Rubber-based farming diversification in Thailand: Sustainable Agribusiness Model

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Authors: Montchai Pinitjitsamut, Lowenberg-DeBoer, Nithicha Thamthanakoon, Sophon Yamklin, Pim Pinitjitsamut, Nararat Rattanamanee, James Katy James, Iona Y Huang,

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Author(s)	Montchai Pinitjitsamut, Nithicha Thamthanakoon, Sophon Yamklin, Pim Pinitjitsamut, Nararat Rattanamanee, Kasetsart University, 50 Ngam Wong Wan Rd, Ladyaow Chatuchak Bangkok 10900, Thailand James Lowenberg-DeBoer, Katy James, Iona Y Huang, Harper Adams University, Newport, Shropshire, TF10 8NB
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Rubber-based farming diversification in Thailand: Sustainable Agribusiness Model

Intercropping in Rubber plantation in Rayong Province, Thailand

Presenters: Montchai Pinitjitsamut, Sophon Yamklin, Nithicha Thamthanakoon.
Other team members: James Lowenberg-Deboer, Nararat Rattanamanee, Pim Pinitjitsamut, Katy James, Iona Yuelu Huang.

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Presentation Objectives:

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- Describe Thai rubber farms and the challenge of volatile rubber prices
- Outline the linear programming (LP) model used to analyse diversification options
- Preliminary LP model results and potential for biological and labour synergies
- Present the potential for price risk management using a portfolio of activities

Note the primary project objective - to support the sustainability of small-scale rubber farming. Specific objectives are to:

1) identify sustainable management strategies for small-scale rubber farmers and
2) develop a capacity-building programme to unlock the blockages to the adoption of such strategies.

Source: J. Lowenberg-DeBoer

Natural rubber tapping is a labour intensive process

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Role of Natural Rubber in the Thai Economy

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- Thailand ranks as the world's largest rubber producer and exporter. Thailand produces about one-third of the world's natural rubber production (36.8%: IRSG, 2015).
- Both cultivated area and total crop have increased significantly in Thailand in recent years: from 2.6 million hectares in 2013 to 3 million hectares in 2015 and 4.51 million hectares in 2018.
- Thailand produced 5.13 million tons of rubber in 2018 and exported nearly 89% of the total (>40 % are exported to China).
- In 2017, the rubber exports were valued at 204,770 million THB (1.34 % of GDP).

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Thai Smallholder Rubber Farms

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- Rubber was first planted in the southern region of Thailand. Now it is planted in all regions of the country.
- Total plantation area (2018) was 4.51 million hectares - 57.51% in southern region.
- 2 million households farm rubber (mostly monoculture).
- 78.5% of rubber farmers are smallholders with plantation area < 2.4 hectares.
- The regional division of the 78.5% is: south - 45.8%; northeast - 24.6%; north - 4.0%; central - 4.1% .
- Although rubber prices increased significantly between 2008 and 2011, they then dropped sharply and there has been high volatility.
- Small rubber farms need to diversify farming activities to adapt to these market fluctuations.

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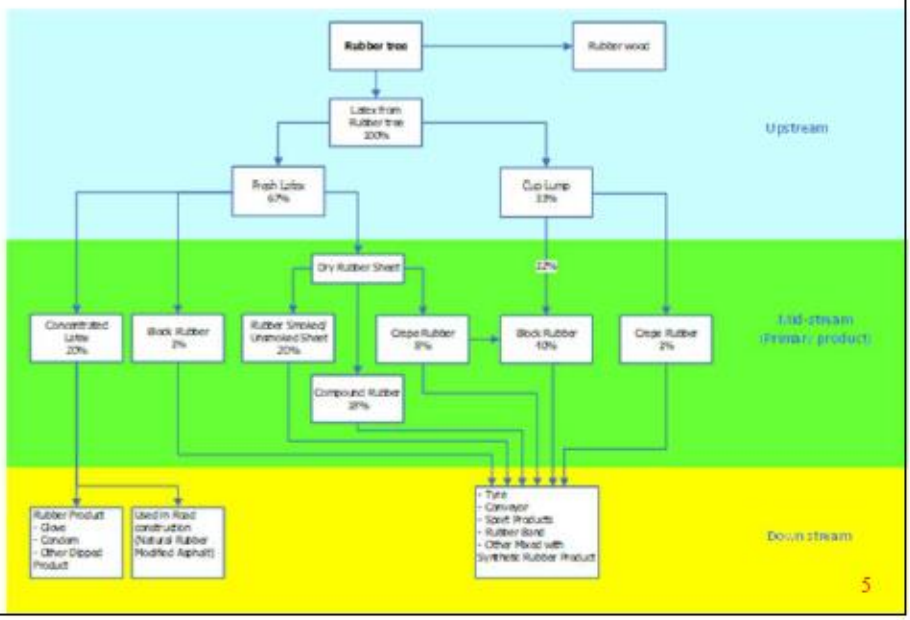
Thailand Rubber Supply Chain



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Standard LP Model Used

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$$Max\ \Pi = \sum_{j=1}^{n} c_j X_j$$

subject to:

$$\sum_{j=1}^{n} a_{ij} X_j \le b_i \text{ for } i = 1 \ldots m$$

$$X_j \ge 0 \text{ for } j = 1 \ldots n$$

where:
X_j = the level of the jth production process or activity,
c_j = the per unit return (gross margin) to fix resources (b_i's) for the jth activity,
a_{ij} = the amount of the ith resource required per unit of the jth activity
b_i = the amount of the ith resource available.

- Basic model assumes profit maximization
- Per unit returns and resources estimated based on farmer interviews and secondary data
- A one year steady state model with a monthly time step
- Optimized with the General Algebraic Modeling System (GAMS)

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Farmer Interviews

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- In depth interviews were conducted with 20 farmers in Surat Thani and Chumphon, Southern Thailand.
- Rubber farming in southern part of Thailand contributes more than 60% of total rubber production.
- Surat Thani province is the largest rubber production area in Thailand. Chumphon is also one of the top rubber production provinces.

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Farmer Interviews

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- The farmers were selected with the assistance of experts from Rubber Farmers Council of Thailand.
- Our inclusion criteria were:
  1. Land size is less than 8 hectare
  2. Farmers grow rubber trees as their main crop
  3. Farmers grow other crops in addition to rubber (not just during the first 3 years of rubber plants)
  4. Farmers grow multi-crops for commercial purposes

The data was jointly analysed by the HAU and KU team during the visit of the Thai team to the UK (September 9-13, 2019).

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Diversification activities in Rubber farm

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- Baegu (*Gnetum gnemon*) – In Thailand leaves used as vegetable
- Chickens for egg production – free range
- Chinese Kale
- Coconut
- Durian Fruit
- Mangosteen
- Oil Palm
- Pineapple – either intercropped in young rubber trees or as a stand alone crop.
- Para Rubber Cup Lump Production with family labour
- Para Rubber Cup Lump Production with intercropped first three years

Durian tree at the Suan Lamai Fruit Farm, Rayong, Thailand

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Biological Synergies

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- Systematic review results indicate that intercropping is mostly limited to young rubber in the first few years after planting
- Intercropping difficult in mature rubber because:
  - Rubber trees are relatively brittle, so planted densely (i.e. in Thailand 438 trees/ha) to reduce damage from wind.
  - Few crop species grow under mature rubber and even fewer benefit from rubber tree shade (e.g. quality of tea grown in some parts of Asia benefits from being produced in partial shade of rubber trees, but not Thailand).
  - Not much browse under mature rubber for grazing livestock
- Consequently, most farm diversification is multi-cropping in separate fields

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Labour Synergies

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- Southern Thailand is a humid, tropical climate, so opportunities for labour synergies are limited.
- Planting of perennial crops often done in May to benefit from higher rainfall on the newly transplanted seedlings, but no intensive crop activities in the dryer December to April period.

Average monthly precipitation over the year

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Offsetting Labour Needs

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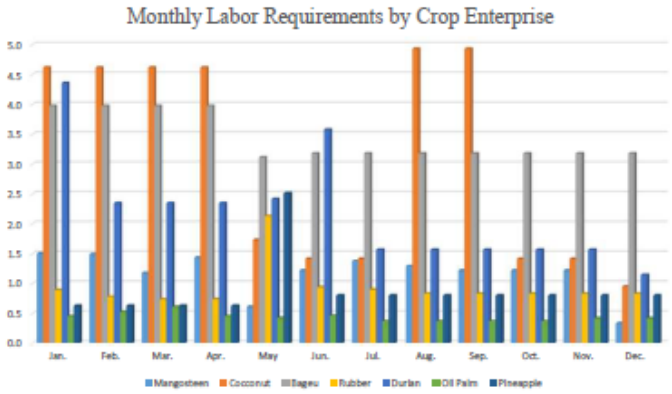
- Rubber, durian and pineapple planted in May.
- Coconut has lower labour requirements in May-July and Oct.-Dec.
- Chickens and kale have high labour needs throughout the year (and are not shown in the chart).



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Baseline Model

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- The baseline model assumes: 2 ha, 1 adult family worker, no hired labour and no "portfolio constraints."
- Because there are no biological synergies and modest offsetting labour requirements, the "no portfolio constraint" solutions choose the most profitable enterprise only. In this case that is durian.
- If durian is not available, the no portfolio constraint solutions chose the next lowest shadow price (e.g. chickens, baegu, kale, coconut, pineapple, oil palm and mangosteen in that order).

No portfolio constraint baseline - 2 ha, 1 adult worker, base prices

ACTIVITIES	OPTIMAL LEVEL, ha	UPPER LIMIT, ha	SHADOW PRICE, THB/ha
Baegu	0	2.0	-467,000
Chickens	0	2.0	-166,700
Chinese_Kale	0	2.0	-561,900
Coconut	0	2.0	-671,300
Durian	2.0	2.0	0
Mangosteen	0	2.0	-747,700
Oil_Palm	0	2.0	-722,900
Pineapple	0	2.0	-700,600
CupLump	0	2.0	-805,800
CupLumpPlus	0	2.0	-805,400

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Portfolio Constraints

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- What if because of limited markets and technical issues, the following limits are imposed: baegu – 0.2 ha max; chickens – 0.2 ha (400 hens); kale – 0.2 ha; and durian – 0.5 ha and coconut, mangosteen, oil palm and pineapple are not available options (i.e. set to zero).
- Solution now is composed of baegu, chickens, kale, durian and about 1 ha of rubber
- This solution holds over a wide range of rubber prices. Even at the recent maximum price of 160 THB/kg for cup lump rubber (April, 2011), the solution is unchanged.

Table 1 - Baseline result - 2 ha, 1 adult worker, base prices with limits on Baegu, chickens, Chinese Kale and Durian, and coconut, mangosteen, oil palm and pineapple unavailable

ACTIVITIES	OPTIMAL LEVEL, ha	UPPER LIMIT, ha	SHADOW PRICE, THB/ha
Baegu	0.2	0.2	336,800
Chickens	0.2	0.2	628,220
Chinese_Kale	0.095	0.2	0
Coconut	0	0	134,560
Durian	0.5	0.5	804,820
Mangosteen	0	0	59,932
Oil_Palm	0	0	84,984
Pineapple	0	0	104,060
CupLump	0	2.0	-552
CupLumpPlus	1.005	2.0	0

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Greater Labour Availability

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- Assume the portfolio constraints, but add another family worker.
- Solution changes slightly to increase kale production and reduce rubber slightly.

Table 2 - Baseline - 2 ha, 2 adult workers, base price with limits on Baegu, chickens, Chinese Kale and Durian, and coconut, mangosteen, oil palm and pineapple unavailable

ACTIVITIES	OPTIMAL LEVEL, ha	UPPER LIMIT, ha	SHADOW PRICE, THB/ha
Baegu	0.2	0.2	338,430
Chickens	0.2	0.2	638,700
Chinese_Kale	0.2	0.2	243,490
Coconut	0	0	134,080
Durian	0.5	0.5	805,390
Mangosteen	0	0	57,739
Oil_Palm	0	0	82,503
Pineapple	0	0	104,780
CupLump	0	2.0	-422
CupLumpPlus	0.9	2.0	0

* Solution same at historical high cup lump price of 160 THB/kg

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Diversification is often driven by risk management

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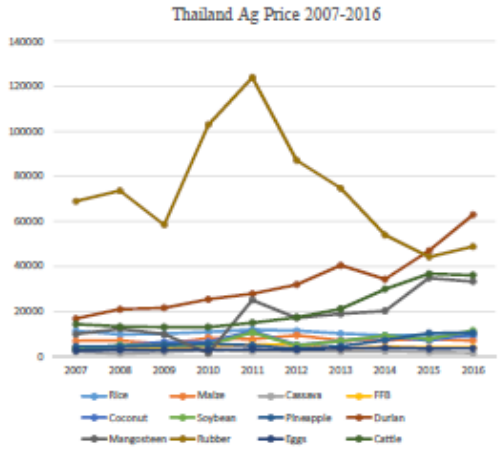
- Ideally, a portfolio is composed of assets and enterprises with offsetting price patterns. When one is up the other is down.
- In chart of prices over time, it is easy to see that rubber price is variable, but not easy to seeing offsetting patterns



* Prices mostly THB/MT, but eggs THB/1000 eggs and cattle THB/head

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Negative price correlations show diversification potential

- Grain and oil crop prices are positively correlated with rubber price.
- Fruit and livestock prices are negatively correlated with rubber prices.

From: Agricultural Statistics of Thailand 2016.

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MOTAD allows risk analysis in an LP model

Add the following constraints to the LP model to create Target MOTAD:

$$T = -\Sigma c_{rj} X_j - Yr \leq 0$$

$$\Sigma p_r Y_r = \lambda$$

$X_j, Y_r \geq 0$ for j=1….n and r=1……s

Where:
T = target level of return
P_r = probability of a state of nature
r = the state of nature
λ = parameter from 0 to M (where M is a large number)

- MOTAD = Minimization of Total Absolute Deviations
- Target MOTAD optimizes with regard to deviations below a desired level of return.
- Target MOTAD generates solutions that are Second Degree Stochastic Dominant (SDSD)
- One option is to re-estimate the unit returns (i.e. c_{rj}) for each year of data and assume the probability of each year is equal (i.e. p_r=1/s).
- The target level of return (i.e. T) might be related to national poverty levels or income needed for family living.

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