การประชุมวิชาการ

“*ศาสตราจารย์สังเวียน อินทรวิชัย* ด้านตลาดการเงินไทย”

ครั้งที่ 24 ประจำปี 2559

การบรรยายเรื่อง

“Thailand’s Weather Insurance:

Existing and Proposed Products”

ผู้บรรยาย ดร.โสมรัศมิ์ จันทรัตน์

วันศุกร์ที่ 25 พฤศจิกายน 2559 เวลา 13:15 - 14:45 น.

ห้อง 205 คณะพาณิชยศาสตร์และการบัญชี

มหาวิทยาลัยธรรมศาสตร์ ท่าพระจันทร์

Development of Agricultural Insurance in Thailand: Existing and Proposed Products

Sommarat Chantarat

Puey Ungphakorn Institute for Economic Research
Bank of Thailand

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Road map

- Agricultural insurance: Why, what, how?
- Agricultural insurance in Thailand
- Framework in designing optimal contract
- Satellite-based agricultural insurance for Thai rice

Thai agriculture is prone to shocks

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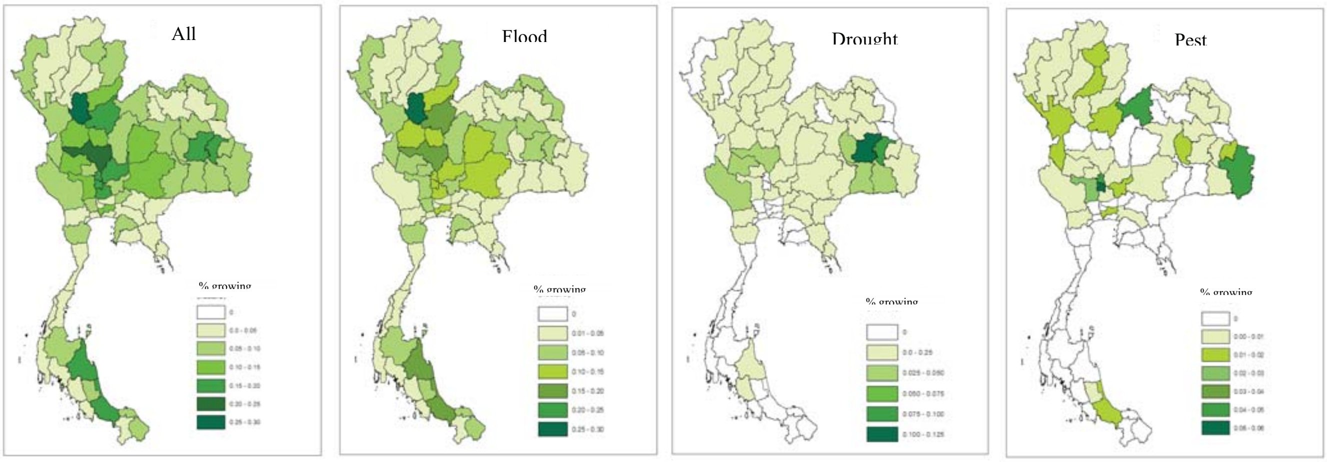
10-year statistics of production losses by key risk



Source: OAE

Increasing vulnerability in agriculture → Key threat to overall financial stability

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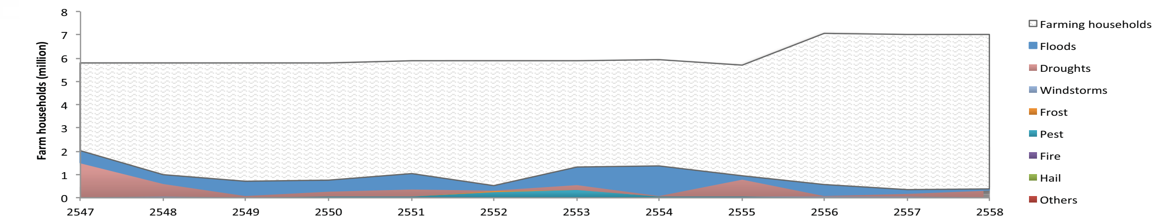
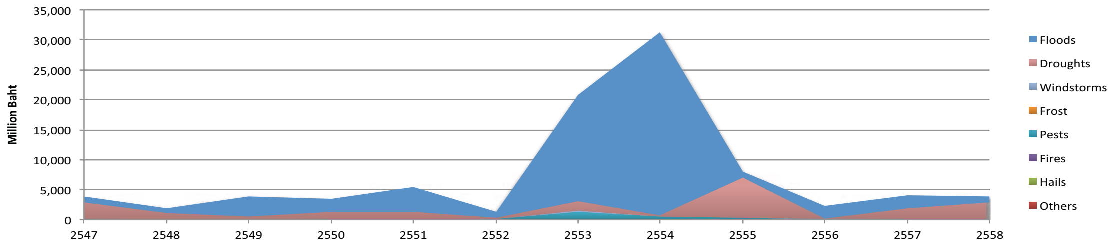


Source: OAE



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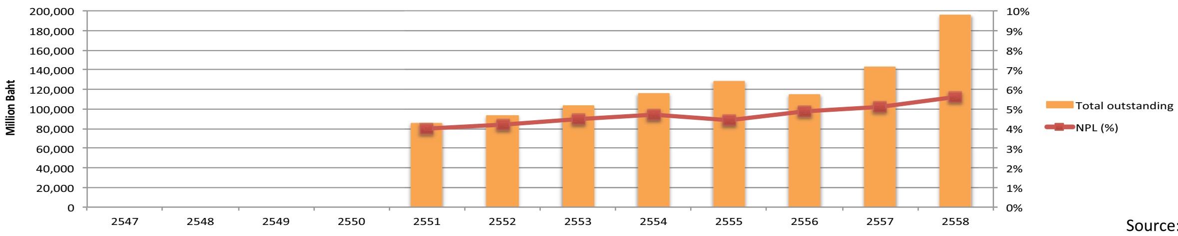
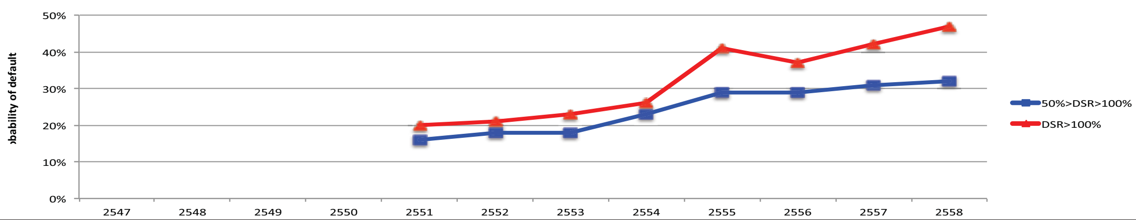
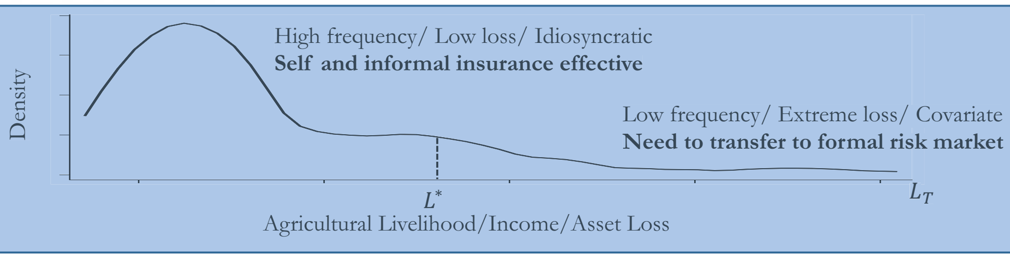


Source: BAAC, BOT



Source: SES

Agricultural insurance



➢ **Two types of agricultural insurance**

Indemnity based insurance

Compensate actual loss, multi-peril or named peril

- Transaction costs of verifying losses
- Adverse selection and moral hazard
- Delay in payouts
- Low basis risk

Existing programs very costly and highly subsidized, not suitable for rural areas with smallholders

Index based insurance (weather/satellite)

Compensate specific loss based on objectively measured index NOT actual loss

- Low costs – no farm-level loss verification
- Low information asymmetry problem
- Fast loss verification and payouts
- Challenges in minimizing basis risk

Promise as a market viable instruments, more suitable for rural areas in DCs

Agricultural insurance in Thailand

2521 2523 2531 2534 2550 2553 2554 2558 2560

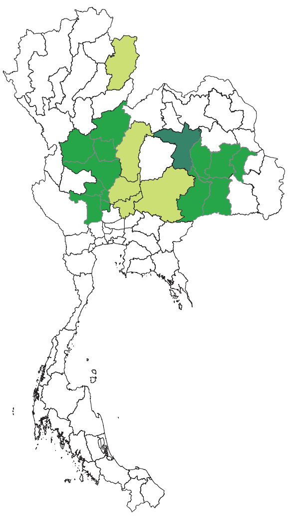
Cotton
Indemnity based
All perils

Corn, sorghum, soybean
Indemnity based
All perils

Maize (subsidized)
Weather index based
Drought in central and northern provinces

Rice
Weather index based
Drought in northeastern provinces

Rice (subsidized)
Top-up disaster relief
Drought, flood, pest, windstorm,
Frost, fire, hail
Nationwide



Issues with current programs

- Basis risk
- Small scale → low diversification
- Lack data for risk-based pricing
- Delays
- Literacy
- Scalability

Existing agricultural insurance in Thailand

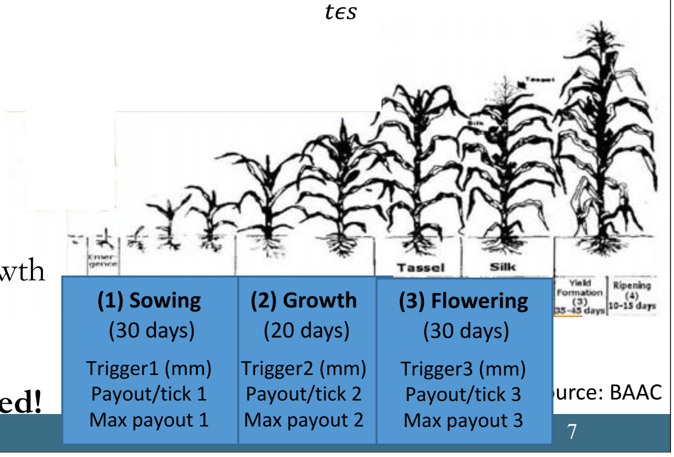
1. Drought index insurance for maize

- World Bank models, BAAC distributes, local insurers underwrite
- For sale since 2550 in Central and Northern provinces
- **Index:** moving dry spells from cumulative rainfall at station (within 25 radius)

27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	total	Threshold	Dry Spell
0.6	0	7.6	0.6	11.8	0.4	0	0	0	0.2										21.2	10	0
	0	7.6	0.6	11.8	0.4	0	0	0	0.2	0									20.6	10	0
		7.6	0.6	11.8	0.4	0	0	0	0.2	0	0								20.6	10	0
			0.6	11.8	0.4	0	0	0	0.2	0	0	0							13.0	10	0
				11.8	0.4	0	0	0	0.2	0	0	0	0						12.4	10	0
					0.4	0	0	0	0.2	0	0	0	0	0					0.6	10	9.4
						0	0	0	0.2	0	0	0	0	0	0				0.2	10	9.8
							0	0	0.2	0	0	0	0	0	0	0.3			0.5	10	9.5
								0	0.2	0	0	0	0	0	0	0.3	10.0		10.5	10	0
									0.2	0	0	0	0	0	0	0.3	10.0	3.9	14.4	10	0

$$MD_t = max(t^* - \sum_{\tau=0}^{9} rain_{t-\tau}, 0)$$

$$Payout_s = P \times max(\sum_{t \epsilon s} MD_t - trigger_s, 0)$$



- **Contract**: 80-day coverage at 3 stages of growth
- **Payout** = sum of 3 stages payouts
- **Premium** = 100 baht/rai – **highly subsidized!**

urce: BAAC

Existing agricultural insurance in Thailand

1. Drought index insurance for maize

- **Very small and decreasing uptakes over time**

Year	Insured farmers	Areas (Rais)	Premium (MB)	Sum Insured (MB)	Payout (MB)
2550	35	962	0.08	1.3	-
2551	338	7,238	0.71	7.6	0.12
2552	817	13,454	1.35	13.3	0.82
2553	2,535	45,918	4.59	58.6	-

- **Key issues**
  - Basis risk (microclimate within 25 km radius, low density of weather stations, design)
  - Product complications → need literacy
  - Small scale → low diversification
  - Not easily scalable

Source: BAAC

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Existing agricultural insurance in Thailand

2. Drought index insurance for rice

- JBIC models, BAAC distributes, Sompo Japan underwrites
- **For sale** since 2553, in Khon Kaen and now all provinces in Northeast
- **Index:** cumulative rainfall at station (within 25 radius)
- **Contract:** 3-month coverage from July-September
- **Payout:** 15% if drought (3-month cum. Rain < upper threshold)
  40% if severe drought (cum. Rain < lower threshold)
- **Premium:** ~4-6% of sum insured
- **Again small and decreasing uptakes**
- **Key issues**
  - Basis risk
  - Expensive (no subsidization)
  - Small scale → low diversification

Year	Insured farmers	Areas (rais)	Premium (MB)	Sum Insured (MB)	payout
2010	1,158	8,040	0.75	16.08	-

Source: BAAC

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Existing agricultural insurance in Thailand

3. Nationwide relief top-up insurance for rice

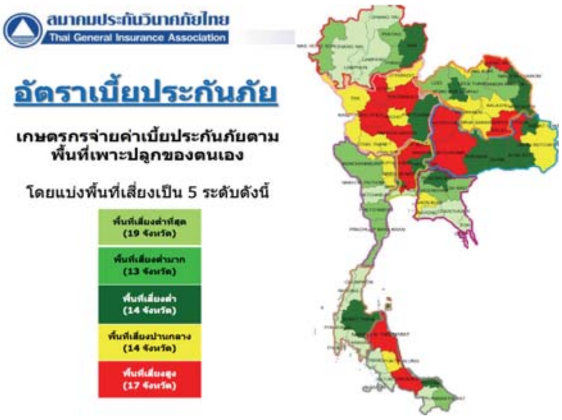
- BAAC distributes, 7 local insurers underwrite, international reinsurer
- **For sale** since 2554 nationwide, free provision by government starting 2559
- **Contract:** 5-month coverage planting
- **Payout:** 1) Farm in pronounced disaster zone 2) Total loss verified by local authority

Source: BAAC

Existing agricultural insurance in Thailand

3. Nationwide relief top-up insurance for rice

- **Premium**: lack micro data to do risk based pricing, highly subsidized!



รายละเอียด (บาท/ไร่)	เบี้ยประกันภัย	เบี้ยประกันภัยรวมภาษีมูลค่าเพิ่มและอากรแสตมป์	รัฐอุดหนุน	เกษตรกรชำระ	*เกษตรกรที่เป็นลูกค้า ธ.ก.ส. ชำระ
พื้นที่เสี่ยงต่ำที่สุด (19 จังหวัด)	115	124.12	64.12	60	50
พื้นที่เสี่ยงต่ำมาก (13 จังหวัด)	220	236.47	166.47	70	60
พื้นที่เสี่ยงต่ำ (14 จังหวัด)	330	335.24	275.24	80	70
พื้นที่เสี่ยงปานกลาง (14 จังหวัด)	420	451.54	361.54	90	80
พื้นที่เสี่ยงสูง (17 จังหวัด)	450	483.64	383.64	100	90

- **Small sale** (less than 2% of growing areas) despite big push from government

	2554	2555	2556	2557	2558
Total insured (rai)	1,059,131	872,440	120	830,674	1,512,139
Total payout (rai)	625,069	538,900	28	115,288	129,299
Total premium collected	136,564,533	112,492,618	43,193	334,931,393	571,809,694
Total indemnity payout	756,487,971	598,717,622	31,108	128,055,225	149,857,099
Loss ratio	554%	532%	72%	38%	26%
Basis risk complaints	High	High	High	High	High

Existing agricultural insurance in Thailand

3. Nationwide relief top-up insurance for rice

- **Key issues**
  - Lack of data for risk-based pricing → prone to information asymmetry
  - Basis risk
  - Long delay in payout
  - Increasing costs and budget burden to government

Key is to find better agricultural risk information (accurate, rich spatial/temporal distribution, transparent, near-real time) to redesign more efficient agricultural insurance

Source: BAAC

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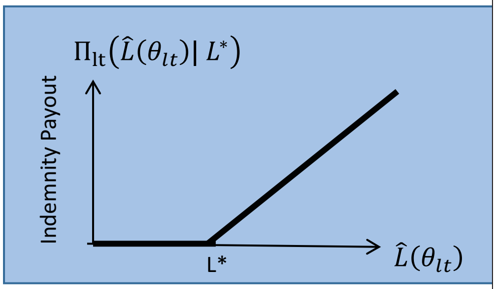
Designing optimal agricultural insurance

1. **Identify loss to be insured ($\boldsymbol{L_{lt}}$)**
   - Identify uninsured loss by testing simple consumption risk sharing hypothesis (e.g., Townsend 1994), L_{lt} is uninsured if $H_0: c = 0$ is rejected

     $\Delta C_{lt} = a_0 + a_l + a_t + bX_{lt} + cL_{lt} + \varepsilon_{lt}$
2. **Select objectively measured risk information or index ($\boldsymbol{\theta_{lt}}$)**
   - Highly correlated with loss, available reliably in near-real time, high spatial distribution, at least 20 years historical profiles
3. **Quantify insurable loss from index ($\boldsymbol{\hat{L}(\theta_{lt})}$)**
   - θ_{lt} needs to explain most of the loss variations:

     $L_{lt} = L(\theta_{lt}) + \varepsilon_{lt} \quad \rightarrow \hat{L}(\theta_{lt})$
   - Use micro data of L_{lt} to minimize basis risk



4. **Insurance contract**
   - Payoff based on $\hat{L}(\theta_{lt})$: $\Pi_{lt}(\hat{L}(\theta_{lt})|\, L^*) = max(\hat{L}(\theta_{lt}) - L^*, 0) \times sum\ insured$
   - Stand-alone contract, group-based contract, interlinked insurance-loan

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Developing agricultural insurance program

5. **Pricing**
   - Actuarial fair premium: burn rate and/or Monte Carlo simulation based on $f(\theta_{lt})$

     $$p(\hat{L}(\theta_{lt})|\, L^*) = E\Pi_{lt}(\hat{L}(\theta_{lt})|\, L^*) = \int \Pi_{lt}(\hat{L}(\theta_{lt})|\, L^*) df(\theta_{lt})$$
   - Commercial premium is then loaded and include catastrophic load $c(MPL)$ increases with maximum probable loss $MPL = VaR_x(P)$

     $$cp(\hat{L}(\theta_{lt})|\, L^*) = \left(E\Pi_{lt}(\hat{L}(\theta_{lt})|\, L^*) + c(MPL)\right) \cdot administrative\ load$$

     Reducing MPL, e.g., through diversification across time and space, or capped loss can thus reduce premium
6. **Optimal contract design** $\Pi_{lt}(\hat{L}(\theta_{lt})|\, L^*)$ solves

   $$\max_{L^*, \alpha_i^*} E(c_{it}) - \frac{\theta}{2}\sigma^2(c_{it}) \quad \text{where } c_{it} = y_{it} + \alpha_i\left(\Pi_{lt}(\hat{L}(\theta_{lt})|\, L^*) - cp(\hat{L}(\theta_{lt})|\, L^*)\right)$$
7. **Effective demand**: when $EU(c_{it}^{\pi}) - EU(c_{it}^{non\pi}) > 0 \rightarrow cer_{it}^{\pi} - cer_{it}^{non\pi} > 0$

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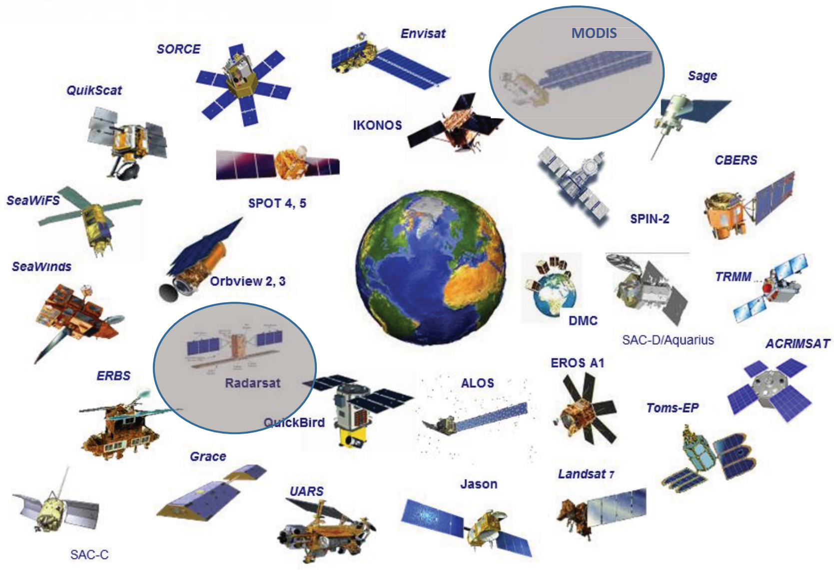
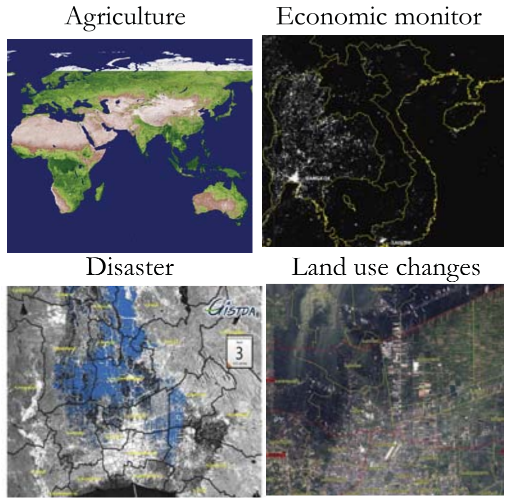
Recent development in space technology





Can satellite data be used to enhance sustainable agricultural risk management in Thailand?

❖ Why satellite data are so special?

- Large coverage at granular level
- High frequency and long history
- Near real time
- Systematic and continuous
- Low cost (for some)

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One of the key challenges in agricultural risk management in Thailand is the lack of data

Key challenge is data

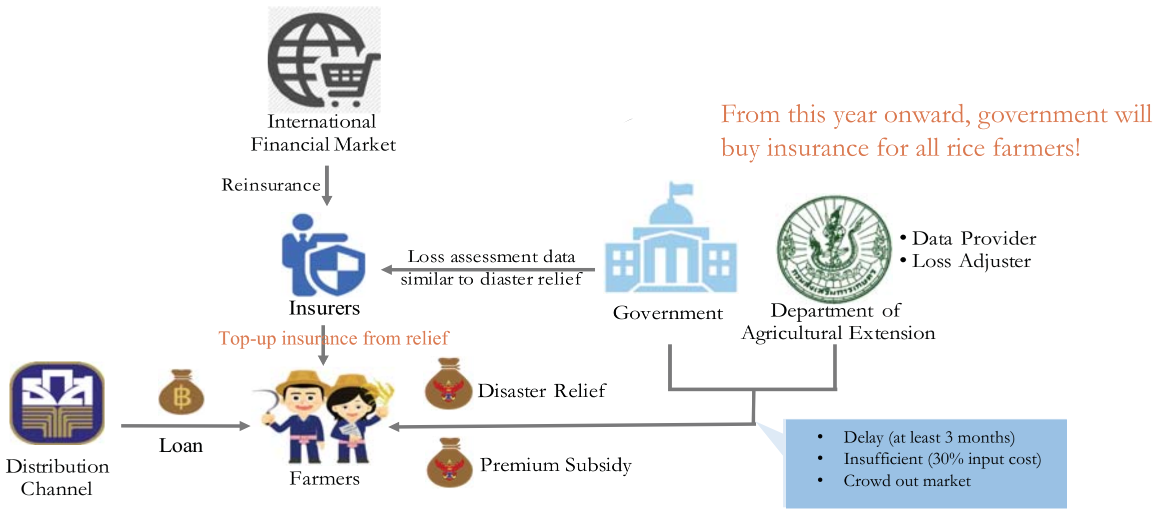
- Lack micro-level risk data
- Lack long historical risk data
- Lack transparency in loss monitoring
- Delay in loss monitoring

Inefficient insurance market

- High cost
- Low value to customer
- Small scale

Less sustainable

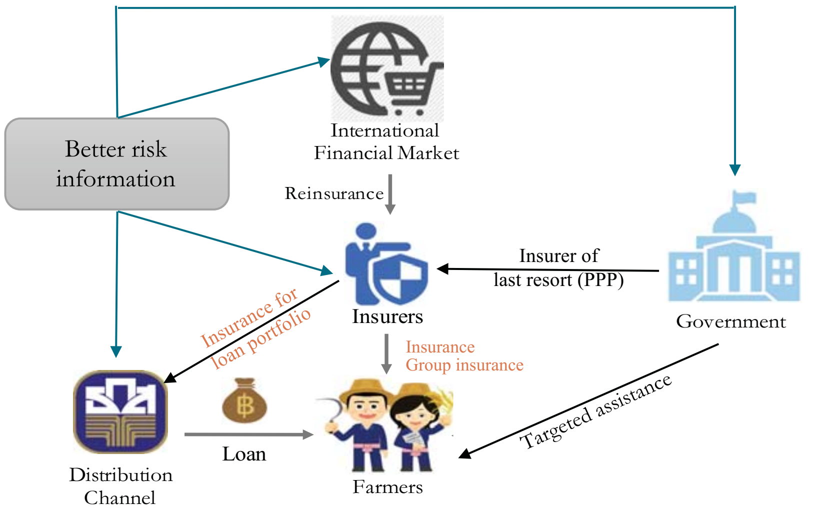
- Less than 2% buy insurance
- Big role of the government



Promise of satellite data in agricultural risk management in Thailand

If satellite data can be used to generate high quality risk information…

Better risk information	Healthy insurance market	More sustainable
1. Accurate 2. Micro-level 3. Long historical data 4. Transparent 5. Near real time	• Risk-based pricing • Various designs of insurance → competition among insurers • Better PPP arrangement	• Active insurance demand • Well-defined role of government to complement market



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We answer two key questions

1. **Can satellite data be used to generate better agricultural risk information?**

Satellite data
- MODIS NDVI
- RADARSAT

\+

GIS data
- Irrigation
- Altitude

→

Household data
- 31,295 rice farmers
- Nationwide
- 10 yrs

2. **What are potential values of satellite-based risk information in development of agricultural insurance market?**

- More sustainable crop insurance market
- More cost effective PPP in risk management with well-defined roles of government

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Can satellite data be used to generate better agricultural risk information?

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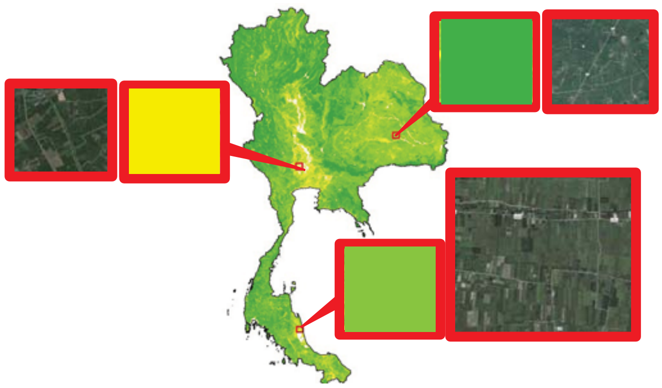
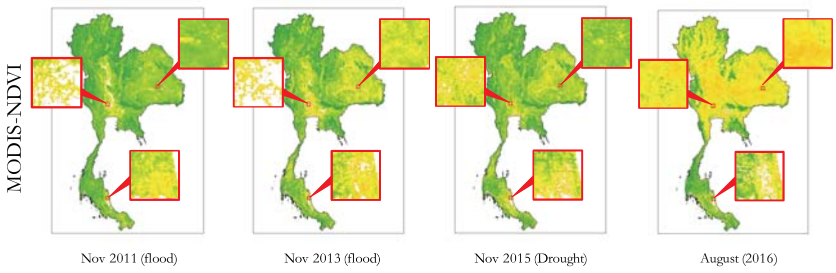
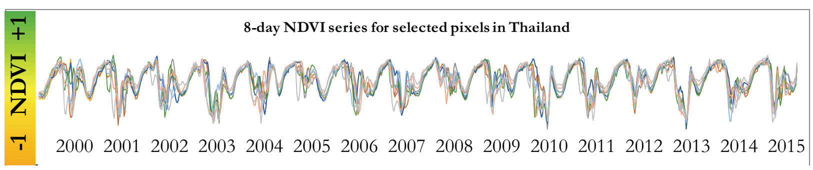
Step 1: Detecting rice production using NDVI







❖ **Normalized Difference Vegetation Index (NDVI)**

- Reflect health and cycle of vegetation
- Every 8 days from 2000-present
- Cover nationwide
- 1 pixel reflects area of 250 m^2 or 40 rai
- 2,260,778 pixels nationwide

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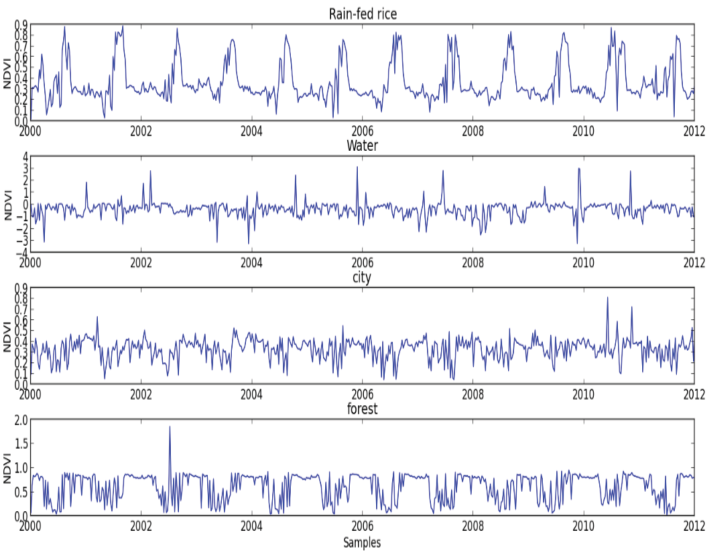
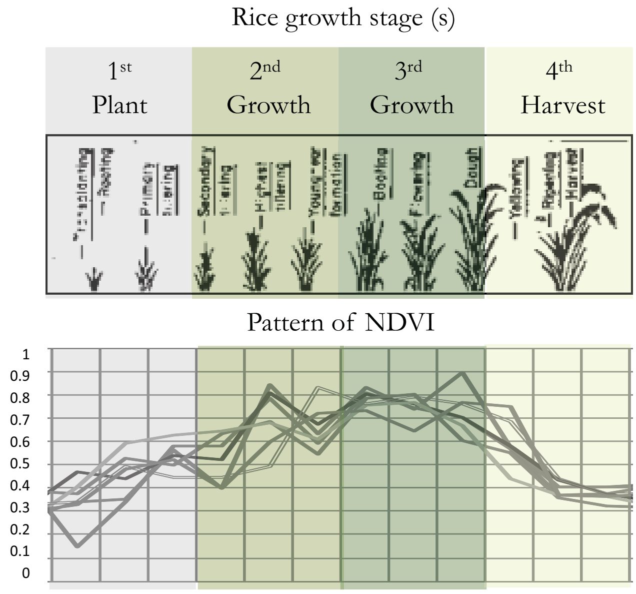
Step 1: Detecting rice production using NDVI

Non-linear estimation model is used to detect rice area, planting and harvesting dates based on curvature of NDVI





Rice growth stage from Murphy (1998)

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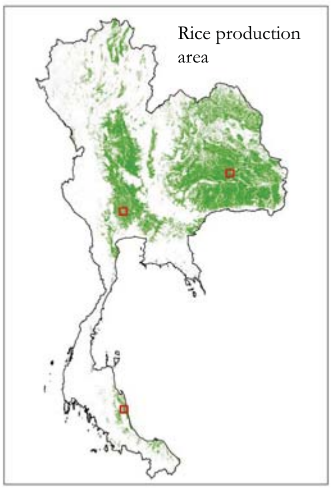
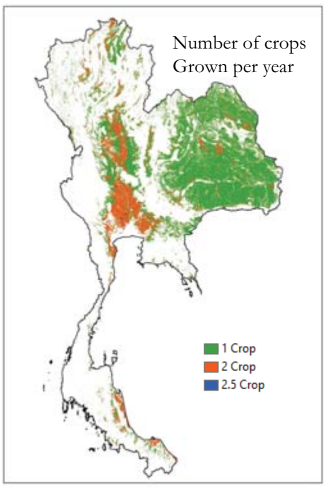
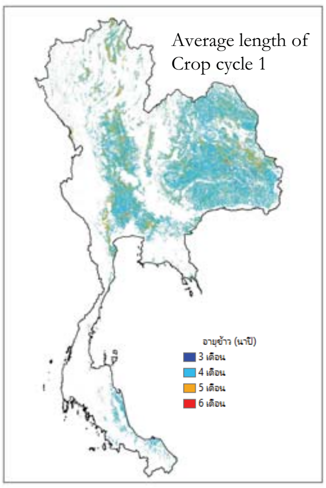
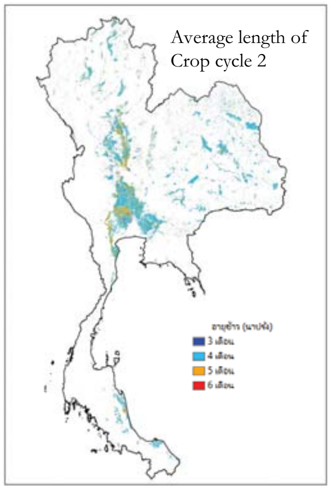
Step 1: Detecting rice production using NDVI

Our results show great variations in cropping patterns across the country





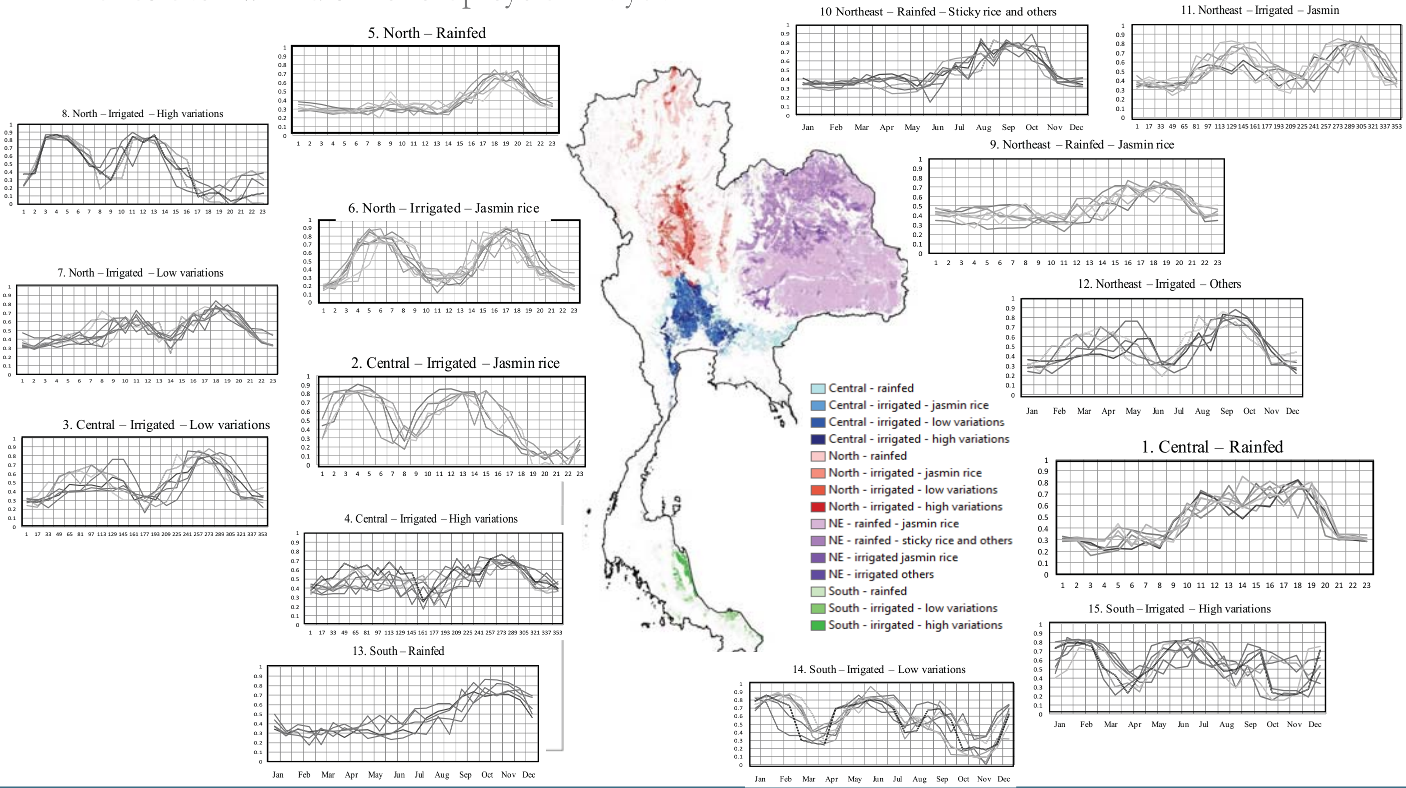




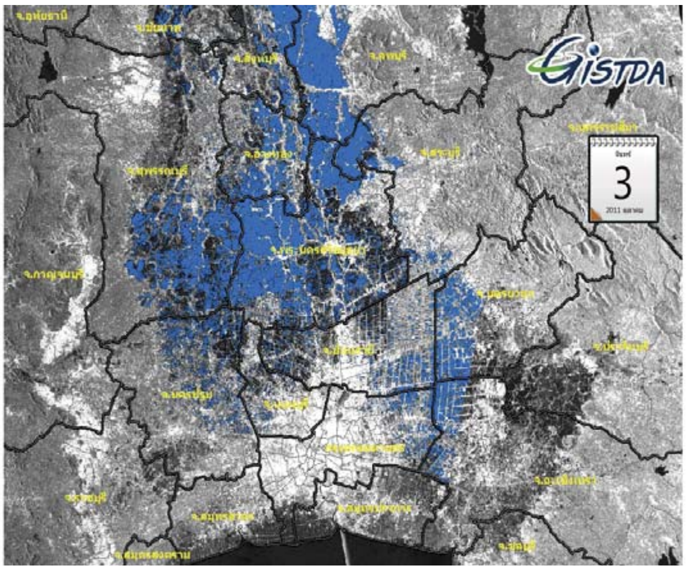
Need to identify *homogenous production zones* so production losses can be estimated separately for each

Step 2: Detecting production loss using NDVI and Flood index

Cluster analysis based on NDVI patterns and other GIS data results in 15 distinct production zones each with distinct crop cycle in a year



Step 2: Detecting production loss using NDVI and Flood index



❖ **Flood index from RADARSAT**

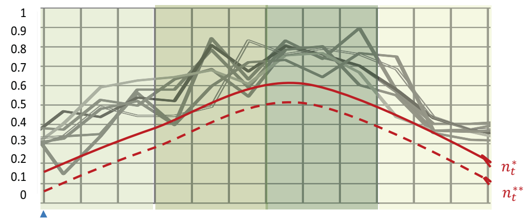
- Reflect flooded area
- Everyday from 2011-present
- Nationwide with resolution of 50m or 8 rai

Step 2: Detecting production loss using NDVI and Flood index

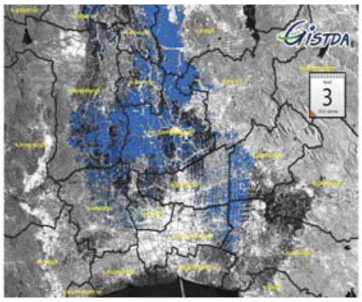
Estimate loss function f ( ) that minimizes sum squared errors in

Farmer's actual losses = f (NDVI, Flood index) + error

Pattern of NDVI after detected planting date in each pixel



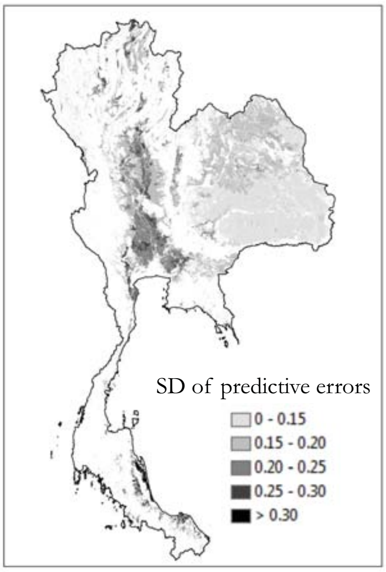
Flood index from RADARSAT

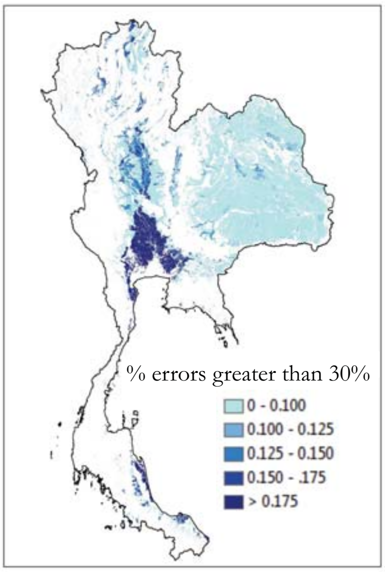


How well can satellite data estimate production losses of farmers?

From predictive errors:

- ❖ Satellite data predicts production losses well in rainfed area but less well in the more heterogeneous irrigated areas
- ❖ Most of predictdive errors lie within +-20% and are especially low during the extreme losses

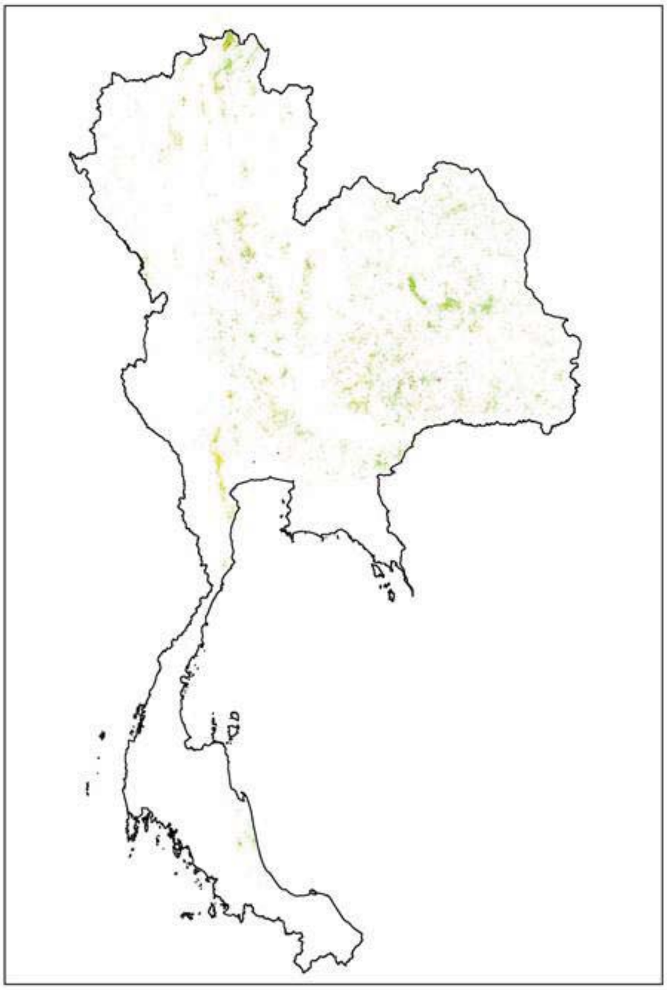




The results imply

- ❖ Need higher resolution data to complement these especially in the complex irrigated zones
- ❖ Still need field verification

Estimated crop cycles and losses at pixel level (selected months)



May 2016

เริ่มปลูก ออกรวง เก็บเกี่ยว

ผลผลิตเสียหาย

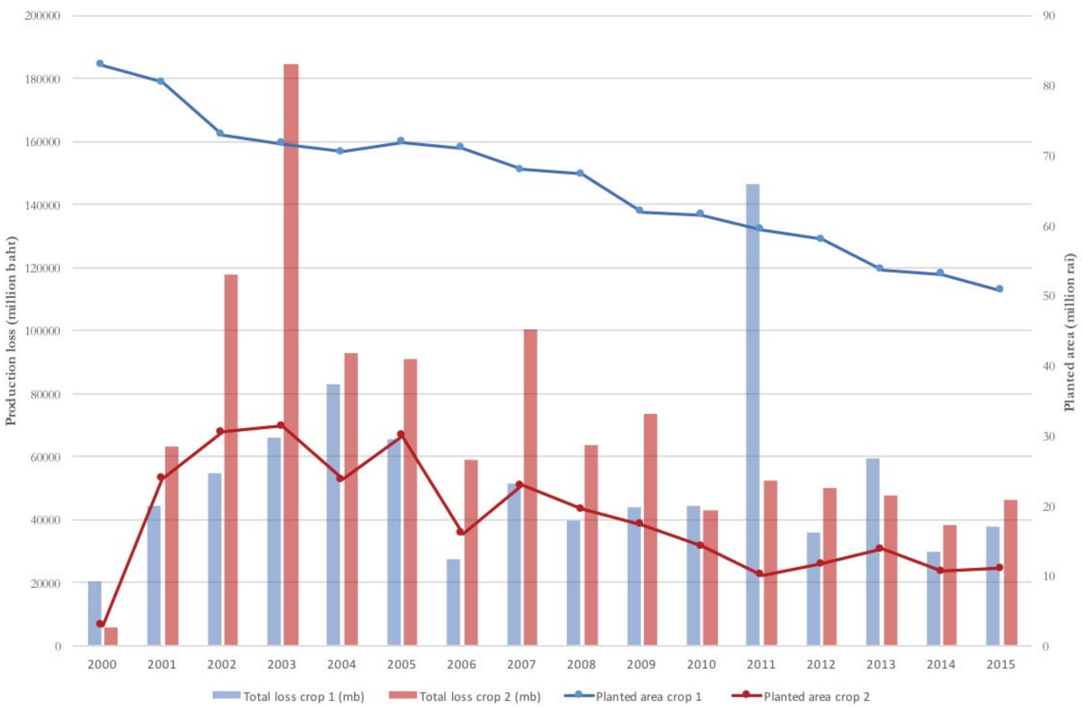
What can we learn from the satellite-based risk information?

Satellite data can really be used to create better agricultural risk information

1. Accurate
2. Micro-level
3. Long historical data
4. Transparent
5. Near real time

What can we learn from the satellite-based risk information?

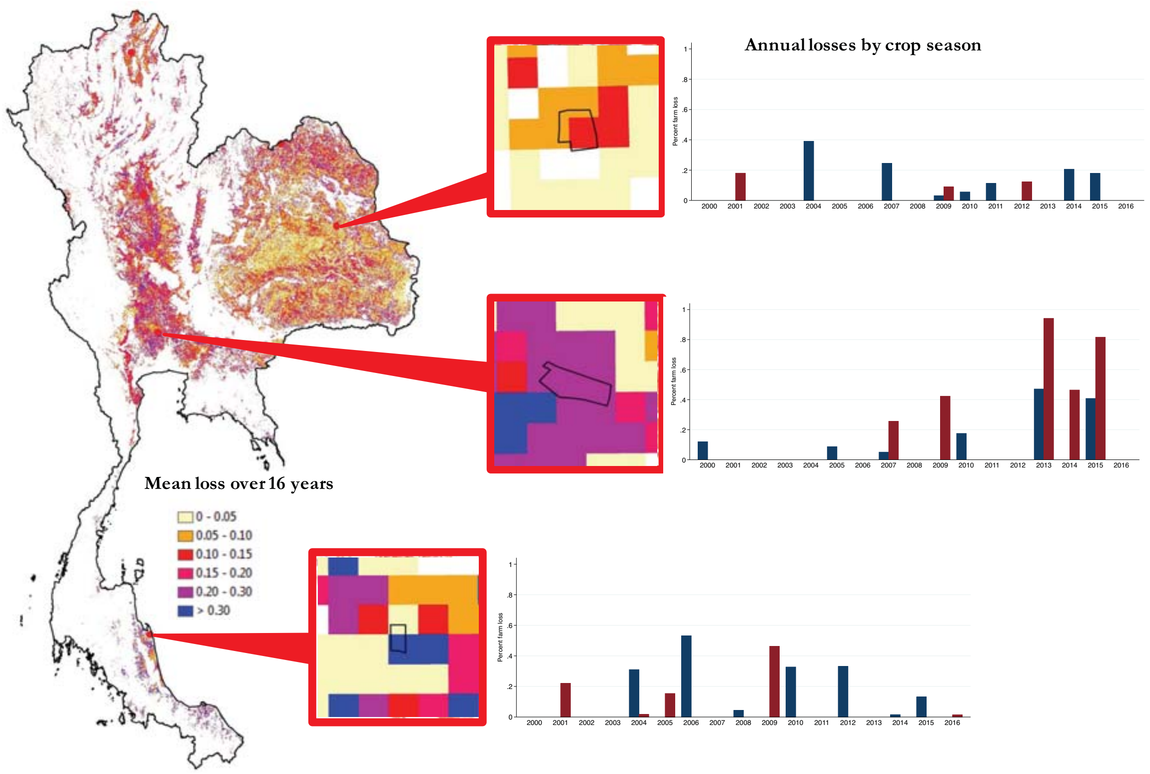
Aggregate rice crop production and total losses of the whole country over time



Note: annual average yield and price from Department of Agricultural Economics are used to estimate total production losses (million baht)

What can we learn from the satellite-based risk information?

Production losses and historical statistics (risk) by farm or area



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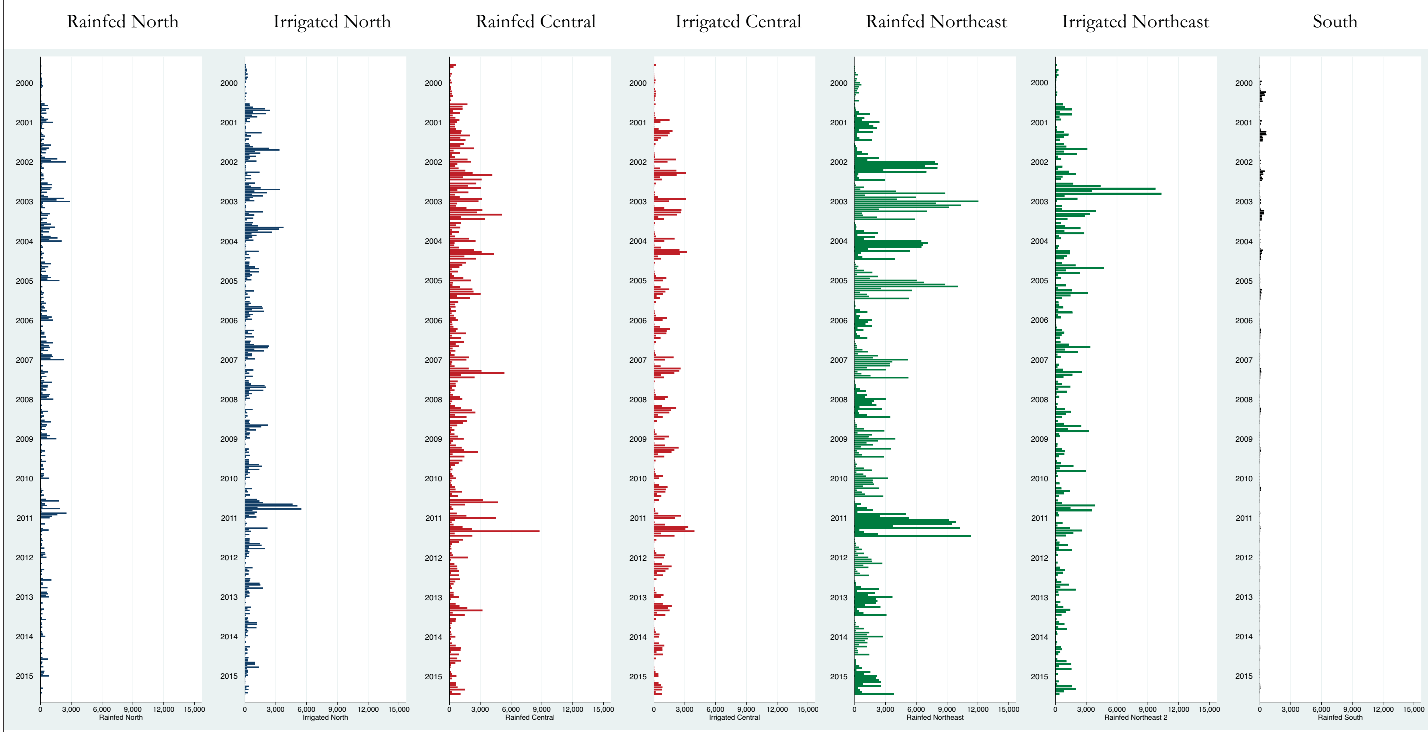
What can we learn from the satellite-based risk information?

Rice production losses appear highly covariate especially in key bad years and within the same region



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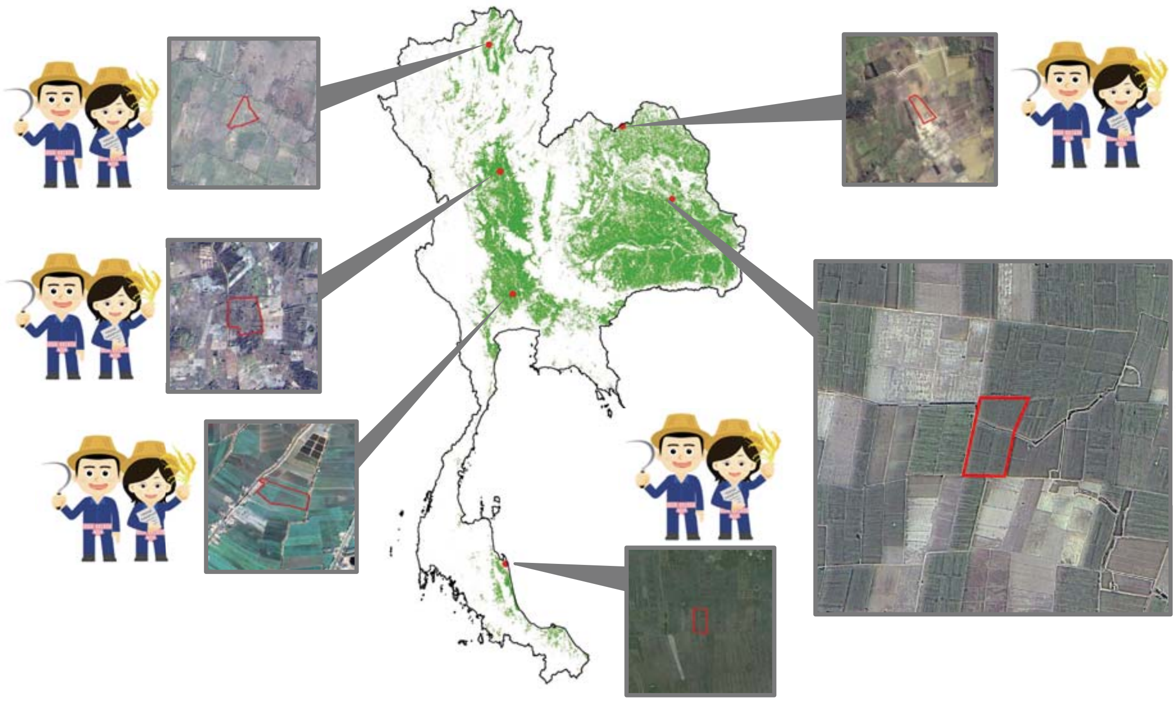
What are potential values of satellite-based risk information in agricultural risk management?

Toward agricultural risk data system

Nicely complement existing initiatives like GISAGRO where farmers can register to Department of Agricultural Extension with GIS-locator of their farm and other information



- Crop
- Price
- Input
- Market
- Loss

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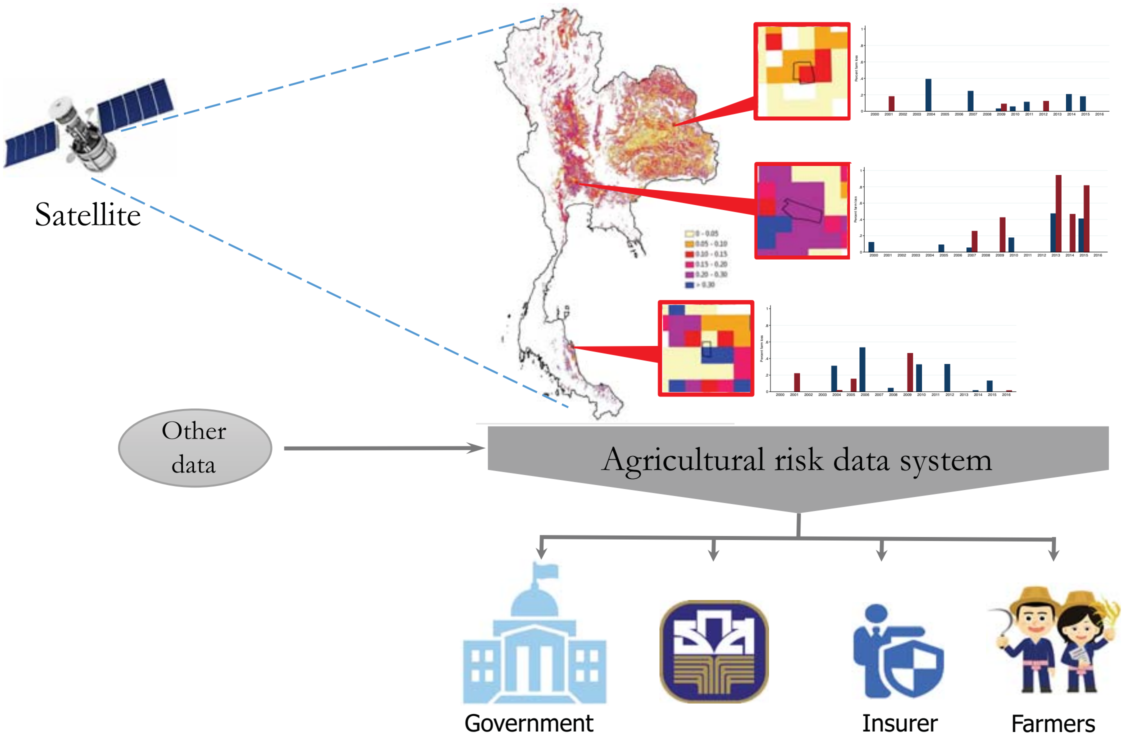
Toward agricultural risk data system

Agricultural risk data system can be generated to provide historical and near-real time monitoring of farmers' rice production be made accessible to all parties



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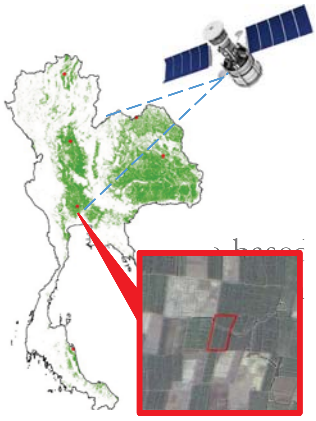
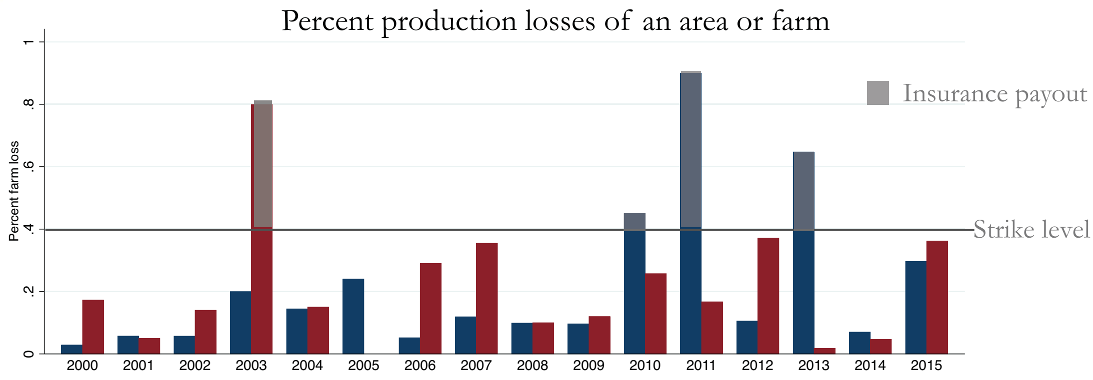
Better risk information for better design of agricultural insurance programs

Satellite-based risk information for each area or farm can be used by insurers to design and price various insurance contracts for farmers, groups, cooperatives, BAAC





If percent production loss > strike level,

Farmers

Insurance payout (%) = Production loss – Strike level

Insurance payout (baht) = Insurance payout (%) × Sum insured × Insured Rai

Sum insured can be expected income per rai, input cost per rai

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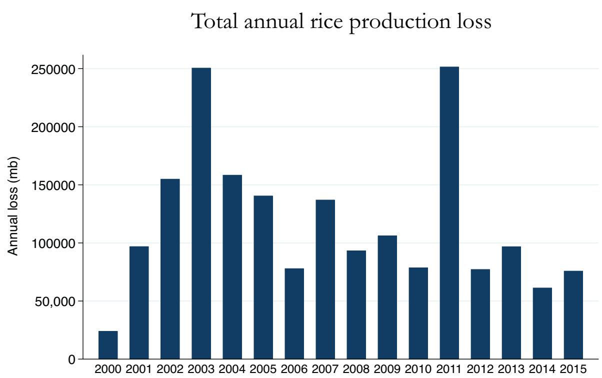
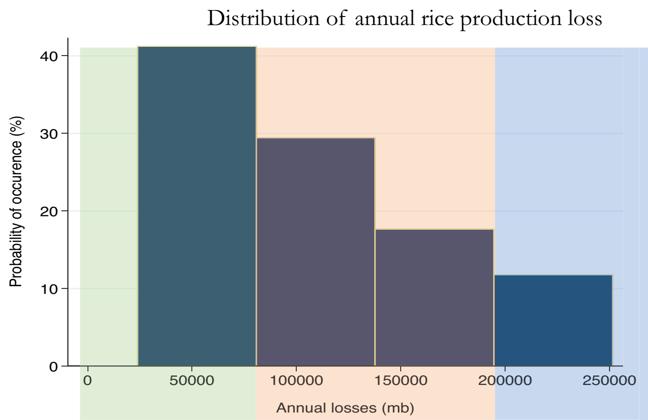
Better risk information for better design of PPP in agricultural risk management of the country

Satellite-based risk information for the whole country can be used to **design the most cost effective Public Private Partnership (PPP)** in agricultural risk management





Most cost-effective PPP in risk management

High frequency Low loss	Medium frequency Medium loss	Low frequency High loss
Manageable by **Farmers**	Sustainable Insurance **Market**	Market fails so need **Govnt** as insurer of last resort

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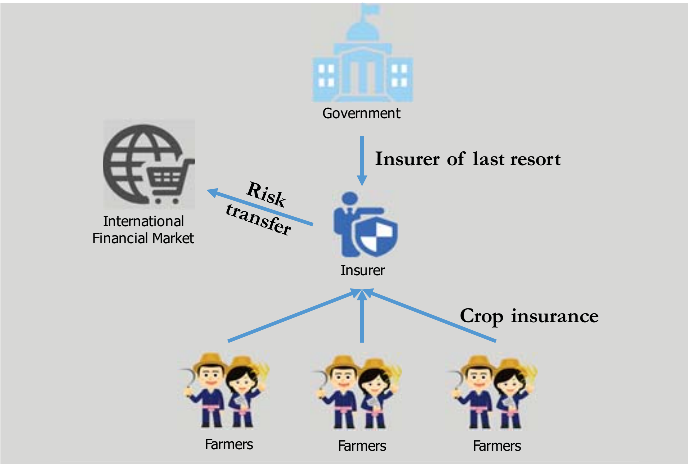
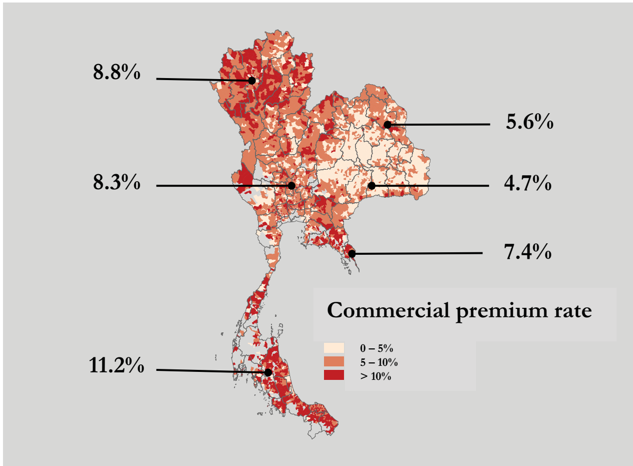
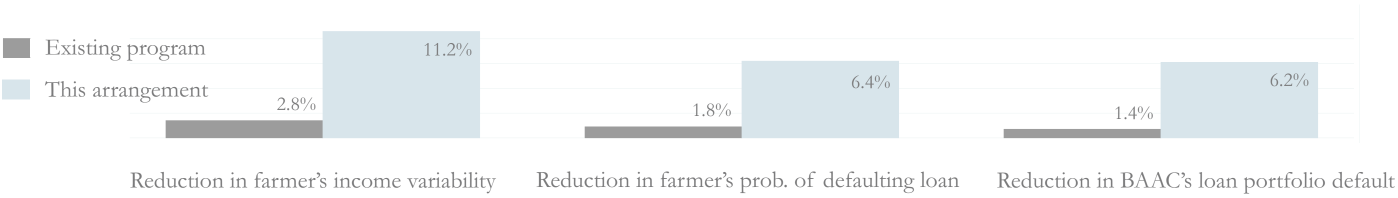
Possible insurance and PPP arrangements

Crop income insurance with government as insurer of last resort





- Worthwhile to ~60% of farmers
- **More than three times larger** impacts *relative to existing program*



per 1,000 million baht that government expects to spend

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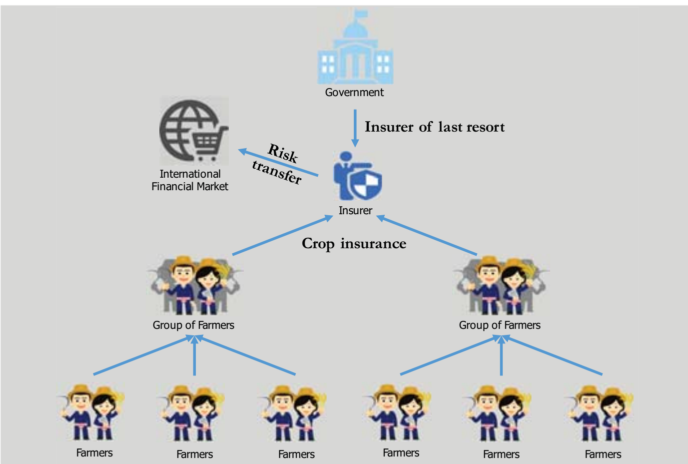
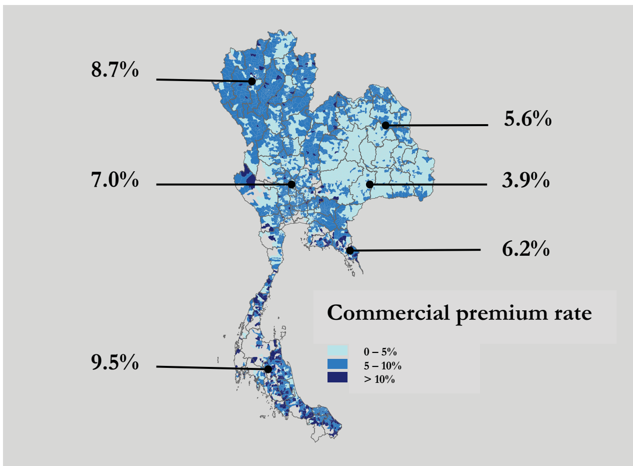
Possible insurance and PPP arrangements

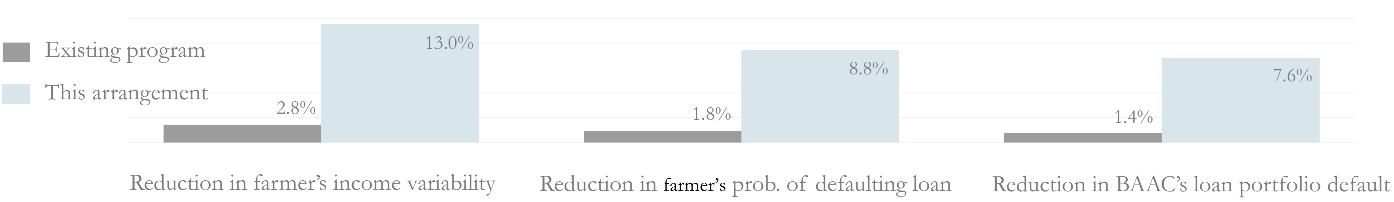
Crop income insurance for cooperatives with government as insurer of last resort





- **More than four times larger** impacts *relative to existing program*

  These are also due in part to the fact that farmers can share risk and predictive errors within group



per 1,000 million baht that government expects to spend

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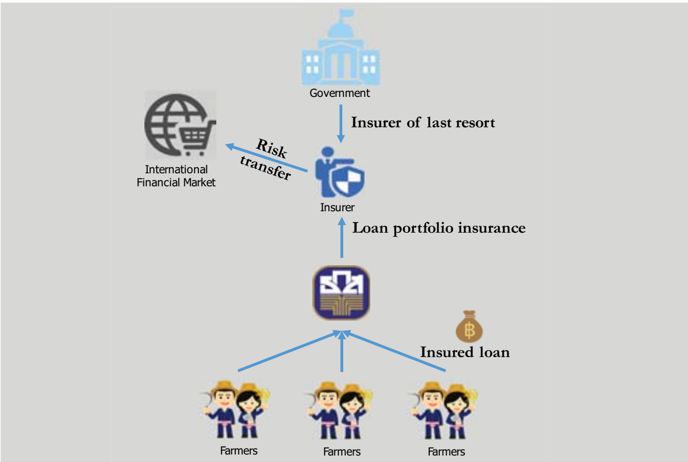
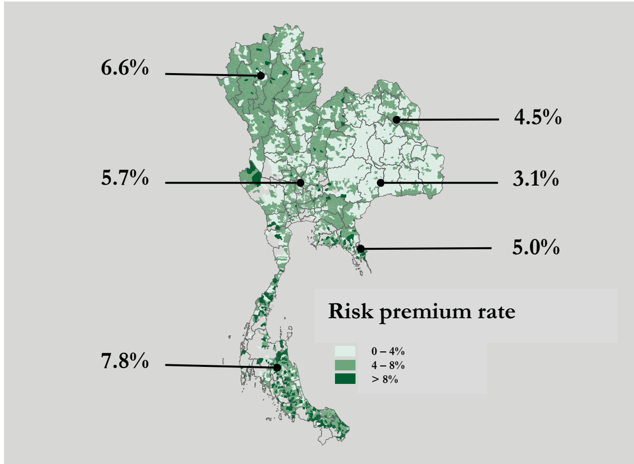
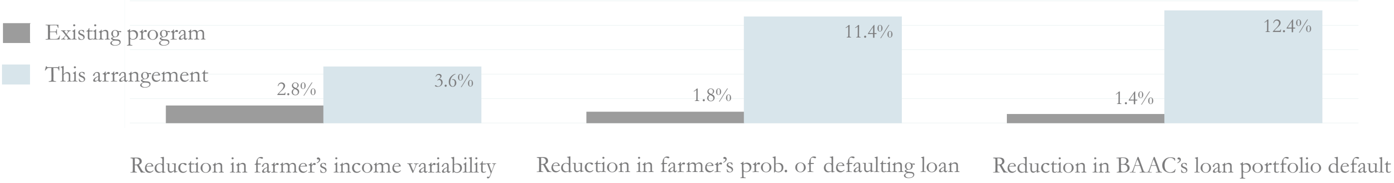
Possible insurance and PPP arrangements

Insured input loan with government as insurer of last resort





- ❖ Worthwhile to ~70% of farmers
- ❖ **More than five times larger** reduction in probability of defaulting input loan *relative to existing program*
- ❖ **More than eight times larger** reduction in BAAC loan portfolio default *relative to existing program*



per 1,000 million baht that government expects to spend

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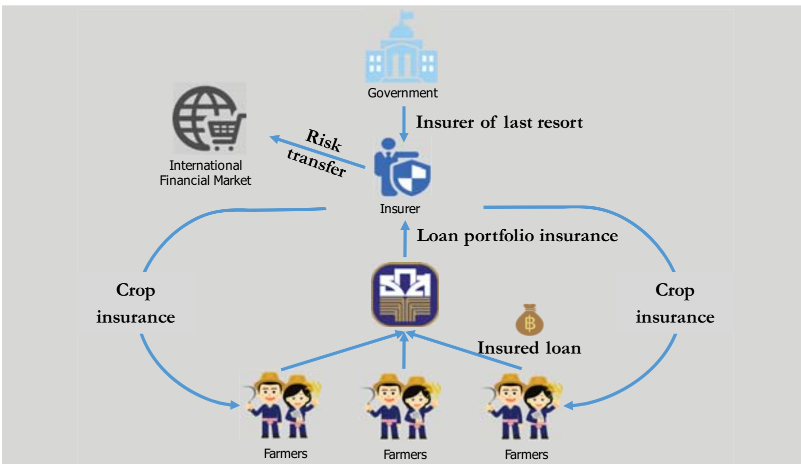
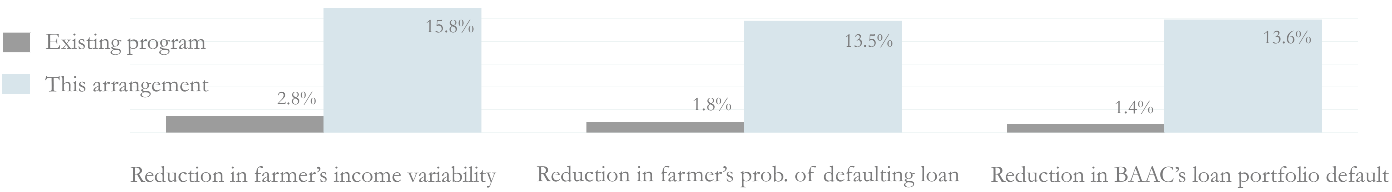
Possible insurance and PPP arrangements

Crop income insurance and insured input loan with government as insurer of last resort



- ❖ Worthwhile to ~70% of farmers
- ❖ **More than five times larger** reduction in income variability and probability of defaulting input loan
- ❖ **More than eight times larger** reduction in BAAC loan portfolio default *relative to existing program*



per 1,000 million baht that government expects to spend

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Ways forward and policy implications

Our research shows that there are values to investing in better agricultural risk information

- ❖ More efficient insurance market
- ❖ Strengthen risk management by farmers, groups and BAAC
- ❖ Less budget exposure to the government

This research is far from inclusive, other potential satellite applications include

- ❖ Improving management of other agricultural risk more importantly price risk
- ❖ Crowding in effectiveness of other agricultural programs (e.g., crop zoning, large farm program, group risk sharing, agricultural SMEs)
- ❖ Enhancing financial deepening with more variety of financial products to farmers

But "Who should invest in data, who should do research, and how do we bring research to materialize and drive policy?"

- ❖ Institutional arrangements to get the market to work first (reform of agricultural risk of the country, laws, risk infrastructure, financial literacy, etc.)