International Journal of Agricultural Technology 2019 Vol. 15(4): 645-664
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

Rubber production system and livelihood of smallholding rubber farming system (SRFS) in southern Thailand: A case study in provinces of Nakhon Si Thammarat, Phatthalung and Trang

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Somboonsuke, B. , Yincharoen, A., Kongmanee, C. and Phitthayaphinant, P. (2019). Rubber production system and livelihood of smallholding rubber farming system (SRFS) in southern Thailand: A case study in provinces of Nakhon Si Thammarat, Phatthalung and Trang. International Journal of Agricultural Technology 15(4): 645-664.

Abstract The farming system, production management, technology usage, livelihood, vulnerability, and factors was examined the influence on the vulnerability of livelihoods of smallholding rubber farmers along with other agricultural activities. The studied locations were those of Pa Bon district, Tamot district, Bang Kaeo district in Phatthalung province; Ron Phibun district and Lan Saka district in Nakhon Si Thammarat Province; and Na Yong district, Kantang district, and Yan Ta Khao district in Trang province. The number of 399 households and 60 key informants were selected as a sample group. The results indicated that working with rubber farming could be classified into 5 systems that were 1) mono-rubber-tree farming system (53.85%), 2) inter-fruit-tree with the rubber-tree farming system(14.48%) such as durian and longkong, 3) rubber-tree with rice farming system (8.27%), 4) rubber-tree with the oil-palm farming system (19.22%), and 5) rubber-tree farming with animal raising system (4.18%). For livelihoods of rubber farmer households under these 5 systems, the results reflected all 5 systems that the social capitals were quite high when the economic capitals were quite low. For the livelihood success among the 5 systems, the study indicated that to get a net income, reducing limitation strategies, and top know well-being under the oil-palm farming system had higher averaged values than all of the other systems. For the 10-year economic model (2017-2026), the study indicated that inter-fruit-tree with the rubber-tree farming system, rubber-tree with the oil-palm farming system, and rubber-tree farming with the animal raising system had high marginal marketing when compared with the others. For the model of rubber production pattern and livelihood under rubber farming system along with other agricultural activities for sustainable development in the 3 provinces, the study classified the system into 4 sub-models s as follows:- 1) production system, 2) support system, 3) strategy and livelihood adjustment system, and 4) the resulted sustainable livelihood system.

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Keywords: smallholder livelihood, rubber smallholding farm, rubber production

Introduction

Rubber is a major and economic crop in the South. In 2016, there were growing areas of rubber for 14.58 million rai in the South (equivalent to 62.46% of the total growing areas of rubber trees for the whole country). The rubber tapping areas in the South were 13.92 million rai which gave yields for 3.14 million tons (equivalent to 71.46% for the whole country yields). The major growing rubber areas in the South are those in Surat Thani province (2.85 million rai), Songkhla province (2.08 million rai), Nakhon Si Thammarat 2.52 million rai), and Trang province (1.62 million rai) (RAOT, 2017). Under the circumstance of low rubber price, this affects household livelihood and livelihood of rubber farmers which many of those rely on the rubber plantations. Although people in the South have their major incomes from rubber plantations, the study found that livelihood of farmers still had high vulnerability and weak viability because of the poverty problems (Office of the National Economic and Social Development Board, 2015). These also have a connection with the structure of the production system, management of production, and utilization of selected technology that may not have ample productivity. Then rubber farmers need to have a direction for production type, farming system, and proper household livelihood that help create income with sustainable livelihood condition. Nakhon Si Thammarat province has rubber growing areas for 2.52 million rai, an average of production for 242 kilograms/rai, and farming households for 161,276 households. Phatthalung province has rubber growing areas for 0.96 million rai, an average of production for 242 kilograms/rai, and farming households for 78,424 households, Trang province has rubber growing areas for 1.62 million rai, an average of production for 223 kilograms/rai, and farming households for 85,978 households (RAOT, 2017). While the rubber price was fluctuating, the study found that farmers in the 3 provinces had adapted to survive themselves and attempted to increase their household incomes. One pattern of such adaptation of those rubber farmers was having the secondary occupation along with the rubber plantation. However, the study found that farmers did not have a clear pattern and even the developing direction that would answer the production questions, livelihood, and sustainable livelihood. This study had an attempt to classify the present rubber production system of SRFS, to examine livelihood and its component of households under SRFS, to analyze component factors of livelihood that affect the success of livelihood of SRFS, and to synthesize the model of connection between the production system and livelihood under SRFS.

Concept relevant to rubber farming system is the concept of rubber farming system which is one pattern of the farming patterns that looks mainly at

doing with rubber plantation (Cherdchom *et al.*, 2009). And also, this is the farming system that pays attention to factors relevant to the production process which those are economic factor, social factor, physical factor, and biological factor which (Somboonsuke *et al.*, 2002) described in details of those factors as the following; 1) Economic and social factors such as marketing system, price, government policy, investment, potential farmer, and management; 2) Physical factors such as area condition, weather condition (temperature, humidity, and rainfall) and 3) biological factors such as farmer, other household activities, and soil fertility. All these factors have related relations that are important parts of productions and the existence of rubber plantation management (Figure 1).

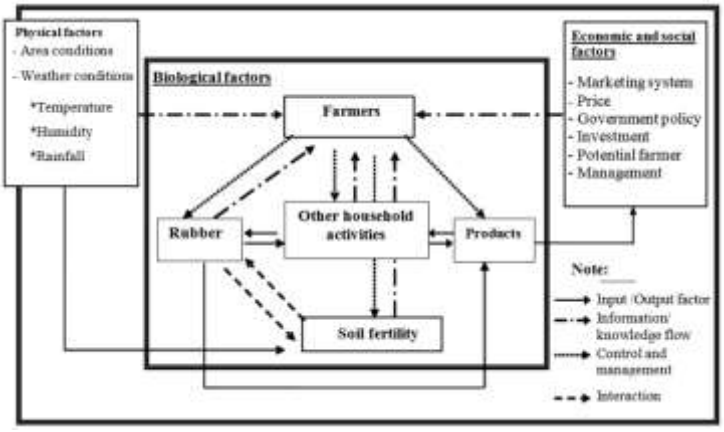

Figure 1. Rubber system in the South at present
Source: Somboonsuke *et al.* (2002).

Sustainable livelihood framework is the study of relationships of the 5 components that will lead to the livelihood of the target group as the following; 1) The context of weakness and uncertainty which relates to the condition that suddenly occurs and has severe effect with tendency, and tendency condition of mobility factors that affect the livelihood way and season change; 2) Asset or capital for livelihood is the major component or in other words is the capital that the target group uses for livelihood process. This has positive relationship for the occurrence of result that affects the optional opportunity of livelihood way influenced directly by the context of weakness and changes of structure and institution such as human capital, natural capital, financial capital, physical capital, and social capital; 3) Structure and process that cause change relate to component that directly affects and causes weakness in the process. This component affects choosing of livelihood way. This component composes of 2 sub-components that are structure and process; 4) Livelihood strategy is the

component relates to optional opportunity that the target group uses as the strategy for livelihood that will have diversity which depend on the feature of topography holding and period in the feature of moving, scattering across places, and linking, and; 5) Result of livelihood is the consequence received from choosing way or strategy of livelihood that expresses sustainable livelihood by having income, living better, reducing weakness, having food security, using sustainable natural resources, etc. (Figure 2, Figure 3)

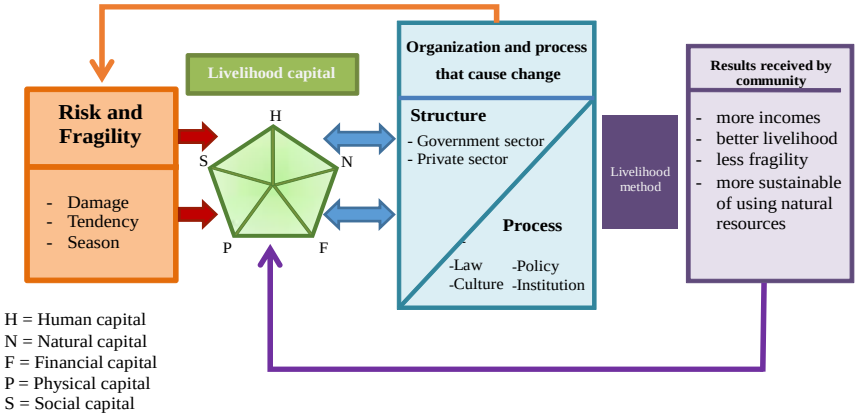

Figure 2. Sustainable livelihood framework
Source: The Department for International Development (DFID), (2001).

(a) (b) (c)

Figure 3. The three studied areas of Nakhon Si Thammarat Province (a), Phatthalung Province (b) and Trang Province (c); **Source:** The Land Development Office, (2017).

Materials and methods

The studied locations were those of Pa Bon district, Tamot district, Bang Kaeo district in Phatthalung province; Ron Phibun district and Lan Saka district in Nakhon Si Thammarat Province; and Na Yong district, Kantang district, and Yan Ta Khao district in Trang province. A number of 399 farmer households

with 60 key informants were selected for this study. The instruments used for this study were a structured interview and an unstructured interview. Descriptive statistics such as percentage, frequency distribution, average, and standard deviation; and referential statistics such as multiple linear regression analysis were calculated for data analysis.

Results

Classification of smallholding rubber farming system

Classification of the farming system used for this study was a mixed principle composed of household agricultural activities, 2) socio-economic and rubber management, and 3) agricultural land utilization. The study found that practicing rubber farming system along with other agricultural activities in the 3 provinces could be classified into 5 systems that were a smallholding rubber monoculture farming system (S1) (53.85%), smallholding rubber – fruit tree farming system (S2) (14.48%), smallholding rubber- rice farming system (S3) (8.27%), smallholding rubber- oil palm farming system (S4) (19.22%), and smallholding rubber - animal raising system (S5) (4.18%) (Table 1).

Table 1. The classification of SRFS of three studied areas of Nakhon Si Thammarat province, Phatthalung province and Trang province

SRFS Types	No. of Farms	Percentage
1.Smallholding rubber monoculture farming system(S1)	210	52.85
2.Smallholding rubber – fruit tree farming system(S2)	58	14.48
3.Smallholding rubber- rice farming system(S3)	33	8.27
4.Smallholding rubber- oil palm farming system(S4)	77	19.22
5.Smallholding rubber- animal raising system(S5)	21	5.18
Total	**399**	**100.00**

Source. The quantitative data collection from 399 farms.

Rubber production system and smallholding rubber farming system

All those farmers had practiced 5 systems by following the principles of household agricultural activities, socio-economic and rubber management, and agricultural land utilization. Moreover, the study indicated that farmers practiced their farming systems by different systems as the below table 2.

The study concluded that the objectives of all production systems aimed at the similar targets that were tried to increase household incomes with the average land holding at 20.96 rai/household (Table 2). All production systems used similar production technology. The major problem of production was weather change that would affect all production systems which farmers had to adjust themselves for the production. However, farmers of all production

systems had experiences of working with rubber plantations. Then farmers could adjust themselves quite easily. For the success of the production by comparing among the 5 systems, the study found the 2 systems that were inter-fruit-tree with the rubber-tree farming system and rubber-tree with the oil-palm farming system in the three southern border provinces had the highest net values at 410,104.2 and 459,303.64 baht/year, respectively. These reflect that both systems would be the best economical options for farmers.

Livelihood of rubber farmer under rubber farming system

For livelihood of farmers under all 5 systems, the study concluded in the point of view of capital that the human capital had the most percentage proportion among those. These reflected that rubber farmers under these 5 systems had potential and capability for production. However, there were some major barriers for livelihood such as price, market, weather change, soil erosion which affected production and income sufficiency of households. The success of livelihood of the 5 systems, the study found that food security was rated at not that high, and asset holding of farmers was rated at a low level. However, the social relationship in the community was still at a high level even though other social capitals were not rated at those high levels. The study concluded that livelihoods of rubber farmers under all 5 systems were at the middle level with having high potential farmers which would be faced the major factor for the development of production for households under all 5 systems.

Factors affecting the livelihood of the five smallholding rubber farming systems

Among vulnerability–capital relationships of the five smallholding rubber farming systems, the smallholding rubber–rice farming system (S3) received the highest R2 value (0.45). It meant that approximately 45 percent of the variation in vulnerability was explained by variation in the five different capitals. Moreover, the R2 values of the remaining smallholding rubber farming systems were 0.43, 0.31, 0.27 and 0.25 for the smallholding rubber–fruit tree farming system (S2), the smallholding rubber monoculture farming system (S1), the smallholding rubber–oil palm farming system (S4), and the smallholding rubber–animal raising system (S5), respectively. The results showed that most capitals of the smallholding rubber–rice farming system (S3) and the smallholding rubber–fruit tree farming system (S2) were at the high level, i.e., human capital, natural capital, and financial capital. The rubber farmers with more capitals tended to have a greater range of options. As a result, they became more resilient to cope with vulnerability.

Table 2. Rubber production systems of 5 SRFS

Factors	S1	S2	S3	S4	S5
Production propose	-source of creating major household income -have ample income for good livelihood -carry on a farming career from an ancestor	-be the major household income -have more enough income -have fruits for household consumption -have a good household livelihood	-be the major household income -have more enough income -have household food security -have a good household livelihood	-be the major household income -have more enough income -expand production to new economic crop for risk reduction -have a good household livelihood	-be the major household income -have more income -for consuming and selling -have a good household livelihood
Physical factors for production	-the average land holding 12.67 rai/ household -soil texture: sandy loam -topography: plain/low plain (41.72%) folded/undulating area (38.82%) high land /mountain (19.46%) -water source: natural water resource	- the average land holding 31.45 rai/ household -soil texture : sandy loam -topography: plain/low plain (59.98%) folded /undulating area (35.65%) high land /mountain (4.37%) -water source: rain and pond	-the average land holding 15.51 rai/ household -soil texture: clay -topography: plain/low plain (81.12%) folded / undulating area (18.88%) - water source: rain and natural water resource	- the average land holding 35.51 rai/ household -topography: plain/low plain (62.88%) folded / undulating area (28.67%) mountain (8.45%) -soil texture: sandy loam	-the average land holding 9.68 rai/ household Topography: plain/low plain (81.45%) folded / undulating area (16.76%) high land /mountain (1.79%) - soil texture: loam - water source: rain and natural water resource
Economic and social features	Economic features -type of land evidence is the title deed -average income 221,542.2 baht/year -average expense 142,146 baht/year -debt 240,098 baht/year -saving 12354.68 baht/year Social features -average age of 57.88 years -gender male (78.62%) female (21.38%) -educational level primary education (41.17%)	Economic features -type of land evidence is the title deed -average income 410,986.2 baht/year -average expense 34,146.02 baht/year -debt 13,061.86 baht/year -saving 17,427.68 baht/year Social features - average age of 47.26 years -gender male (87.12%) female (12.88%) -educational level primary education (38.67%)	Economic features -type of land evidence is the title deed -average income 64,937.85 baht/year -average expense 71,032.64 baht/year -debt 124,774.12 baht/year -saving 13,274.25 baht/year Social features -average age of 62.31 years -gender male (71.19%) female (28.81%) -educational level primary education (52.78%)	Economic features -type of land evidence is the title deed -average income 459,303.64 baht/year -average expense 153,271.31 baht/year -debt 233,102.70 baht/year -saving 27,884 baht/year Social features -average age of 52.31 years -gender male (89.76%) female (13.24%) -educational level primary education (72.46%)	Economic features -type of land evidence is the title deed -average income 132,478.72 baht/year -average expense 90,872.12 baht/year -debt 40,532 baht/year -saving 8,752 baht/year Social features -average age of 52.31 years -gender male (92.47%) female (7.53%) -educational level primary education (93.56%)

Factors	S1	S2	S3	S4	S5
	-marriage status married (85.47%) -Buddhist (97.85%)	-marriage status married (92.47%) -Buddhist (100%)	-marriage status married (72.36%) -Buddhist (100%)	-marriage status married (78.69%) -Buddhist (100%)	-marriage status married (87.35%) -Buddhist (98.35%)
Production Weakness	-the uncertainty of weather problem -rubber is vulnerable to disease -rubber price is inconsistent	-the uncertainty of weather problem -rubber is vulnerable to disease -rubber price is inconsistent	-the uncertainty of weather problem -rubber is vulnerable to disease -rubber price is inconsistent -uncertainty of rain	-the uncertainty of weather problem -rubber is vulnerable to disease -rubber and oil palm prices are inconsistent	-the uncertainty of weather problem -rubber is vulnerable to disease -rubber and oil palm prices are inconsistent
Production advantages	-have experience and skill -proper area for rubber farming	-have experience and skill -proper area for rubber farming	-have experience and skill -proper area for rubber farming	-have experience and skill -proper area for rubber farming -topography is low plain proper for oil palm farming	-have experience and skill -proper area for rubber farming -topography is low plain proper for oil palm farming
Using technology for the production	**rubber** -the average rubber farming labor 2.31 workers /household -rubber breed: RRIM600 (95.32%), RRIT 251 (4.68%) -rubber age: 14.87 years -growing space: 3x7 meters (71.50%), 3x8 meters (20.27%), 6x4 meters (8.23%) -average number of rubber trees: 76.20 trees/rai -chemical fertilizer applying: 546.04 kg./rai, frequency: 1.81 times/yr -weeding control: lawn mower (70.14%), chemicals (22.35%), using tractor (7.51%)	**rubber** -the average size of rubber land: 19.32 rai/household -average rubber farming labor 2.27 workers /household -breed: RRIM600 (100%), -rubber age: 22.83 years -growing space: 3x7 meters (80.21%), 3x8 meters (19.79%) -average number of rubber trees: 72.00 trees/rai -chemical fertilizer applying: 237.18 kg./rai, frequency: 1.50 times/yr -weeding control: lawn mower (40.00%), chemicals (60.00%), the frequency of weeding control: 2.00 times/yr	**rubber** -the average size of rubber land: 8.85 rai/household -average rubber farming labor 1.7 workers /household -breed: RRIM600 (100%) -rubber age: 21.25 years -growing space: 3x7 meters (95.21%), 6x4 meters (4.79%) -average number of rubber trees: 68.25 trees/rai -chemical fertilizer applying: 264.29 kg./rai, frequency: 1.03 times/yr -weeding control: lawn mower (94.12%), chemicals (5.88%), -the frequency of weeding control: 1.60 times/yr	**rubber** -the average size of rubber land: 13.74 rai/household -average rubber farming labor 2.12 workers /household -breed: RRIM600 (100%) -rubber age: 16.56 years -growing space: 3x7 meters (97.21%), 6x4 meters (2.79%) -average number of rubber trees: 75.25 trees/rai -chemical fertilizer applying: 232.29 kg./rai,frequency: 2.25 times/yr -weeding control: lawn mower (78.25%), chemicals (21.75%), -the frequency of weeding control: 1.32 times/yr -tapping system: 1/3S3d4	**rubber** -the average size of rubber land: 9.68 rai/ household -average rubber farming labor 1.75 workers /household -breed: RRIM600 (87.72%), RRIT251 (11.28%) -rubber age: 22.51 years -growing space:3x7 meters (92.37%) -average number of rubber trees: 73.25 trees/rai -chemical fertilizer applying: 269.23 kg./rai , frequency: 1.25 times/yr -weeding control: lawn mower (73.68%), chemicals (12.81%), used as animal feed (13.51%), -the frequency of weeding

Factors	S1	S2	S3	S4	S5
	-frequency of weeding control: 2.2 times/yr -tapping system: 1/3S3d4 (89.27%), other tapping systems (10.73%) -average selling price: 34.33 baht/kg -production type: latex (92.47%) raw rubber sheet, (7.53%) -source of selling production: local buyer (81.02%), farmer group (18.98%), -benefit ratio: 50:50 (72.35%), 60:40 (12.14%)	-tapping system: 1/3S3d4 (80.27%) -other tapping systems (19.73%) -average selling price: 33.75 baht/kg -production type: cup lump (75.90%), Latex (20.10%), raw rubber sheet (4.90%) -source of selling production: local buyer (92.66%), community cooperatives (7.37%) -benefit ratio: 50:50 (57.20%), 60:40 (24.8%) **fruit tree** -the average size of fruit tree farming 12.13 rai/household -breed: mangosteen - growing space 9x9 meters -average rubber tree 20 trees/rai -breed: durian -growing space 10x10 meters -average rubber tree 16 trees/rai -chemical fertilizer applying: 50 kg/rai -frequency 1.78 times/yr -age of fruit tree that gives yield 7.67 years -recent age of fruit tree 18.64 years -labor 2.47 workers	-tapping system: 1/3S3d4 (82.14%) -average selling price: 32.34 baht/kg -production type: latex (92.36%) -source of selling production: local buyer (100%) -benefit ratio: 50:50 (98.04%), 65:35 (1.96%) **rice** -the average size of the rice field 6.66 rai/household -breeds: Sangyod, Chiang, Roseberry -fertilizer applying: chemicals 50 kg/rai, -frequency 1.78 times/yr -age of fruit tree that gives yield 55-60 days -labor 2.23 workers -disease and weed control: chemicals (98.58%) -source of selling rice: local markets, middlemen	(89.21%) -average selling price: 33.44 baht/kg -production type: latex (97.65%) -source of selling production: local buyer (100%) -benefit ratio: 50:50 (82.31%), 70:30 (18.69%) **oil palm** -the average size of oil palm land 21.77 rai/household -breeds: Surat Thani 2, growing space 9x9 meter -average number of rubber trees 20 trees/rai -fertilizer applying: chemicals 75 kg/rai, -frequency 3.75 times/yr -age of oil palm that gives yield 2.8 years -recent age of oil palm 12.34 years -labor 2.23 workers -disease and weed control: mechanical method (100%) -source of selling oil palm: factory /oil palm bunch collection center/ middlemen/local markets,	control: 2.0 times/yr -tapping system: 1/3S3d4 (94.74%), other tapping systems (5.26%) -average selling price: 34 baht/kg -production type latex (98.56%) -source of selling production: local buyer (98.14%) farmer group (1.86%) -benefit ratio: 50:50 (85.96%), 60:40 (5.26%), 55:45 (8.78%) **animal raising** -the average animal raised: 3.29 animals /household -breeds: native cow, beef cattle -raising methods: free-range husbandry/rubber plantation husbandry -labor 1.36 workers -source of selling: middlemen/local markets

Factors	S1	S2	S3	S4	S5
		-disease and weed control: mechanical method (92.33%) chemicals (7.67%) -source of selling fruit: Hua-it market (Nakhon Si Thammarat)/middlemen/ local markets			
Success of production	-average rubber production 786.73 kg/rai/yr -total incomes of rubber 178,854 baht/yr -net income 112,522.41 baht/yr	-average rubber production 786.73 kg/rai/yr -fruit production 2,863.75 kg/rai/yr -total incomes 410,986.2 baht/yr -total incomes of rubber 123,243.2 baht/yr -total incomes of fruits 287,563 baht/yr -net income 410,104.2 baht/yr	-average rubber production 723.43 kg/rai/yr -rice production 421.32 kg/rai/yr -total incomes 120,342.41 baht/yr -total incomes of rubber 72,372.36 baht/yr -net income 64,937.85 baht/yr	-average rubber production 772.64 kg/rai/yr -total production of oil palm 18,768 kg/rai/yr - total incomes 445,782.64 baht/yr -total incomes of rubber 113,521 baht/yr -net income 459,303.64 baht/yr	-average rubber production 754.73 kg/rai/yr - total incomes of rubber 127,884.72 baht/yr -total incomes 147,342.51 baht/yr -net income 117,874.08 baht/yr
Suggestion from farmers	-Government units should give promotion and support continually. -There should have more management to create networking or grouping to reduce underselling problem caused by the middleman. -There should have the training to create a secondary career for smallholding rubber farmers.	-Government units should give promotion and support continually. -There should have more management to create networking or grouping to reduce underselling problem caused by the middleman. -There should have the training to create a secondary career for smallholding rubber farmers.	-Government units should give promotion and support continually. -There should have more management to create networking or grouping to reduce underselling problem caused by the middleman. -There should have the training to create a secondary career for smallholding rubber farmers.	-Government units should give promotion and support continually. -There should have more management to create networking or grouping to reduce underselling problem caused by the middleman. -There should have the training to create a secondary career for smallholding rubber farmers.	-Government units should give promotion and support continually. -There should have more management to create networking or grouping to reduce underselling problem caused by the middleman. -There should have the training to create a secondary career for smallholding rubber farmers.

Table 3. Livelihood of rubber farmer of five SRFS

	S1	S2	S3	S4	S5
Component of weakness and fragility	• The tendency of price change, wage (87.55%) • barrier/limitation - labor shortage (62.53%) - unfair market (70.11%) • season - season change with rain uncertainty (97.9%) - soil degradation (95.5%) - ample water	• The tendency of price change, wage (76.72%) • barrier/limitation - labor shortage (52.12%) - unfair market (74.59%) • season - season change with rain uncertainty (84.25%) - soil degradation (89.36%) - ample water	• The tendency of price change, wage (72.35%) • barrier/limitation - labor shortage (48.78%) - unfair market (85.65%) • season - season change with rain uncertainty (92.58%) - soil degradation (81.15%) - ample water	• The tendency of price change, wage (92.14%) • barrier/limitation - labor shortage (87.54%) - unfair market (74.59%) • season - season change with rain uncertainty (91.24%) - soil degradation (98.28%) - ample water	• The tendency of price change, wage (76.35%) • barrier/limitation - labor shortage (52.14%) - unfair market (62.19%) • season - season change with rain uncertainty (94.76%) - soil degradation (87.36%) - ample water
Component of an asset for livelihood	-human capital had average at 80.22 (high level) -natural capital had average at 70.04 (high level) -financial capital had average at 41.39 (medium level) -physical capital had average at 63.67 (medium level) -social capital had an average at 60.14 (medium level) -by analyzing the total image of human capital under mono-rubber tree farming system, the study found average at 63.09 (medium level)	-human capital had average at 80.24 (high level) -natural capital had average at 77.56 (high level) -financial capital had average at 67.49 (high level) -physical capital had average at 58.49 (medium level) -social capital had an average at 72.13 (high level) -by analyzing the total image of human capital under mono-rubber tree farming system, the study found average at 71.58 (high level)	-human capital had average at 79.42 (high level) -natural capital had average at 82.28 (high level) -financial capital had average at 68.59 (high level) -physical capital had average at 70.24 (high level) -social capital had an average at 62.18 (medium level) -by analyzing the total image of human capital under mono-rubber tree farming system, the study found average at 72.54 (high level)	-human capital had average at 81.14 (high level) -natural capital had average at 68.87 (high level) -financial capital had average at 39.42 (medium level) -physical capital had average at 51.88 (medium level) -social capital had an average at 58.14 (medium level) -by analyzing the total image of human capital under mono-rubber tree farming system, the study found average at 59.89 (medium level)	-human capital had average at 79.27 (medium level) -natural capital had average at 61.33 (medium level) -financial capital had average at 49.28 (medium level) -physical capital had average at 64.87 (medium level) -social capital had an average at 57.18 (medium level) -by analyzing the total image of human capital under mono-rubber tree farming system, the study found average at 62.39 (medium level)

	S1	S2	S3	S4	S5
Organization and process that causes a change	organization structure -Received help from the government sector (33.4%) -the Working unit that provided help e.g. RAOT (52.3%) -Being a member of the organization group: cooperatives (30.19%) -Group: farmer group (19.23%)	organization structure -Received help from the government sector (52.54%) -the Working unit that provided help e.g. RAOT (48.47%) -Being a member of the organization group: cooperatives (63.98%) -Group: farmer group (58.54%)	organization structure -Received help from the government sector (51.51%) -the Working unit that provided help e.g. RAOT (63.24%) -Being a member of the organization group: cooperatives (53.47%) -Group: farmer group (39.35%)	organization structure -Received help from the government sector (24.35%) -the Working unit that provided help e.g. RAOT (26.91%) -Being a member of the organization group: cooperatives (19.30%) -Group: farmer group (16.36%)	organization structure -Received help from the government sector (24.58%) -the Working unit that provided help e.g. RAOT (37.36%) -Being a member of the organization group: cooperatives (22.69%) -Group: farmer group (17.73%)
Component of strategy for livelihood adaptation	-Changed production pattern that served the need of market (67.04%) -Adjusted tapping day, properly (30.11%) -Substituted breed that gives high yield (20.11%) -Reduced production cost (40.87%) -Increased diversity in rubber plantation (28.12%)	-Changed production pattern that served the need of market (64.58%) -Adjusted tapping day, properly (39.35%) -Substituted breed that gives high yield (45.65%) -Reduced production cost (58.56%) -Increased diversity in rubber plantation (42.23%)	-Changed production pattern that served the need of market (78.25%) -Adjusted tapping day, properly (27.14%) -Substituted breed that gives high yield (22.24%) -Reduced production cost (52.25%) -Increased diversity in rubber plantation (62.34%)	-Changed production pattern that served the need of market (71.12%) -Adjusted tapping day, properly (18.25%) -Substituted breed that gives high yield (19.36%) -Reduced production cost (35.25%) -Increased diversity in rubber plantation (18.27%)	-Changed production pattern that served the need of market (61.24%) -Adjusted tapping day, properly (28.14%) -Substituted breed that gives high yield (23.35%) -Reduced production cost (47.29%) -Increased diversity in rubber plantation (39.77%)
Component of success livelihood	-Had a good level of social relation (87.13%) Finance -Had enough incomes (68.77%) -Had sufficient food and facilities (60.87%) -Had a medium level of sanitation (56.83%) -Owned assets at medium level (24.93%)	-Had a good level of social relation (91.22%) Finance -Had enough incomes (78.88%) -Had sufficient food and facilities (79.35%) -Had a medium level of sanitation (75.58%) -Owned assets at medium level (40.29%)	-Had a good level of social relation (82.14%) Finance -Had enough incomes (77.68%) -Had sufficient food and facilities (68.58%) -Had a medium level of sanitation (62.36%) -Owned assets at medium level (41.12%)	-Had a good level of social relation (75.46%) Finance -Had enough incomes (49.58%) -Had sufficient food and facilities (73.17%) -Had a medium level of sanitation (48.97%) -Owned assets at medium level (22.24%)	-Had a good level of social relation (92.79%) Finance -Had enough incomes (61.36%) -Had sufficient food and facilities (77.57%) -Had a medium level of sanitation (54.24%) -Owned assets at medium level (31.49%)

Among relationships between vulnerability and transforming structures and processes of the five smallholding rubber farming systems, the R2 value of the smallholding rubber–fruit tree farming system (S2), was the highest (0.70) (Figure 4). It meant that approximately 70 percent of the variation in vulnerability was explained by variation in transforming structures and processes. In addition, the R2 values of the remaining smallholding rubber farming systems were 0.46, 0.40, 0.39, and 0.31 for the smallholding rubber monoculture farming system (S1), the smallholding rubber–rice farming system (S3), the smallholding rubber–animal raising system (S5), and the smallholding rubber–oil palm farming system (S4), respectively. The results indicated that more than half of the rubber farmers in the smallholding rubber–fruit tree farming system (S2) and the smallholding rubber–rice farming system (S3) received supports from related government sectors, especially the RAOT. Moreover, these rubber farmers were members of the cooperatives. Therefore, the impacts of external shocks, e.g., floods and storms attacked the farmers became less severe.

Among vulnerability–livelihood strategy relationships of the five smallholding rubber farming systems, the R2 value of the smallholding rubber–animal raising system (S5) was the highest (0.70). It meant that approximately 70 percent of the variation in vulnerability was explained by variation in livelihood strategies. Furthermore, the R2 values of the remaining smallholding rubber farming systems were 0.61, 0.46, 0.44, and 0.38 for the smallholding rubber–rice farming system (S3) (Figure 4), the smallholding rubber–oil palm farming system (S4), the smallholding rubber–fruit tree farming system (S2), and the smallholding rubber monoculture farming system (S1), respectively. The results revealed that more than half of the rubber farmers in all smallholding rubber farming systems changed their production system to satisfy consumer needs. In addition, they attempted to reduce the cost of agricultural production and increased diversity in their rubber plantation area. These strategies help cushion the possible adverse effects of the vulnerability context.

Among the capital–livelihood strategy relationships of the five smallholding rubber farming systems, the R2 value of the smallholding rubber–oil palm farming system (S4) was the highest (0.57) (Figure 4). It meant that approximately 57 percent of the variation in the five different capitals was explained by variation in livelihood strategies. Moreover, the R2 values of the remaining smallholding rubber farming systems were 0.54, 0.48, 0.42, and 0.32 for the smallholding rubber–rice farming system (S3), the smallholding rubber–fruit tree farming system (S2), the smallholding rubber–animal raising system (S5), and the smallholding rubber monoculture farming system (S1),

respectively. The rubber farmers' ability to switch between multiple strategies to secure their livelihoods could generate more capitals.

Among relationships between livelihood strategies and livelihood outcomes of the five smallholding rubber farming systems, the R2 value of the smallholding rubber–oil palm farming system (S4) was the highest (0.66) (Figure 4). It meant that approximately 66 percent of the variation in livelihood strategies was explained by variation in livelihood outcomes. In addition, the R2 values of the remaining smallholding rubber farming systems were 0.47, 0.45, 0.40, and 0.39 for the smallholding rubber–animal raising system (S5), the smallholding rubber–rice farming system (S3), the smallholding rubber monoculture farming system (S1), and the smallholding rubber–fruit tree farming system (S2), respectively. If the rubber farmers do not achieve the expected outcomes, e.g., more income, and improved food security, they will switch their strategies according to the perceived circumstances.

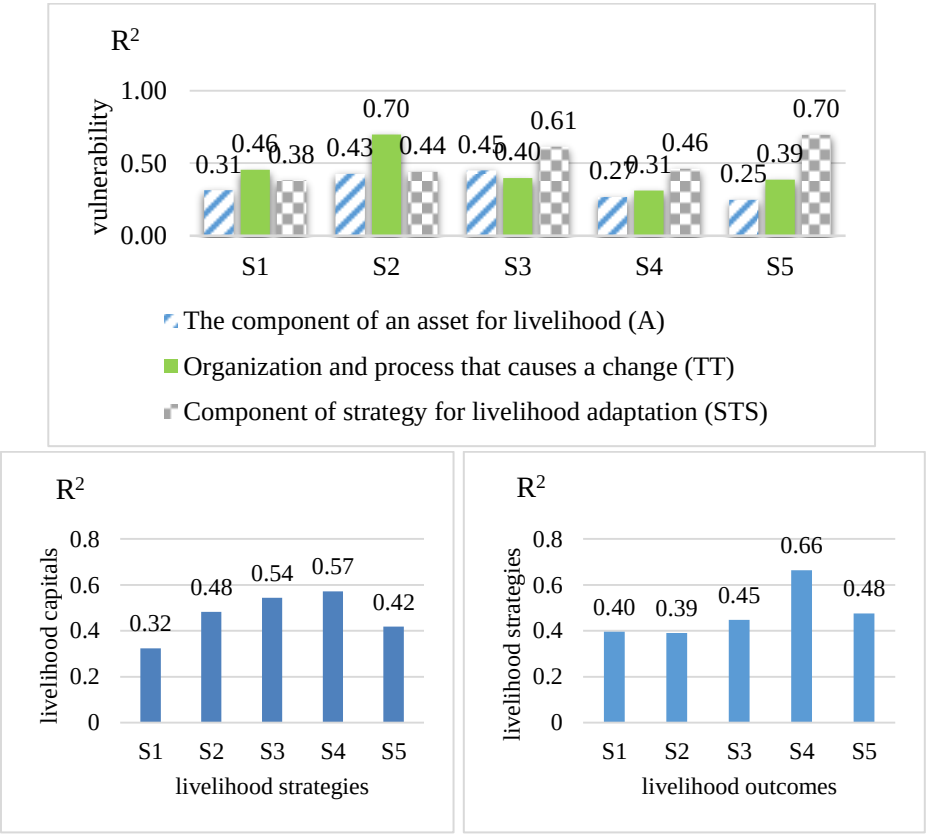

Figure 4. Factors affecting the livelihood of the five smallholding rubber farming systems

Comparison systems of practicing rubber farming along with other agricultural activities

The total incomes of farmer households under these different systems reflected that the total incomes of farmer households doing mono-rubber-tree farming system had the lowest incomes when those doing the oil-palm farming system and inter-fruit-tree with the rubber-tree farming system had high incomes when compared with the other systems (Figure 5).

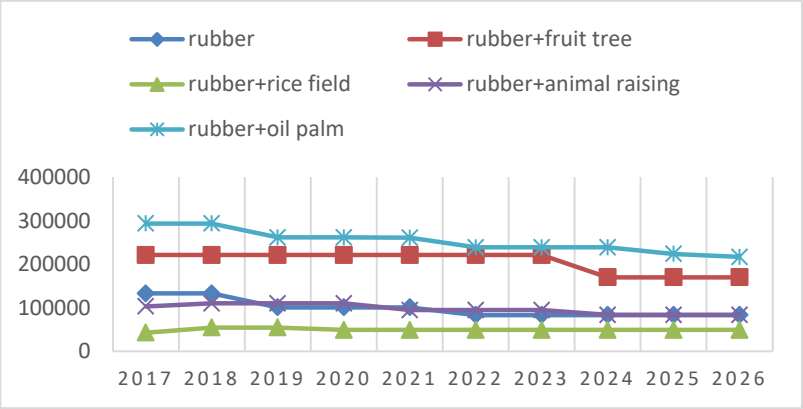

Figure 5. The economic model for the comparison of five SRFS

The connection of economy, society, and rubber production with the sustainable livelihood of five SRFS

Economic features with livelihood

According to the economic data, household incomes and household expenses have interrelation with the saving level and debt situation affected by the fluctuation price of rubber production and unfair marketing situation. Those would affect the risk of the production process that would make a difference to household capital level and fragility of the production system. Then farmers have to adapt themselves to response the economic needs (Nusang, 2006). For example, farmers need to have secondary income for their households in order to be able to manage the household income with high efficiency.

Social features with livelihood

From the study, data reflected that social features such as knowledge, educational level, experience, being a group member, relevant production policy had effects on the decision process. Furthermore, the participating process relevant to the production process and marketing process would affect

the process of risk management which relates to human capital and social capital. Farmers have to select strategies for the adaptation by building the concept and creating innovation to increase values of building more household incomes and livelihood strength. These would lead to results of good livelihood by having food security, convenient facilities, and community interaction (Boonchu, 1990). In short, these are increasing the potential of human capital and social capital for even more potential of the production process.

Rubber production with livelihood

The proper technique of the production process would affect the efficiency of the production process. Nevertheless, the production process would need to have proper physical factors and proper biological factors (Athipanan, 1999). These factors would lead to the selection of the production process that harmonizes the location situation. The aforementioned factors will relate to the process of risk management which aim for the good quantity and quality of the production. However, physical factors and biological factors have interaction with a fragility that is the natural capital in the component of the weakness of livelihood that directly affects the success of livelihoods such as production resources, food security, and farmers' good sanitation.

In short, economic features, social features, and the production process would have interaction among themselves by employing proper policy and production plan that would bring to the selection of livelihood strategies for the production process. These would lead to the success of livelihood by having more incomes, food security, ample assets for livelihood, worth production resources, good sanitation condition, good participation, and good interaction with people in the community.

Synthesizing model connected among economy, society, and production with the livelihood of rubber farmer households under five SRFS

Synthesizing model connected among economy, society, and production with the livelihood of rubber farmer households under the smallholding of the mono-rubber-tree farming system shows the connection between the production system and livelihood. Such a model can be classified into 4 Sub-models as the following (Figure 6).

1) Sub-model: Production System is a systematic concept composed of 4 production factors that are physical factors, biological factors, economic factors, and social factors. These factors have relations among themselves and conjunctively perform their duties to reduce the risk of production that will lead to target or propose of production under the recent situation. Such production factors have relations with livelihood factors.

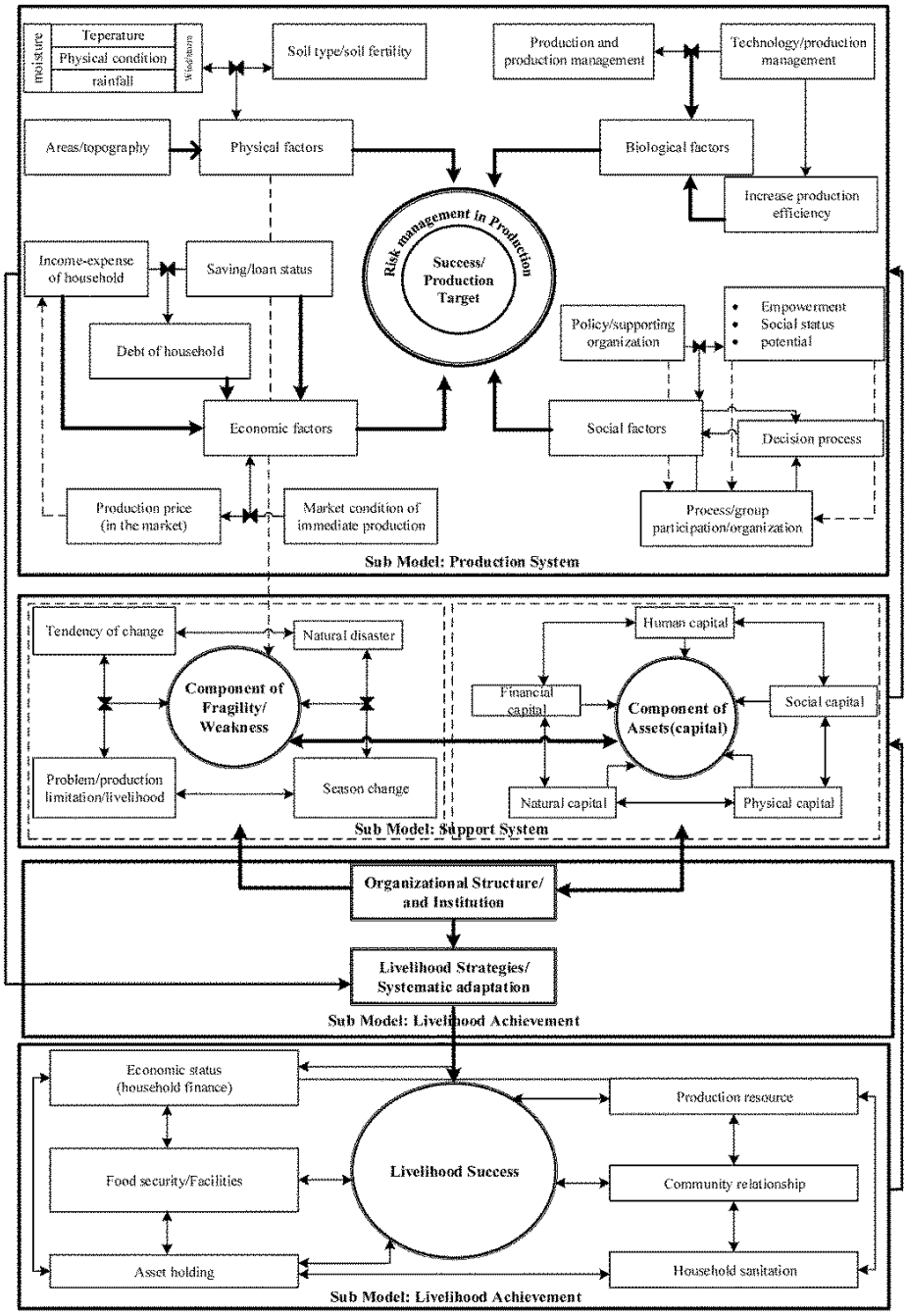

Figure 6. The model synthesized for rubber production pattern and livelihood under rubber farming system along with other agricultural activities for sustainable development in the 3 provinces

2) Sub-model: Support System is a sub-model composed of livelihood component in term of assets that will have relation with weakness component and fragility. Both systems will help strengthen to promote and support the production system and move forward efficiently. In addition, there will be a relation with strategies and livelihood adaptation.

3) Sub-model: Strategic and Livelihood Adjustment System is a sub-model that has relation with a decision supporting system by changing structure and institution that will strengthen the components of livelihood, weakness, fragility, and assets and will lead to the strategies and adaptation for proper livelihood.

4) Sub-model: Strategies and adaptation of livelihood will lead to the results or success of livelihood of practicing rubber farming along with another agricultural-activity system that has indicators such as recent economic (financial) status, food security, asset holding, production resources, community interaction, and sanitation (Choengsa-at, 1991). Such results will affect the component of assets in the future as details following.

Discussion

SRFS could be classified into 5 systems that were 1) mono-rubber-tree farming system (53.85%), 2) inter-fruit-tree with the rubber-tree farming system (14.48%) such as durian and longkong, 3) rubber-tree with rice farming system (8.27%), 4) rubber-tree with the oil-palm farming system (19.22%), and 5) rubber-tree farming with animal raising system (4.18%). The total incomes of farmer households under these different systems reflected that the total incomes of farmer households doing mono-rubber-tree farming system had the lowest incomes when those doing the oil-palm farming system and inter-fruit-tree with the rubber-tree farming system had high incomes when compared with the other systems This result is similar to previous research at the three borders provinces (Pattahani Narathiwat and Yala provinces) that incomes of farmer household doing oil-palm with the rubber-tree and doing fruit-tree with the rubber-tree had high incomes (Cherdchom *et al.,* 2009) . For livelihoods of rubber farmer households under these 5 systems, the results of this study reflected all 5 systems that the social capitals were quite high when the economic capitals were quite low. For the livelihood success among the 5 systems, the study indicated that net income, reducing limitation strategies, and well-being under the oil-palm farming system had higher average values than all of the other systems. For the 10-year economic model (2017-2026), the study indicated that inter-fruit-tree with the rubber-tree farming system, rubber-tree with the oil-palm farming system, and rubber-tree farming with the animal

raising system had high marginal marketing when compared with the others. This result is similar to previous research that studied at Koa Phra community the Southern Thailand that these system are highest incomes and livelihood sustainability (Somboonsuke *et al.,* 2009). For the model of rubber production pattern and livelihood under rubber farming system along with other agricultural activities for sustainable development in the 3 provinces, the study classified the system into 4 sub-systems based on the conceptual model the adjustment of smallholding rubber-based farming system that were 1) Sub-model: Production System, 2)Sub-model: Support System, 3) Sub-model: Strategy and Livelihood Adjustment System, and 4) Sub-model: The Resulted Sustainable Livelihood System. For the Suggestion: (1) Under the fluctuation of rubber price, holding the principle of livelihood by the Philosophy of Sufficiency will be the solution for farmer households under this system. 2) Promoting of mixed rubber farming that can create food security, household economy, and risk reduction of production and livelihood such as promoting to grow plants for the secondary income and to have the secondary career to earn incomes from the rubber plantation. 3) Reducing the cost of production and providing production factors at a cheap expense such as fertilizer. 4) Promoting for grouping and giving knowledge relevant of managing group process, understanding rubber situation, marketing for cost reduction, and reducing advantage caused by local buyers. 5) Giving knowledge and promoting rubber processing and other agricultural products processing for more added-values.

Acknowledgement

This research was supported by Natural Rubber Innovation Research Institute, Prince of Songkla University (Grant No.NAT6003965).

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(Received: 5 March 2019, accepted: 30 June 2019)