if any. While paying attention to the expenses, the
416 household temporarily invested its savings in other crops, mostly rice, but also cassava and
417 sometimes rubber. This temporary extension of other crops was possible through the credit-land
418 contract locally called "jamnong" (mechanism 9). The financial lending position of these smallholders
419 allowed them to quickly access an already productive crop, to take full advantage of it during the
420 period of the loan, and at the end of the contract, to get their initial savings back. These smallholders
421 therefore mobilized their social and financial capitals to access land capital, which until then was
422 limited. The reversibility of this contract limited the risks of the investment in a new crop compared
423 with a permanent investment inducing a deeper change in the farm structure. However, there is a
424 risk that the owner who temporarily transferred land use right cannot pay back at the end of the
425 contract, which would lead to a deep change in farm structure, since the lender would have to get
426 full ownership on the land (and would not get his financial capital back).

427
428 Jamnong is a long-established form of contract. However, with the rubber price decrease, its
429 implementation was more frequent perhaps accompanying a process mentioned by several

smallholders, namely the fall in the rubber price largely impacted the economy of rural areas and local markets. As not all individuals had access to formal financial services, some were encouraged to stimulate informal lending networks to borrow money.

D: Mobilizing household labor to minimize rubber costs and maintain rubber income

These smallholders had no off-farm activities or other crops. Their system was marked by rigidity at the level of remunerative activities but flexibility at the level of the resources in family manpower which was used to respond to the rubber price decrease. The smallholders first reduced household consumption expenditure (mechanism 14) and then stopped using hired labor for tapping (mechanism 3) or for rubber fertilization. The reduction in the cost of rubber activity was possible due to the available family manpower. The strategy adopted aimed at minimizing costs while limiting the loss of rubber income (fertilization was maintained). These smallholders tried to overcome the crisis without making major changes. The adaptation mechanisms were reversible but may not be restored to the original state with a rise in the rubber price.

E: Renewing part of the plantation and reallocating labor to other activities

These smallholders seized the opportunity of the low rubber price to renew part of their plantations (mechanism 10), diversify their crops (mechanism 8) and intensify or develop their non-agricultural activities (mechanism 13). Felling a rubber plantation decreased the workload for rubber activity and thus family labor could be invested in other activities, on-farm or off-farm.

This adaptation strategy was irreversible and had a long term footprint as the off-farm activities chosen were part of the household's long-term development and replanting rubber trees was a long-term investment.

F: Adopting technical and financial adjustments to maintain the systems

455 These smallholders had the same objective, namely to absorb the crisis within their systems, but
456 used three different approaches.

457 The first was adopted by the poorest smallholders who tried to absorb the decline in rubber income
458 by reducing their household consumption expenditure (mechanism 14) and by borrowing money to
459 close the financial gap between their needs and their revenue (mechanism 15). Often, they were
460 already over-indebted by having overlapping loans, with the most recent ones being used to repay
461 the older ones. These smallholders did not reduce the investment in rubber fertilization. Indeed,
462 rubber growing remained their main source of income. As they had no financial flexibility, they chose
463 to secure their rubber income even if the capital invested could be better valorized through other
464 activities.

465

466 The second situation corresponded to smallholders who reduced rubber fertilization expenses
467 (mechanism 1). Half of them also reduced their household expenditure (mechanism 14), while the
468 other half did not change anything. After reducing capital investment, some households relied on
469 existing off-farm diversification and flexibility with household expenses; others simply relied on their
470 pre-existing financial resources.

471

472 The third situation concerned smallholders who changed the form of rubber product sold
473 (mechanism 4) to increase the frequency of payment facilitating the management of their daily
474 expenses. Some smallholders also tried to increase the number of tapping days (mechanism 2) to
475 offset the loss of income. In parallel, farmers absorbed household income loss through a reduction in
476 consumption expenditure (mechanism 14).

477

478 These smallholders mobilized different mechanisms to absorb the economic disruption in a passive
479 way; their strategy aimed at weathering the crisis without impacting their activity system.

480

G: Adopting technical adjustments to reallocate production factors and develop off-farm activities

The main technical adjustment of these smallholders was a change in the form of rubber sold (mechanism 4) to increase the income frequency. These smallholders implemented the same combination of coping mechanisms as the third case in strategy F; however, they were doing so for a different reason, as they reallocated production factors to strengthen a weakened system. The adjustments aimed at diversifying their income off-farm (mechanism 13).

These adjustments released time by reducing the workload and demand on capital by reducing household consumption expenditure. This time and capital, combined with a higher income frequency, allowed investment in off-farm business such as a street food stall, which required daily liquidity for working capital. The combination of the mechanisms mobilized allowed smallholders to better overcome the low rubber income and to redistribute production factors to orient the smallholders toward a more stable situation. This transformation might remain in time, even though the household could also return to its initial state.

H: Developing long term on-farm diversification

Moderately wealthy, these farmers reduced household consumption expenditure, without affecting basic needs or education (mechanism 14). They also developed other pre-existing crops (mechanism 8)—mainly cash crops such as sugar cane or cassava. These crops did not replace rubber plantations which were always renewed, but they provided additional income. This type of change was reversible since it only concerned short-term crops.

Having financial flexibility due to the other crops, these households reduced the expenses for rubber fertilization (mechanism 1) to optimize in the short term the capital investment and to balance the decreasing income of the activity. It was also a risk management mechanism; indeed, limiting the investment in fertilization allowed the smallholders to minimize the loss if they lacked the manpower

to tap all the rubber trees, and therefore could not valorize the capital invested by exploiting the maximum potential of the plantation.

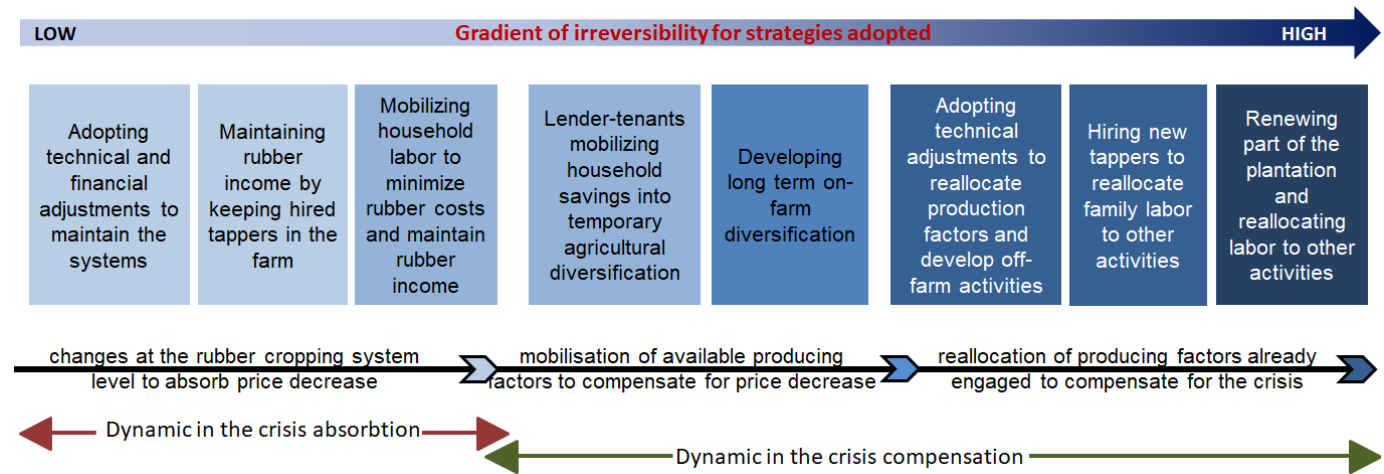
3.3 Three types of adaptation strategies, three temporal footprints

To simplify the description of farmers' responses to the decreasing rubber price, it is worthwhile considering the level of reversibility of the changes. Three major types of adaptation strategies were identified: (i) reversible adjustments at the level of activity system variables, to strengthen the capacity of disturbance absorption within the system, in order to maintain the smallholder systems and overcome the crisis; (ii) mobilization of available production factors invested in an activity that allows, in a longer time perspective, for compensation for the disturbances caused by the crisis. This type of adaptation was reversible, but its implementation expressed motivation in the medium-to-long term; (iii) reallocation of the production factors already mobilized at the level of the rubber cropping system toward other activities, to compensate the disturbances caused by the crisis. This latter type of adaptation induced a deeper transformation in the distribution of the production factors in the activity system and was anchored in a long-term vision.

These three main types of strategies corresponded to two main trends (Figure 3): absorption dynamics and the dynamics of compensation. The smallholders who based their strategy on the flexibility of the system in place and attempted to absorb the shock through adjustments in the variables of the rubber cropping system were defined as smallholders who tried to maintain themselves and overcome the crisis without transformation. The mechanisms mobilized were reversible and did not induce compensatory mechanisms for the crisis. This was the absorption dynamics observed in the three provinces.

The smallholders who mobilized available production factors to compensate for the fall in rubber income were involved in compensation dynamics. This was possible in Buriram and Rayong provinces and the mechanisms mobilized were reversible. This behavior reflected a desire to anchor the changes over a longer period and generated a transformation in the activity system. However, some smallholders made adjustments to reallocate the production factors within the activity system and so underwent a deeper transformation that was less reversible. This was observed in Rayong and Phattalung provinces. This redistribution generated a certain locking of production factors at the activity level and was part of a longer time perspective. Therefore, sacrifices were made at the level of the rubber activity in favor of investment in other activities that allowed the smallholders to feed a dynamic of compensation for the crisis.

Figure 3: Dynamics, trends and strategies of adaptation to cope with rubber price decreases based on an increasing irreversibility gradient (from left to right)

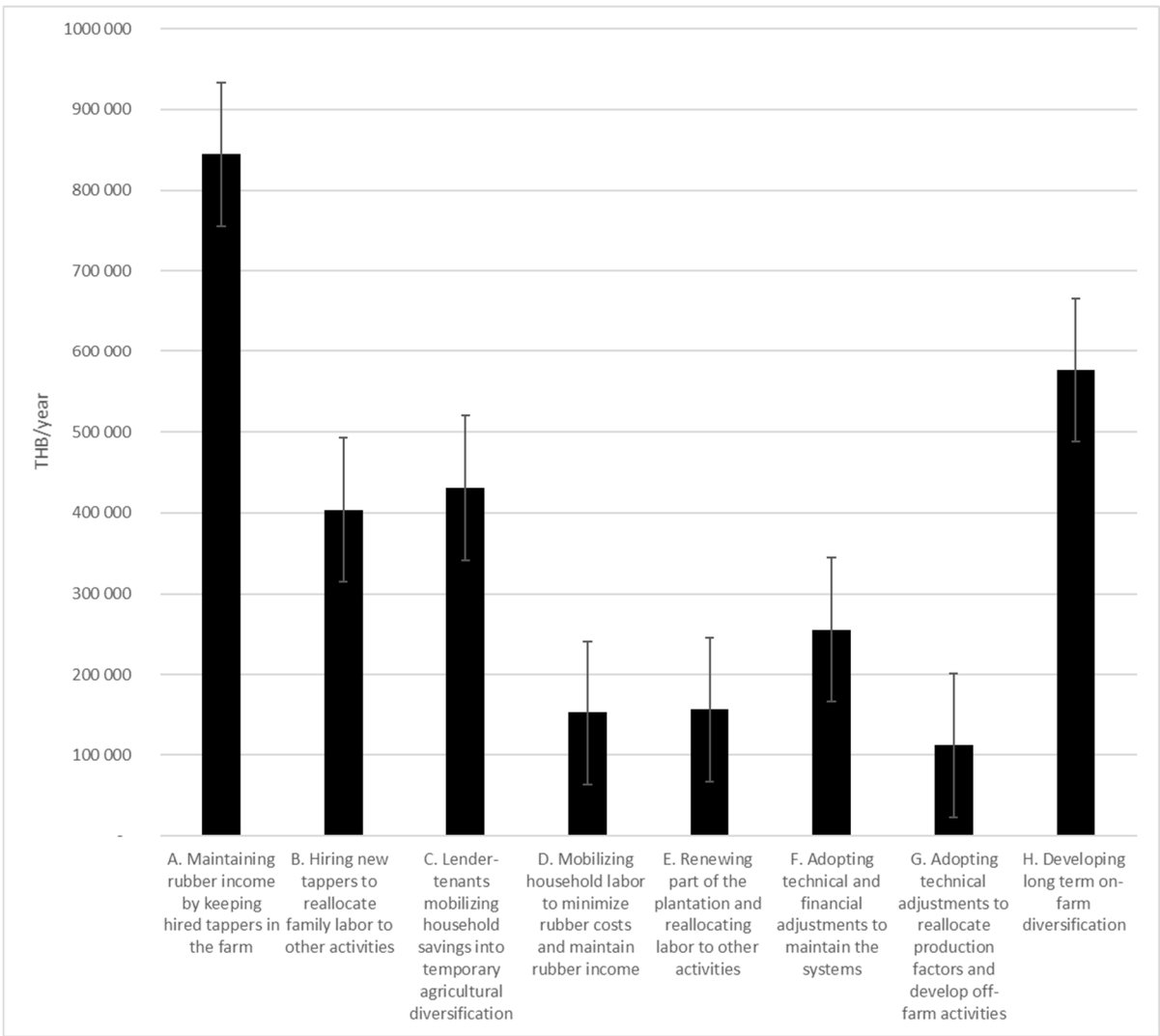


3.4 Economic status of the farmers in the different groups of strategy

Since the response of the rubber households to the rubber price decrease could be related to their economic situation, we looked at the total household income as well as the total area under rubber plantations and the area of mature rubber plantations. There was a high variability of the average

household incomes between the different groups of coping strategies but also within each group (Figure 4). It is important to mention that it is difficult to assess precisely the income of the rubber smallholders by survey. Indeed, the rubber activity can generate income throughout the year with different frequencies depending on the form of the rubber product sold; it can be almost daily in the case of rubber farmers in Thailand. Moreover, the interviewed rubber smallholders generally did not record their sales information. So the results presented should be considered as approximates. However, despite the approximation, these data allowed a comparison between groups and provided some insights to understand better farmers' responses to the price decrease.

Figure 4: Average total household income for the different coping strategies adopted for the year 2016



569

570 The area under rubber plantations (both total and mature) also presented important variability

571 between the groups and within the groups (Figure 5).

572 Observing figures 4 and 5, we can gather four subsets of rubber households. Two groups (A and H)

573 gathered well-to-do smallholders with large rubber areas (total and mature) and the highest average

574 total income. Group B was medium-sized rubber area (total and mature) and had average total

575 income. For four groups (D, E, F, G), the income was lower as well as the area of mature rubber

576 plantations. Group C had small rubber area (total and mature), whereas it had a high average total

577 income. This is to relate with its financial resources giving the ability of using the land credit contracts

578 in order to temporaly extend their mature rubber areas. Finally, for all the groups except C, it seems

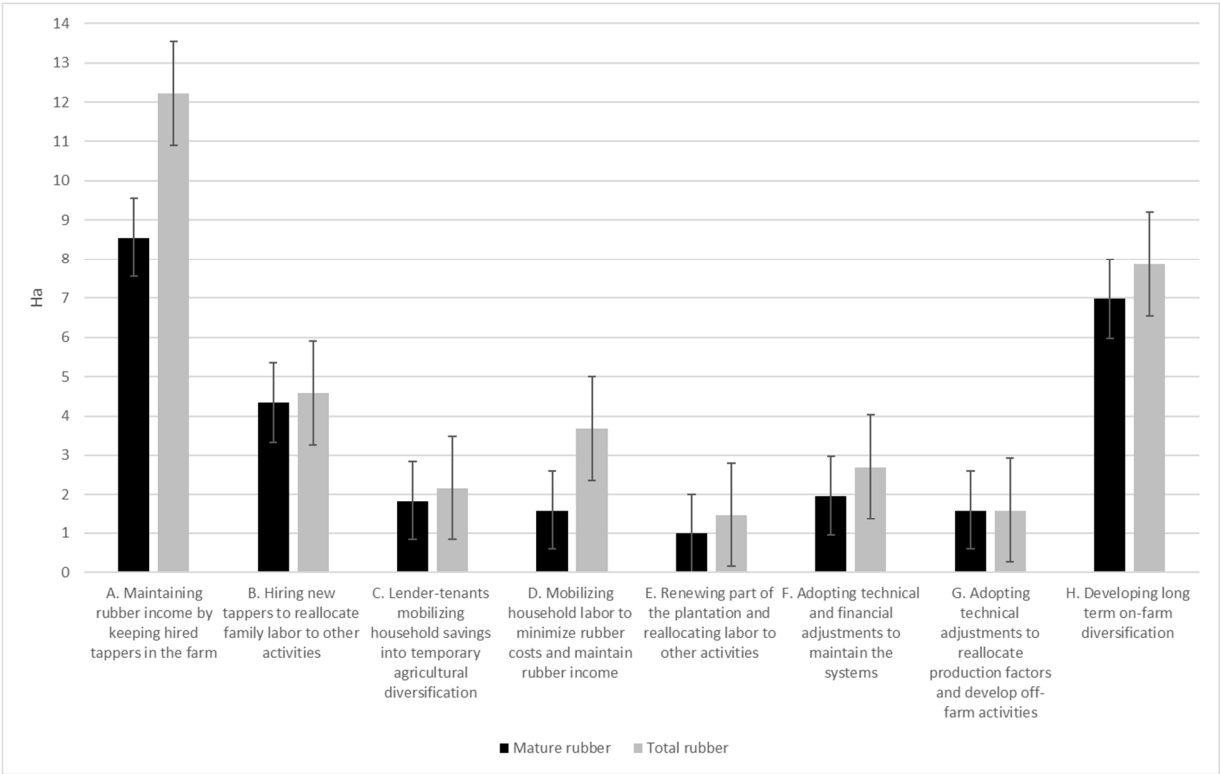
579 that the level of income could be related to the area of mature rubber plantations, suggesting the

580 importance of rubber in the income.

581 Figure 5: Average area of rubber plantations: total rubber plantations and mature plantations for the

582 year 2016

583



4. Discussion

4.1 Family rubber farmers resilience to market shocks

The results showed a high diversity in the strategies adopted by rubber farmers when facing rubber price decreases. This diversity in response by long-term crop producers facing market shocks has been observed previously (Vongvisouk & Dwyer, 2016). The strategies adopted by Thai rubber farmers present similarities with the strategies observed in other crisis contexts. For instance, in spite of the low coffee price, there was expansion and intensification of coffee areas and finally only a few farmers sold their land or reduced the area under coffee (Eakin et al, 2014). Low and variable coffee prices also induced economic diversification (Padron & Burger, 2015). However, the response by rubber farmers to a price decrease also showed some divergences. In several countries and for different crops (Vimard et al, 1997; Samper, 2010), a decrease in the commodity price led to conversion to other crops. In Thailand, when the current study was conducted, the abandonment of rubber cropping appeared limited; some farmers even took the opportunity of this crisis to renew the production capital, especially in historical rubber-producing areas. This may have been encouraged by the long-term government support for rubber replanting and by the market for rubber wood. Perennial crops usually require high levels and long terms of investment. Once the plantation is there, reconversion is possible, but it has a cost and is an irreversible decision in the short term. Therefore, it is more difficult to change with a long-term crop than for a short-term crop. This structural factor of crop longevity may explain time lags and can lead to incremental adaptations rather than transformative change (Darnhofer, 2014). As a consequence, when the price decreases, perennial crops farmers first try to survive; reconversion is done only when the commodity price is so

low that it does not allow the household to subsist. It seems that even with a low price (around USD 1.5/kg for RSS3 rubber grade in 2016), rubber remained the best crop opportunity. Our results are consistent with other work conducted in Southern Thailand where some farmers diversified their sources of income but even for farmers more dependent on rubber, this crop remained a good option for the future (Andriesse & Tanwattana, 2018). Almost 20 years ago, Penot & Ruf (2001) had already observed that throughout the history of rubber cultivation, in spite of the fluctuations, the rubber price had never dropped to the point where it would discourage farmers to grow rubber.

Another phenomenon associated with the commodity price decrease could be the sale of land (Ruf & Gerard, 2000; Bathfield et al, 2013). Nonetheless this also was limited in the Thai rubber sector. Because of the adjustments at different levels in their systems and the jamnong credit-land contract, farmers were able to avoid this irreversible change that could have led them to increased poverty. However, even if the situation was not evident in our study, jamnong could also lead to loss of land for the borrowers who may not be able to pay the credit back.

Despite the long-term character of the rubber crop, the technical adjustments provided some flexibility with limited risks in the short term. Technical change offers potential flexibility that is often used first by farmers facing a crisis (Bathfield et al, 2013). These adjustments at the rubber cropping system level offer levers for action allowing reaction in the short term at different levels (workload, cost, income frequency) without compromising the profitability of the activity. The adjustments include the possible reduction of fertilization expenses and a change in the type of product. Share-tapping contracts also provided important flexibility to maintain labor for harvesting. This probably explains the persistence of this labor contract (Kongmanee, 2015) and may make a difference with other countries using wage labor for latex harvesting. In such countries, low rubber prices have resulted in increased rubber farmer poverty as well as a shortage of labor for latex harvesting since tappers leave this sector for more remunerative ones (Aidenvironment, 2016). The ability of farmers

to accept remuneration for their factors of production, notably labor, below the market price is another well known flexibility and factor of resilience for family farms (Lamarche, 1991).

In addition, in our study, different levels of resource endowment provided different levels of flexibility. Farmers employing hired labor for latex harvesting were usually those with the largest rubber plantation areas. They could adopt flexible mechanisms at the rubber cropping system level that were all reversible adjustments. In contrast, the farms using only family labor and with small landholdings were more vulnerable and needed to implement more profound and irreversible changes in their systems.

Finally, some rubber farms were able to mobilize their “buffer capability” to absorb the price decrease without any change in their structure or function and their “adaptive capability” allowed them to adjust and develop within the same trajectory (same goals and values), implementing reversible changes. However, so far, very few farms have mobilized their “transformative capability” which means they would implement radical changes (Darnhofer, 2014). The fact that only a few of these radical changes were adopted by rubber farmers to face a rubber price decrease suggests that until 2017, rubber households had not yet been cast into poverty. Even if the drop in the rubber price was sudden and following a historically high price (Figure 1), most farmers considered that the situation remained viable and would finally return to the situation of the 1990s and 2000s. We found only two kinds of households in difficulty: the smallest farms that were highly dependent on rubber income and those who contracted debts during the period of high rubber prices and fell into over indebtedness when the rubber price dropped. However, overall, this study once again showed the flexibility of family forms of agriculture (Chayanov, 1990).

4.2 Return on methodological choices

The methodology adopted was based on the utilization of a survey previously conducted in 2012. Using this survey as a basis presented some drawbacks. Due to the composition of the 2012 sample and the difficulties to meet again with the same farmers, it was not possible to have a balanced distribution of all the three types of farms based on the labor used and previously identified in our own unpublished work. Interviewing farmers in 2017 who were not in the initial sample could have corrected the bias. However, we found it more relevant to remain within the 2012 sample to satisfy our stated objective, and having an accurate description of the situation of the farms in 2011 appeared very valuable in the analysis of the changes. In addition, during the final restitutions organized in each province, exchanges with farmers and extension officers allowed the validation of the observations beyond the cases interviewed.

The combination of two approaches with complementarities provided some robustness to the analysis process and the results. The sustainable rural livelihood framework appeared very useful to quantify rubber household capital and its possible mobilization. This gave a robust starting point to analyze farmers' decisions using the activity system approach and to try to understand farmers' practices considering their poly-rationality in a systemic perspective (Gasselin et al, 2014).

5. Conclusion

This study focusing on the impact of the rubber price crisis on Thai farmers highly dependent on rubber income illustrates the adaptation of family agriculture when faced with a major economic shock. The strategies adopted showed that so far, the farmers could overcome the crisis. They themselves acknowledged that the changes were limited. The study was conducted after a period of 6 years of decreasing rubber prices, which was sudden and substantial. However, the period of low price was not as long as has been experienced, such as during the 1990s (Penot & Ruf, 2001). We consider that the study was conducted at the beginning of a new rubber price crisis and family

farmers with their well-known resilience and capacity of adaptation were able to cope with and adjust to this new situation. Nonetheless, things could change if there is a continued low price trend in the medium term. The rubber price is not expected to increase again before mid-2020 (Jacob, 2018). So, for how long can rubber households remain resilient? With a long-lasting crisis, the proportion of farmers implementing radical and irreversible changes may increase with important consequences for the long term of the rubber industry.

Several mechanisms applied at different levels from the rubber plot to the household were adopted to overcome the crisis. However, the present study showed that analyzing farmers' practices is a major key to understanding family agriculture. Indeed, practices and change in farmers' practices are parts of the farmers' strategies and therefore, they are very useful to describe and retrace the strategies (Yung & Zaslowsky, 1992). Setting up a tool for farms diagnosis and long term monitoring of the farm would allow studying practices in detail and following the evolution of the households in the medium and long terms. It illustrates the interest of empirical surveys documenting households' assets and performance, based on a selected sample of diverse farm types. This would provide policy makers with information to optimize rubber policy to support family farming and thus contribute to maintaining and/or increasing its resilience to shocks that are getting more and more unpredictable.

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